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Research Article

Woody Species Composition, Structure, and Regeneration Status of Gosh-Beret Dry Evergreen Forest Patch, South Gondar Zone, Northeast Ethiopia

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Owing to its variable topographic features, Ethiopia is endowed with rich biological resources. However, nowadays, these vital resources, mainly forests, are declining alarmingly, largely, due to agricultural expansion and energy consumption. This study was conducted at Gosh-Beret forest with the objective of investigating the status of forest species. Fifty-one main plots, spaced at a 100 m interval, were laid on north-south oriented transects. Within the main plots, five subplots, at each corner and center, were set to collect data for juveniles. In each plot, individuals of each woody species were identified and recorded. Percent cover abundance of each woody species per plot was genuinely estimated, which was later converted into the modified Braun–Blanquet scale. For each mature woody species, diameters at breast height (DBH ≥ 2 cm) were measured. Hierarchical cluster analysis was performed to identify community types. The Shannon–Wiener diversity index and Sorensen's similarity coefficient were used to compare the species diversity and composition among communities, respectively. The structure and regeneration status of the forest species were analyzed using structural parameters and size-class ratios, respectively. A total of 52 woody species distributed in 35 families were recorded. Fabaceae, Euphorbiaceae, and Asteraceae were the most dominant families with 4 species each. The overall species diversity of the forest was 2.6, and five community types were generated from cluster analysis. In the study forest, frequency and density of species decrease with increasing frequency and density classes. Likewise, density of individuals in each class decreases as DBH classes increase. The total basal area of the forest was 19.81 m^2ha^{-1}, and the forest was at fair regeneration status with species having small IVI values and few/no seedlings. Therefore, immediate conservation measures are required to save species with small IVI values and few/no seedlings.

1. Introduction

Ethiopia is characterized by a range of variable topographical features; a huge latitudinal spread and an immense altitudinal range resulted in great variation in climate and soils [1]. This variety led to the emergence of habitats that are suitable for the evolution and survival of various plant species [2]. This makes Ethiopia as one of the few countries in Africa where virtually major types of natural vegetation are represented, ranging from thorny bushes and tropical forests to mountain grasslands. According to [3], the vegetation of the country is very heterogeneous and estimated to contain 6025 different species of higher plants, of which about 10% are endemic.

The vegetation of Ethiopia is, thus, segregated into different plant communities that show spatial and temporal variations across landscapes resulting from differences in environmental gradients. Therefore, the evaluation of variation of environmental variables is essential to understand the factors governing the distribution of species [4]. Variations in the patterns of plant communities with variations in environmental variables were demonstrated in [5]. Such information is relevant to undertake appropriate conservation measures. Besides, examination of patterns of vegetation structures could provide valuable information about their regeneration status that could help devise conservation strategies [6]. The vegetation structure is maintained by the process of regeneration. Plants regenerate via soil seed banks, seedling banks, and vegetative parts [7]. Many plant species possess combinations of these that widen the ecological range and degree of persistence under fluctuating environmental conditions [8]. Physical and biotic factors (competition, herbivory, and disease) as well as disturbance regimes influence regeneration processes, and thereby, determine the abundance of species.

Though forest resources are vital for all lives on earth, it faces several challenges that lead them to diminish rapidly and alarmingly to several folds [9, 10]. The causes for forest loss are many and interconnected. Associated with geometric population growth, energy requirement and demand for agricultural lands increased dramatically that attributed to the major decline of forests. About 94% of the country's fuel demand relies on biomass alone [11], of which trees and shrubs contribute the largest proportion. According to [12], the natural forests of the country have been cleared within the last 30 to 50 years as the demand for energy (for charcoal and firewood), food, and fodder has increased.

Likewise, Gosh-Beret forest, dry evergreen Afromontane forest patch, found in the matrix of agricultural lands and settlements, is facing pressure from agricultural land expansion and fuel wood collection. Thus, the status of this natural forest is dawdling through time as a consequence of the increase of local people pressure for the satisfaction of their daily life. Studying the status of forests is crucial to clearly visualize the anthropogenic activities as well as environmental factors affecting the vegetation of the area. The lack of such basic information is one of the serious problems that affect conservation of forests [13]. To take appropriate conservation measures, basic scientific information regarding the status of the forest is, thus, required. Therefore, the objectives of this study were to (a) assess woody plant species composition, (b) identify plant community types, (c) analyze the patterns of the vegetation structure, and (d) evaluate the regeneration status of the forest.

2. Methods

2.1. Description of the Study Area. The study was conducted at Gosh-Beret dry evergreen Afromontane forest patch in Guna Begie-Midir district, South Gondar zone, Amhara region, Northeast Ethiopia. Kimir-Dingay, the capital of the district, is found 695 km north of Addis Ababa, the capital of Ethiopia (Figure 1). The district is boarded by Meketewa in the north, Ebinat in the northwest, East Estie in the south, Lay Gayint in the east, and Farta district in the west.

Guna Begie-Midir district is a new district established in 2017 by taking 17 kebeles (smallest administrative unit) from Farta district. The geographical position of the district ranges from 11°52′0″ to 11°57′5″ N latitude and 38°8′0″ to 38°11′0″ E longitude, with the altitude ranging from 1200 to 4120 m.a.s.l. Mount Guna, the 4th highest peak in the country, is located in this district. The study area (forest) consists of chains of rugged mountains, with the altitude extending from 2325 to 2560 m.a.s.l., with a geographical position ranging from 11054′10″ to 11°54′25″ N latitude 38°09′01″ and 38°09′23″ E longitude.

Meteorological data obtained from the National Meteorological Services Agency (from 2010 to 2019) showed that the mean annual maximum and minimum temperatures were 25.6°C and 6.8°C, respectively, and the mean annual rainfall was 1546 mm. The study area obtained high rainfall between June and October and low rainfall from March to May. Generally, the study area has a unimodal rainfall pattern, which gradually increases in the periods between February and June, reaches at the highest peak in July and August, and then falls down from September to January (Figure 2).

According to the Guna Begie-Midir District Agricultural Office (2019), the study area is generally characterized by mountainous topography with a cool to moderate climate, locally known as Dega (70%). The forest area is featured by the slope facing, largely, north to south side with the flat summit, and it is crossed by a big river, Hamus Wonze, which drains into the Ribb Dam.

Like other parts of the country, large parts of the district were covered by continuous vegetation until recently. However, vegetation has been destroyed by anthropogenic activities such as agricultural expansion. The depletion of vegetation is very rapid, leaving the area with remnant of small patches of forests and shrub lands encircled by large tracts of cultivated lands. Gosh-Beret is one of the dry evergreen montane forest patches characterized by different trees and shrubs interspersed with climbers and herbs with few wildlife inhabiting the forest (such as apes, monkeys, bushbuck, klipspringer, antelopes, common fox, hyenas, rabbit, porcupine, and various kinds of birds). Despite destruction of the vegetation around the study area, Gosh-Beret Forest is still, relatively, maintained for long time due to the protection of the forest by the government. Currently, Gosh-Beret forest covers about 435 hectares of land.

The inhabitants of the study area are from Amhara ethnic groups and speak Amharic language. The majority of the people are orthodox Christians (99.6%), and the major land use types in the area are farmland (45.3%), pasture (14%), forest with other vegetation types (16%), rural settlement (7.4%), degraded land (2.5%), and other landforms (14%). Human population growth resulted in a shortage of farm and grazing lands. The economy of local people is predominantly based on subsistence agriculture. The local people are involved in the collection of forest products (fuel wood and construction material) for domestic consumption and income generation. They partly depend on medicinal plants, most of which are harvested from the wild, to fulfill their healthcare needs.

2.2. Vegetation Sampling. The reconnaissance survey was carried out in October 2019 in order to get general information about the physiognomy of vegetation and determine sample size, plot size, sampling techniques, and alignments of transect lines. Floristic and environmental data collections were performed from March to April 2020.

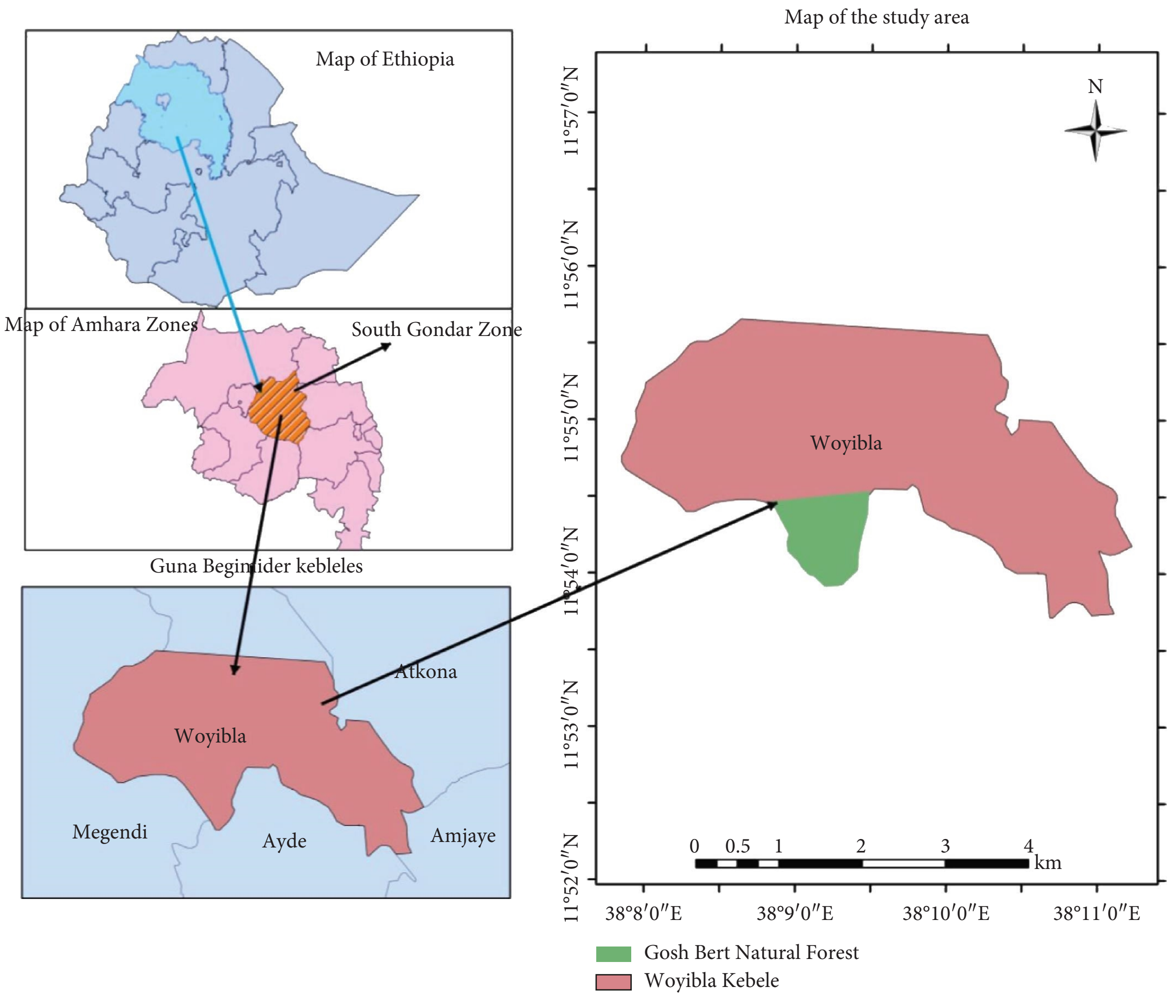

Figure 1: Map of the study area.

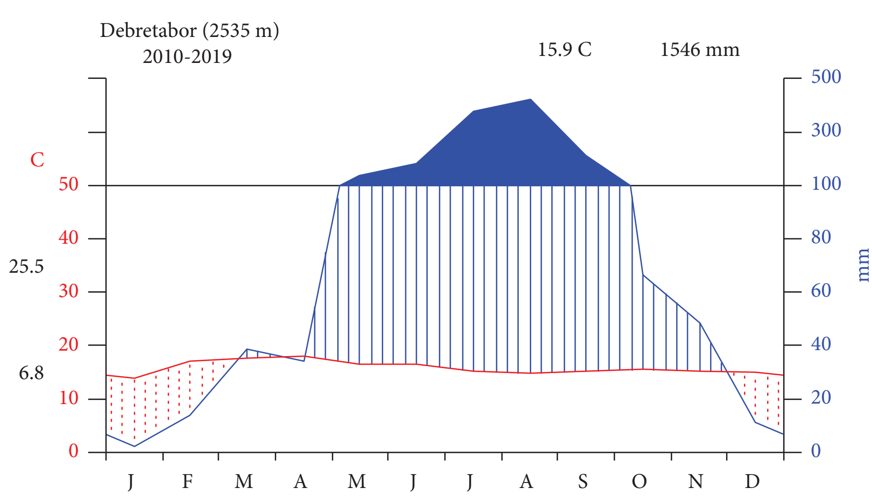

Figure 2: Climadiagram (data source: Amhara Meteorological Service Agency, 2020).

A systematic random sampling technique was used to collect vegetation data. Following [14], eight parallel line transects, spaced at 100 m intervals, were laid across the forests in a north-south direction using a Suunto compass. A total of 51 sample plots, with a size of 20 m × 20 m, were laid on the line transects at every 100 m interval. To collect data on seedling and saplings, five subplots of 2 m × 2 m, one at each corner and one at the center of the main plot, were laid, as used in [15].

In each plot, all woody species were counted and recorded by their local or scientific names or by codes depending on the familiarity of the species. Woody plant species which were difficult to identify in the field were collected, coded, pressed, and dried properly using plant presses and brought to the University of Gondar Herbarium where taxonomic identification was performed. Any woody plants having circumferences ≥6.3 cm were measured at 1.3 m above the ground so as to calculate diameter at breast height (DBH) following [16–18], and later, the circumference was converted into DBH using the formula DBH = C/π, where C is circumference and π is pi. Individual plants with DBH <2 cm were counted as juveniles, and those with height up to 1.5 m were counted as seedlings, whereas those between 1.5 m and 3 m height were counted as saplings, as used in [19]. In each subplot, density of size classes (seedlings, saplings, and adults) was calculated in order to determine the regeneration status of forest species. The ground cover, in percent, for each woody species in each plot, was estimated genuinely and was later converted into cover-abundance values using the modified 1–9 Braun–Blanquette scale [20, 21]. Environmental gradients of each plot were measured as follows: the altitude and the position were measured by using Garmin GPs 60, the aspect was measured using a compass, and the slope was measured using Suunto clinometers.

2.3. Data Analysis

2.3.1. Community Classification. Hierarchal cluster analysis was carried out based on the abundance of 48 species and 51 sample plots using R statistical software to group the vegetation into plant community types. The similarity ratio was used to determine the resemblance function, and Ward's method was used to minimize the total within group mean square or residual squares [22]. The community types which were identified from the cluster analysis was further refined in a synoptic table, and species occurrences were summarized as synoptic cover-abundance values. Dominant species (where the community named) of each community type was identified based on their higher synoptic values.

2.3.2. Species Diversity and Similarity among Community Types. Species diversity of the communities was computed by the Shannon–Wiener Diversity Index (H′) using the R statistical program:

$$H' = -\sum_{i=1}^{s} P_i \ln P_i, \quad (1)$$

where H' = Shannon Diversity Index, s = the number of species, P_i = the proportion of individuals, and ln = natural logarithm to base n

Evenness was calculated using the formula: $J = H'/H' \max = (\sum_{i=1}^{s} P_i ln P_i / lns)$, where J = evenness, $H' \max = H'$ maximum = lns, and s is the number of species [20]

Floristic similarities among different plant communities and other similar Ethiopian forests were calculated by employing Sørensen's similarity index [20, 23] using the formula Ss = $(2a)/(2a + b + c)$, where Ss = Sørensen's similarity coefficient, a = the number of species common to both samples, b = the number of species found only in sample 1, and c = the number of species found only in sample 2.

2.3.3. Vegetation Structure. The frequency, density, diameter at breast height, basal area, and Importance Value Index were used to analyze the vegetation structure of woody species.

Frequency (F) was computed as follows: (number of plots in which a species occur/total plots laid) × 100, where the value of each species was, then, sorted in increasing order and grouped into five frequency classes (in %): (1) 0–20, (2) 21–40, (3) 41–60, (4) 61–80, and (5) 81–100. The percentage distribution of individuals of species in each class was used to assess the distributional patterns of species in the forest patch.

Density (D) was calculated as follows: (number of above ground stems of *a* species/sample area in hectare) × 100, where D is expressed as the percentage for each species so as to assess the vegetation structure. It was, then, sorted in increasing order and grouped into seven density classes (in %): (1) ≤5, (2) 5.01–20, (3) 20.01–35, (4) 35.01–50, (5) 50.01–65, (6) 65.01–80, and (7) >80

Diameter at breast height (DBH) was calculated from the circumference of each adult woody species using the formula: $D = C/\pi$, where D = diameter at breast height, C = circumference, and π = constant with value 3.14.

DBH was, then, classified into six DBH classes (in cm): (1) ≤5, (2) 5.1–10, (3) 10.1–15, (4) 15.1–20, (5) 20.1–30, and (6) >40. The percentage number of individuals in each DBH class was calculated to assess the structural patterns of the forest patch.

The basal area (BA) was calculated from the value of DBH using the formula:

$$\text{basal area}\,(BA) = \frac{\pi d^2}{4}, \quad (2)$$

where d denotes the diameter at breast height in meters and π is a constant = 3.14.

The Importance Value Index (IVI) was generated from the sum of relative frequency (RF), relative density (RD), and relative abundance (RDO) [20]:

$$\begin{aligned}
\text{IVI} &= \text{RD} + \text{RF} + \text{RDO}\\
\text{relative density of a species (RD)} &= (\text{number of all individuals of a species/total number of all individuals of the sample}) \times 100\\
\text{relative frequency of a species (RF)} &= (\text{the number of plots where } a \text{ species occur/total occurrence for all species of the sample}) \times 100\\
\text{relative dominance of a species (RDO)} &= (\text{basal area of } a \text{ species/total basal area of the sample}) \times 100.
\end{aligned} \tag{3}$$

2.4. Regeneration Status. Regeneration status of trees and shrubs was analyzed using density ratios between age classes (seedlings, saplings, and adults). Regeneration status of the forest was stated (labeled) based on the density ratio classes recommended by [24] as "good" if presence of seedling > sapling > adult trees, "fair" if presence of seedling > sapling < adult trees, and "poor" if a species survives only in the sapling stage, but not as seedlings.

3. Results and Discussion

3.1. Species Accumulation Curve. During vegetation sampling, the number of species accumulates with the increasing area sampled. However, the number of newly added species decreases as the sampling effort continues. Such a trend of species accumulation could be represented graphically using a species accumulation curve. A curve labeled off (or in other cases a curve approximately reaching an asymptote) indicated that no new species would be added if the sampling effort is further continued [25]. This could prove that representative samples have been taken from the study area. The species accumulation curve in Figure 3 is labeled off, indicating that further sampling effort will not bring change in the species number, which proved that representative data were collected from the study forest.

3.2. Floristic Composition. A total of 52 woody species representing 35 families were identified (Table 1). Compared to other forests (except Wanzaye and Yemrehane Kirstos Church), Gosh-Beret forest has lower species richness (Table 2). The reasons for variations in species richness in the study area might be due to excessive anthropogenic disturbances and disparity in conditions for regeneration.

Fabaceae, Euphorbiaceae, and Asteraceae were species-rich families (4 species each), followed by Lamiaceae (3 species) and Rosaceae, Oleaceae, Sapindaceae, Loganiaceae, Capparidaceae, and Rutaceae (2 species each), whereas the remaining families had 1 species each. The dominance of Fabaceae and Asteraceae agreed with the report in the Flora of Ethiopia and Eretria. In addition, the dominance of Fabaceae is mentioned in other similar previous studies [18, 28]. This indicated that the dominance of these families might be due to the adaptation potential to wider agro-ecologies in various climates with efficient pollination and dispersal mechanisms.

Species in Asteraceae, for instance, are morphologically endowed with parachute-like structures. These are adapted for air dispersal and are capable of being blown high up, especially during strong winds [32]. Increased chances of successful establishment of the diaspores after arrival in various areas (refugia) could have allowed the species and genera of these dominant families to establish successful populations. This is often possible through physiological and/or genetic adaptation such as increased power of germination as well as ability to withstand the vagaries of extreme climatic conditions and biotic competition for scarce resources, especially during the initial colonization of virgin habitats [33].

Of the total plant species identified, 38.5% were trees, 46.1% were shrubs, and the remaining 15.4% were liana species. High numbers of shrubby species were also mentioned by some previous studies [26, 27]. Lower number of tree species (high number of shrubby species) in the forest could indicate that the forest is either protected recently or still under high pressure of anthropogenic factors.

Endemic species accounted for 5.8% of the total species recorded (Table 3). The endemic species proportion is lower than the proportion reported in the Flora of Ethiopia and Eretria (10%), Gedo (10.64%) [34], and Kumuli dry evergreen Afromontane (7%) [27]. This might be due to the smaller size of the forest and the less topographic heterogeneity of the study area.

3.2.1. Overall Species Diversity and Equitability of the Forest Species. The overall species diversity (H') and evenness of the study forest were found to be 2.6 and 0.66, respectively. Shannon–Weiner diversity is high when it is above 3.0, it is medium when it is between 2.0 and 3.0, and it is low when it is smaller than 2.0 [20]. Thus, the overall species diversity of the forest is medium. The species evenness value ranges between 0 and 1. When it is 0, the area is dominated by single species, and when it is 1, species are evenly distributed in the area [20, 35]. The result indicated that the species in the study forest are little over 50% evenly distributed, i.e., had medium evenness. Thus, the study forest has medium diversity and evenness.

In addition, compared to other dry evergreen Afromontane forests (Table 4), the diversity and evenness of the forest were low. This might be due to local anthropogenic disturbance of the forest for different purposes (fire wood,

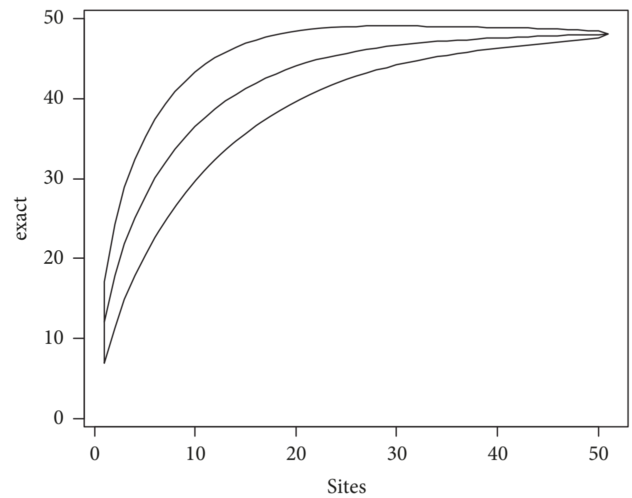

Figure 3: Species area curve.

Table 1: List of woody plants in Gosh-Beret forest with their frequency & density.

No	Species scientific names	Family namess	Habit
1	*Acacia abyssinica* Hochst. ex. Benth	Fabaceae	Tree
2	*Acanthus sennii* Chiov	Acanthaceae	Shrub
3	*Acokanthera schimperi* (ADC) Schweinf	Apocynaceae	Shrub
4	*Albizia schimperiana* Oliv.	Fabaceae	Tree
5	*Allophylus abyssinicus* (Hochst) Radlk	Sapindaceae	Tree
6	*Bersama abyssinica* Fresen.	Melianthaceae	Shrub
7	*Brucea antidysenterica* J.F.	Simaroubaceae	Shrub
8	*Buddleja polystachya* Fresen	Loganiaceae	Tree
9	*Calpurnia aurea* (AiT) Benth	Fabaceae	Shrub
10	*Capparis tomentosa* (AiT) Beth	Capparidaceae	Climber
11	*Carissa spinarum* L.	Apocynaceae	Shrub
12	*Clausena anisata* (Wild) Benth.	Rutaceae	Shrub
13	*Clematis simensis* (Roxb.) Kurtz	Ranunculaceae	Climber
14	*Clerodendrum myricoides* (Hochst) Vatke.	Lamiaceae	Shrub
15	*Clutia lanceolata* Forrsk	Euphorbiaceae	Shrub
16	*Cordia africana* Lamp.	Boraginaceae	Tree
17	*Croton macrostachyus* Hochst. ex. Del.	Euphorbiaceae	Tree
18	*Discopodium penninervium* Hochst.	Solanaceae	Shrub
19	*Dodonaea angustifolia* L.F	Sapindaceae	Shrub
20	*Dombeya torrida* (J.FGamel) P.Bamps	Sterculiaceae	Tree
21	*Dovyalis abyssinica* (A.Rich) Warb.	Flacourtiaceae	Shrub
22	*Dregea rubicunda* Schum.	Asclepiadaceae	Climber
23	*Echinops longisetus* A.Rich.	Asteraceae	Shrub
24	*Ekebergia capensis* Spam	Meliaceae	Tree
25	*Entada abyssinica* Steud. ex A.Rich	Fabaceae	Climber
26	*Euphorbia candelabrum*Tremaux. ex, Kotschy	Euphorbiaceae	Tree
27	*Ficus sur* Forssk.	Moraceae	Tree
28	*Grewia ferruginea* Hocsht. ex. A. Rich	Tiliaceae	Tree
29	*Hibiscus macranthus* Hochl. ex. A. Rich.	Malvaceae	Climber
30	*Jasminum abyssinicum* L.	Oleaceae	Climber
31	*Juniperus procera* Hochst.ex.Engl.	Cupressaceae	Tree
32	*Laggera tomentosa* (Sch. Bip.ex. A. Rich) Olivu. &Hiern	Asteraceae	Shrub
33	*Maytenus arbutifolia* A.Rich.	Celastraceae	Shrub
34	*Myrica salicifolia* Hochst. ex. A.Rich.	Myricaceae	Tree
35	*Myrsine africana* L.	Myrsinaceae	Shrub
36	*Nuxia congesta* R.Br.ex.Fresen.	Loganiaceae	Tree
37	*Olea europaea* subsp. *cuspidata* L. (Wall.ex.J.Don) Cif.	Oleaceae	Tree
38	*Otostegia integrifolia* Benth	Lamiaceae	Shrub
39	*Osyris quadripartita* Decn.	Santalaceae	Shrub

Table 1: Continued.

No	Species scientific names	Family namess	Habit
40	*Phytolacca dodecandra* L.Herit	Phytolaccaceae	Climber
41	*Premna schimperi* Engl.	Lamiaceae	Shrub
42	*Prunus africana* Hook.f.	Rosaceae	Tree
43	*Rhus glutinosa* A.Rich subsp. *glutinosa*	Anacardiaceae	Shrub
44	*Ricinus communis* L.	Euphorbiaceae	Shrub
45	*Ritchiea albersii* Gilg.	Capparidaceae	Shrub
46	*Rosa abyssinica* Lindley	Rosaceae	Shrub
47	*Rumex nervosus* Vahl.	Polygonaceae	Shrub
48	*Salix subserrata* (Willd) R.H. Archer and Jordaan	Salicaceae	Tree
49	*Solanecio gigas* Vatke	Asteraceae	Shrub
50	*Teclea nobilis* Delile.	Rutaceae	Tree
51	*Urera hypselodendron* (Hoschst.) ex.A. Rich.	Urticaceae	Climber
52	*Vernonia myriantha* Hook	Asteraceae	Shrub

Table 2: Species richness comparisons of the study forest with other DAFs of Ethiopia.

Forests	Number of species	Authors
Amoro	57	[26]
Alemsaga	88	[17]
Yegof	76	[18]
Kumuli	133	[27]
Tara Gedam forest	114	[28]
Yemrehane Kirstos Church	39	[29]
Gosh-Beret	52	Present study
Wanzaye	49	[30]
Zegie	113	[31]

Table 3: Endemic species in Gosh-Beret forest and their IUCN status.

Scientific names	Family	Habit	IUCN category
Acanthus sennii	Acanthaceae	Shrub	Near threatened
Solanecio gigas	Asteraceae	Shrub	Least concerned
Rhus glutinosa	Anacardiaceae	Shrub	Not evaluated

Table 4: Species diversity (H), richness (S), and evenness (E) comparison of the study forest with other DAFs of Ethiopia.

No.	Forests	S	H′	J	Sources
1	Tara-Gedam	113	2.98	0.65	[28]
2	Kumuli	133	2.97	0.6	[27]
3	Yemrehane Kirstos church	39	2.88	0.79	[29]
4	Wanzaye	49	3.15	0.81	[30]
5	Gosh-Beret	52	2.6	0.66	Present study
6	Yegof	76	2.26	0.57	[18]
7	Zegie	113	3.72	0.84	[31]
8	Ylat	60	2.94	0.84	[36]
9	Dangila	73	3.5	0.82	[37]

farming tools, income, food, construction, and medicine) as observed during data collection. Low species diversity and evenness values reveal ecosystem instability, unhealthiness, and improper species interaction [20] that would imply the need to conserve the forest to restore its floristic diversity as well as to reduce human pressure.

3.3. Plant Community Types. Cluster analysis of floristic data generated five different community types (Figure 4).

3.3.1. Maytenus arbutifolia-Bersama abyssinica Community. This community type was distributed between the altitudinal ranges of 2325 and 2413 m.a.s.l. It was represented by 14 plots and 30 associated species (Table 5). Most of the plots of the community were situated in the north-west direction. *Teclea nobilis* and *Albizia schimperiana* were the dominant tree species. *Calpurnia aurea, Vernonia myriantha,* and *Solanecio gigas* were the dominant species in the shrubby layer, whereas *Entada abyssinica* was the dominant liana (Table 6).

Since sample plots were close to the surrounding village, they were exposed to human impacts such as collecting firewood, grazing, and charcoal production. Most of the plots, thus, were under the influence of human encroachment that might relatively result in lower species diversity (2.51), species evenness (0.74), and species richness (30) of the community type.

3.3.2. Euphorbia candelabrum-Acokanthera schimperi Community. Species in this community were spread between 2386 and 2535 m.a.s.l. altitudinal ranges. Eleven plots represented the community with 34 associated species (Table 5). Most plots were situated in the northwest direction. *Teclea nobilis* and *Albizia schimperiana* were the dominant tree species, whereas *Calpurnia aurea*, *Carissa spinarum, Vernonia myriantha,* and *Dovyalis abyssinicum* were common in the shrub layer. *Dregea rubicunda, Entada abyssinica,* and *Clematis simensis* were common lianas. *Hibiscus macranthus* and *Prunus africana* were indicator species of this community (Table 6). Relative to community 1, the influence of human activities is reduced as plots in this community were far from the surrounding village, resulting in a relatively higher species diversity (2.76), species evenness (0.78), and species richness (34).

3.3.3. Albizia schimperiana-Entada abyssinica Community. Species in this community were distributed in altitudes ranging from 2370 to 2530 m.a.s.l. Fifteen plots, with a total of 45 species, were clustered in this community (Table 5). The majority of plots were laid in southwest and northwest directions. Along with the dominant species used to name the community, *Teclea nobilis* and *Euphorbia candelabrum* were the common tree species in the community. The dominant shrub species were *Carissa spinarum, Maytenus arbutifolia,* and *Calpurnia aurea. Entada abyssinica* was the dominant climber (liana) species. *Ficus sur* and *Myrsine africana* were indicator species of this community (Table 6).

This community had 2.81 species diversity, 0.73 species evenness, and the highest species richness (45), which might be due to furthest distances of plots from the village, and most of the plots were found in gentle slopes where soil erosion is low. In addition, local people believed that this part of the forest is the habitat of wild animals including hyenas. Moreover, some plots in this community were found on sloppy and inaccessible sites where human and grazer influences are reduced, which agreed with the work in [17] who stated that sloppy nature of sites, which are not easily accessible to disturbance through selective cutting and grazing, maintains better species composition and richness.

3.3.4. Vernonia myriantha-Laggera tomentosa Community. Species in this community were distributed in altitudes ranging from 2395 to 2515 m.a.s.l. It was represented by the smallest number of plots (6) and 30 associated species (Table 5). The majority of the plots were oriented to southeast directions. Relative to other community types, this community was the most diverse (2.98), with relatively equitable representation of each species (0.87). This community is, thus, expected to be stable and healthier. This might be due to reduced human and livestock pressure as plots were found in inaccessible and sloppy areas. The dominant tree species were *Albizia schimperiana, Croton macrostachyus*, *Teclea nobilis,* and *Olea europaea* subsp. *cuspidata. Jasminum abyssinicum* and *Phytolacca dodecandra* were common climbers (lianas). This community was dominated by shrubby species such as *Calpurnia aurea, Maytenus arbutifolia, Clausena anisata,* and *Dodonaea angustifolia* (Table 6). Selective cutting of tree species for different purposes and ongoing ecological succession of the component species might be the reason for the dominance of shrubby species.

3.3.5. Juniperus procera-Acanthus sennii Community. Species in this community were distributed in higher altitudes ranging from 2490 to 2560 m.a.s.l. Five plots with 23 associated species were included in this community (Table 5). The majority of the plots were oriented to the southeast and south directions. It has the second highest species evenness value (0.83) and the least species richness (23). The least species richness might be attributed to agricultural land encroachment as plots were located around crop lands. The dominant tree species included in the community were *Euphorbia candelabrum, Acacia abyssinica,* and *Teclea nobilis*. *Carissa spinarum, Calpurnia aurea,* and *Maytenus arbutifolia* were common species in the shrub layer. *Entada abyssinica* was the common climber in the community (Table 6).

3.4. Species Composition Similarities among Communities. The overall similarity coefficient among communities ranges from 63 to 84% (Table 7). Sorensen's similarity coefficient was used to detect similarities among plant communities. Based on this, similarity in species composition slightly varied among communities. Relatively, the highest similarity was observed between communities 1 and 2 (84%), which might be due to close proximity of the communities or exposure to similar environmental factors that led to similar adaptation. The least similarity was observed between communities 1 and 5, 2 and 5, and 3 and 5 (63%). This might be due to differences in altitudinal gradients or environmental or anthropogenic factors, leading them to have relatively lower similarities.

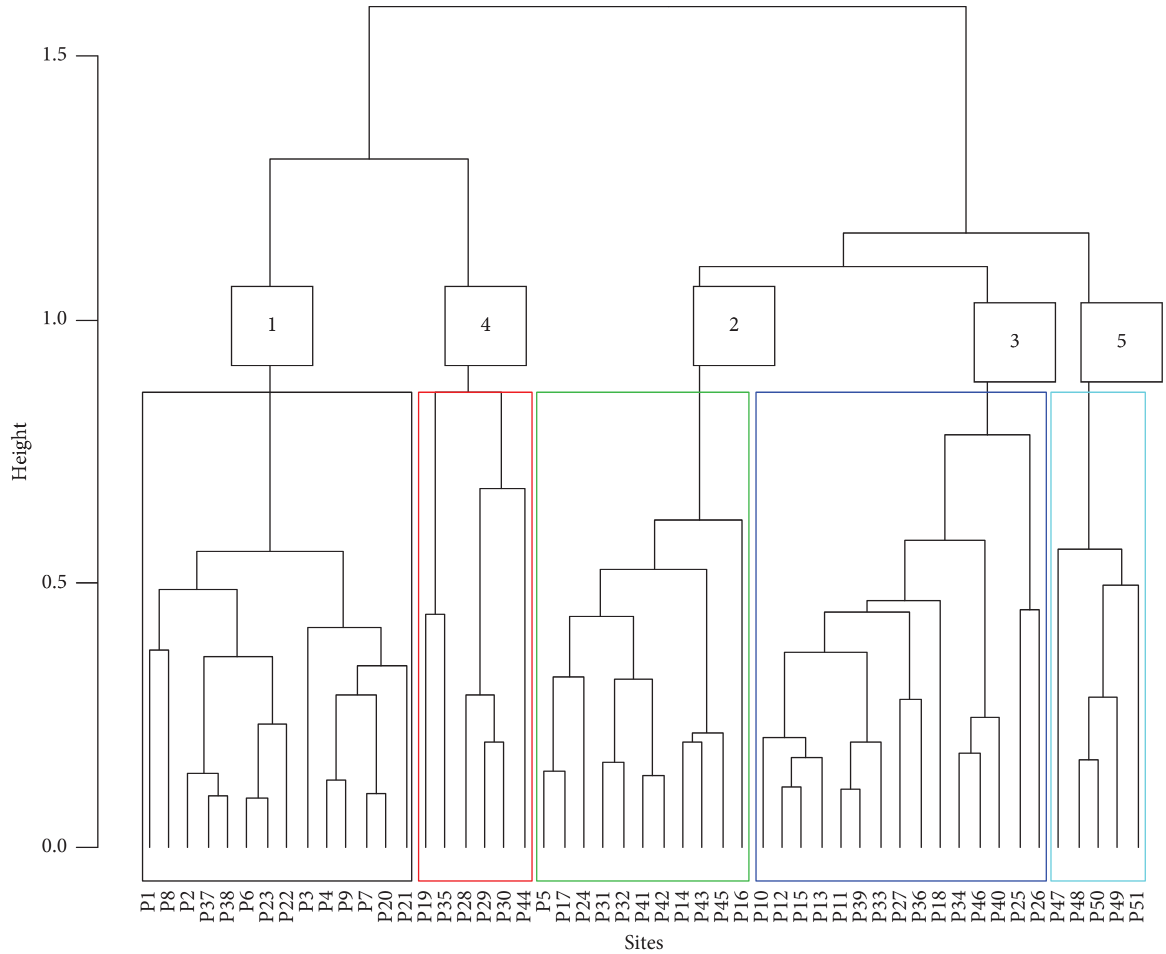

Figure 4: Clusters generated from agglomerative hierarchical classification.

Table 5: Clusters generated from cluster analysis.

Communities	Number of plots	Plots
1	14	1–4, 6–9, 20–23, 37, 38
2	11	5, 14, 16, 17, 24, 31, 32, 41–43, 45
3	15	10–13, 15, 17, 25–27, 33, 34, 36, 39, 40, 46
4	6	19, 28–30, 35, 44
5	5	47, 48, 49, 50, 51

Table 6: Species with a synoptic value ≥0.5 in at least one of the clusters.

Scientific names	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Vernonia myriantha	3.79	2.73	0.53	**5.00**	0.00
Teclea nobilis	5.36	5.45	5.40	2.33	2.80
Solanecio gigas	1.21	0.09	0.13	1.00	0.00
Phytolacca dodecandra	0.43	0.36	0.27	1.67	0.20
Osyris quadripartita	0.07	0.00	0.20	0.50	0.20
Maytenus arbutifolia	**6.79**	3.73	3.53	3.00	2.20
Laggera tomentosa	0.86	0.27	0.60	**4.00**	0.80
Juniperus procera	0.00	0.00	0.00	0.00	**4.80**
Jasminum abyssinicum	0.00	0.00	0.27	2.17	0.00
Euphorbia candelabrum	0.07	**5.00**	1.73	0.17	4.00

Table 6: Continued.

Scientific names	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Entada abyssinica	1.93	0.64	**2.87**	0.33	1.00
Dovyalis abyssinica	0.07	1.09	0.20	0.00	0.00
Dodonaea angustifolia	0.00	0.00	0.13	1.67	0.80
Croton macrostachyus	1.29	0.36	0.53	2.17	0.00
Clutia lanceolata	0.14	0.82	0.80	2.67	0.00
Clausena anisata	0.29	0.91	0.40	1.17	0.00
Carissa spinarum	1.43	5.00	6.13	5.00	7.00
Capparis tomentosa	0.43	0.18	0.07	0.67	0.00
Calpurnia aurea	5.36	5.55	4.80	6.33	5.20
Brucea antidysenterica	0.57	0.09	0.33	0.00	0.00
Bersama abyssinica	**4.07**	1.91	0.93	0.00	0.00
Albizia schimperiana	2.36	1.45	**4.67**	2.50	2.60
Acokanthera schimperi	0.36	**3.55**	0.73	0.00	0.20
Acanthus sennii	0.07	0.73	0.53	1.67	**2.80**
Ficus sur	0.00	0.00	0.52	0.00	0.00
Myrsine africana	0.00	0.00	0.5.	0.00	0.00

The bold values indicate plants with maximum synoptic values in each community type (cluster) by which the community name is given.

Table 7: Sorensen's similarity coefficient among communities.

Communities	1	2	3	4	5
1	1				
2	0.84	1			
3	0.81	0.81	1		
4	0.68	0.71	0.81	1	
5	0.63	0.63	0.63	0.78	1

3.5. Vegetation Structure

3.5.1. Frequency. The most frequent species was *Maytenus arbutifolia* (98%), followed by *Calpurnia aurea* (96.1%), *Teclea nobilis* (92.3%), *Carissa spinarum* (88.2%), and *Albizia schimperiana* (88.2%) (Table 8). The frequent occurrence indicates the successful reproduction and adaptation of a species to the area [4]. Dispersion of species was classified into 5 frequency classes (Figure 5). The trend showed a higher number of species (66.7%) in frequency class 1, followed by a continuous decrease in the number of species up to frequency class 4 from which the species number started to increase till frequency class 5.

Frequency indicates the homogeneity and heterogeneity of a given vegetation in which the high number of species in higher frequency classes and the low number of species in lower frequency classes show similar species composition (higher homogeneity), while the large number of species in lower frequency classes and the small number of species in higher frequency classes indicate higher heterogeneity (Lambrecht, 1989). Thus, from the result, it can be said that the vegetation of the study forest is more or less heterogeneous. Similar results were reported by previous studies [17, 38]. Heterogeneity of vegetation might be attributed to habitat preferences among species, species characteristic for adaptation, degree of disturbance, and availability of suitable conditions for regeneration [39].

3.5.2. Density. The total density of mature woody species (DBH ≥2 cm) of the study forest was 1586.75 individuals ha^{-1}, which is lower than that of Yegof (1,768.13 stems ha^{-1}) [18], Tara Gedam (3,001 stems ha^{-1}), Abebaye (2,850 stems ha^{-1}) [28], and Zengena (2,202 stems ha^{-1}) [38] dry evergreen Afromontane forests but higher than that of Hugumburda (1,218 stems ha^{-1}) [40] and Wof Washa (698.8 stems ha^{-1}) [41] in Ethiopia. Variations in density distributions can be attributed to differences in topographic gradients and habitat preferences of different tree and shrub species forming the forest as well as the differences in degrees of anthropogenic influences [42].

Species that contributed the highest number of individuals ha^{-1} was *Carissa spinarum* (809.72 ha^{-1}), followed by *Calpurnia aurea* (570.58 ha^{-1}), *Teclea nobilis* (519.48 ha^{-1}), and *Maytenus arbutifolia* (515.24 ha^{-1}) (Table 8), respectively. The highest number of individuals ha^{-1} could mean that the species is under good reproduction and recruitment despite the presence of trampling, grazing, and other anthropogenic disturbances. The density distribution of species in the density classes showed more or less zig-zag patterns (Figure 6). A similar result was also reported by the authors of [17] who pointed out that such a pattern showed selective cutting of species for different purposes.

3.5.3. Diameter at Breast Height (DBH) Distribution. A total of 1586.75 individuals ha^{-1} of woody plant species (DBH ≥2 cm) were recorded from the forest. The DBH distribution was classified into 6 DBH classes. Most of the individuals were distributed in the lowest DBH classes, showing a continuous decrease towards higher DBH classes. Such a distribution of individuals represents an inverted J-shape curve (Figure 7). A similar pattern was reported by previous

Table 8: Density (D), relative density (RD), basal area (BA), relative BA, frequency (F), relative frequency (RF), and IVI for mature woody plant species.

Scientific names	D	RD	BA	RDO	F	RF	IVI
Albizia schimperiana	387.96	9.25	8.99	45.41	88.2	7.23	61.89
Carissa spinarum	809.72	19.30	1.6	8.1	88.2	7.23	34.63
Calpurnia aurea	570.58	13.60	1.07	5.39	96.07	7.88	26.87
Teclea nobilis	519.49	12.38	0.94	4.72	92.15	7.56	24.66
Euphorbia candelabrum	229.56	5.47	2.23	11.26	49.01	4.02	20.75
Maytenus arbutifolia	515.24	12.28	0.02	0.08	98.03	8.04	20.40
Croton macrostachyus	218.56	5.21	1.79	9.06	52.94	4.34	18.61
Entada abyssinica	225.76	5.38	0.13	0.68	54.9	4.5	10.56
Vernonia myriantha	187.17	4.46	0.12	0.61	66.66	5.47	10.54
Juniperus procera	28.96	0.69	1.04	5.23	9.8	0.8	6.72
Bersama abyssinica	43.11	1.03	0.06	0.29	43.13	3.54	4.86
Acanthus senni	97.01	2.31	0.01	0.06	25.49	2.09	4.46
Phytolacca dodecandra	21.54	0.51	0.12	0.62	37.25	3.05	4.18
Olea europaea subsp.*cuspidata*	17.16	0.41	0.32	1.59	21.56	1.77	3.77
Clausena anisata	21.63	0.52	0.02	0.09	33.33	2.73	3.34
Acokanthera schimperi	21.07	0.50	0.03	0.13	31.37	2.57	3.20
Laggera tomentosa	13.7	0.33	0	0	27.45	2.25	2.58
Otostegia integrifolia	62.19	1.48	0	0.01	9.8	0.8	2.29
Clutia lanceolata	25.97	0.62	0	0.01	19.6	1.61	2.24
Nuxia congesta	6.86	0.16	0.2	1.01	9.8	0.8	1.97
Brucea antidysenterica	14.7	0.35	0	0	19.6	1.61	1.96
Acacia abyssinica	7.31	0.17	0.22	1.12	7.84	0.64	1.93
Dombeya torrida	8.82	0.21	0.08	0.4	15.68	1.29	1.90
Ekebergia capensis	4.41	0.11	0.16	0.8	11.76	0.96	1.87
Allophylus abyssinicus	6.33	0.15	0.14	0.72	11.76	0.96	1.83
Capparis tomentosa	10.78	0.26	0.02	0.12	15.86	1.3	1.68
Solanecio gigas	1.96	0.05	0	0	17.6	1.44	1.54
Dodonaea angustifolia	24.97	0.60	0.02	0.08	9.8	0.8	1.48
Dovyalis abyssinica	6.89	0.16	0	0.02	15.68	1.29	1.47
Ficus sur	1.96	0.05	0.17	0.86	5.88	0.48	1.39
Buddleja polystachya	3.88	0.09	0.06	0.31	9.8	0.8	1.20
Rosa abyssinica	12.26	0.29	0.01	0.05	9.8	0.8	1.14
Dregea rubicunda	5.88	0.14	0.04	0.19	9.8	0.8	1.13
Clematis simensis	4.9	0.12	0.03	0.14	9.8	0.8	1.06
Cordia africana	3.92	0.09	0.02	0.11	9.8	0.8	1.00
Osyris quadripartita	5.44	0.13	0.01	0.06	9.8	0.8	0.99
Rumex nervosus	7.8	0.19	0	0	9.8	0.8	0.99
Urera hypselodendron	7.35	0.18	0.05	0.27	5.88	0.48	0.93
Rhus glutinosa subsp.*glutinosa*	4.35	0.1	0	0	0.8	0.8	0.9
Jasminum abyssinicum	8.8	0.21	0	0	7.84	0.64	0.85
Discopodium penninervium	3.44	0.08	0.01	0.06	7.84	0.64	0.78
Premna schimperi	2.94	0.07	0.04	0.18	5.88	0.48	0.73
Grewia ferruginea	4.41	0.11	0.01	0.04	5.88	0.48	0.63
Clerodendrum myricoides	2.94	0.07	0	0.01	5.88	0.48	0.56
Ritchiea albersii	2.94	0.07	0	0.01	5.88	0.48	0.56
Prunus africana	1.47	0.04	0	0.02	5.88	0.48	0.54
Myrsine africana	0.98	0.02	0.02	0.08	1.96	0.16	0.26
Hibiscus macranthus	0.98	0.02	0	0	1.96	0.16	0.18

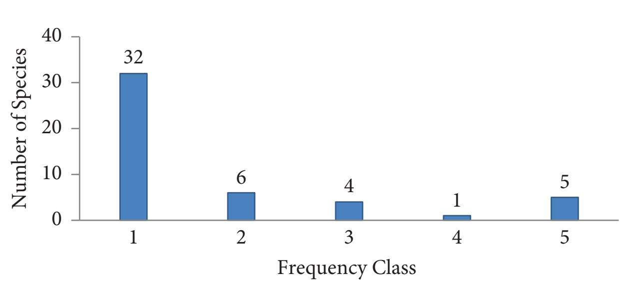

Figure 5: Frequency class distribution of woody species in Gosh-Beret forest.

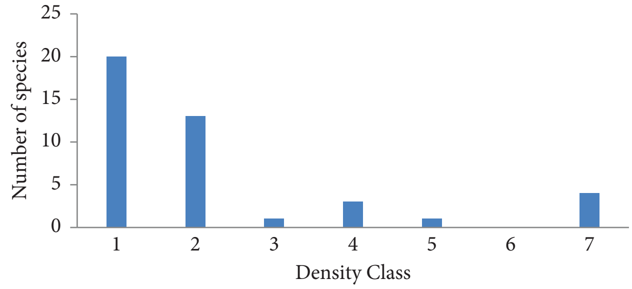

Figure 6: Density class of mature tree species.

similar studies [17, 28, 38, 41]. This implies a good reproduction and recruitment status of the species in the forest [43].

3.5.4. Population Structure for Some Selected Woody Species. The analysis of the population structure of the selected woody species based on density of DBH resulted in four patterns (Figures 8(a)–8(d)). The first pattern was inverted J-shape. This pattern was also reported by several previous similar studies [28, 30, 41, 43]. Such a structure showed good reproduction and recruitment [43] (Figure 8(a)). Plant species showing this pattern were *Teclea nobilis, Capparis tomentosa, Dombeya torrida, Entada abyssinica,* and *Calpurnia aurea.*

The second pattern was a bell-shaped distribution (Figure 8(b)) where lower classes have a lower number of individuals followed by an increase in the number of individuals towards middle classes and then a progressive decrease towards higher DBH classes. The woody plant species included in this pattern were *Albizia schimperiana, Nuxia congesta, Euphorbia candelabrum, Juniperus procera, Ficus sur, Allophylus abyssinicus, Ekebergia capenis, Olea europaea,* and *Croton macrostachyus.* Similar results were shown in [30, 43]. A bell shape follows a Gaussian distribution pattern indicating poor reproduction and recruitment of species, which might be associated with the overharvesting of seed-bearing individuals or the presence of only some seed-bearing individuals [43].

The third pattern consisted of those species occurred only in lower DBH classes (classes 1 and 2). This type of population structure was also reported in [19] that suggested the good reproduction and bad recruitment status of the species. The species in this pattern include *Acokanthera schimperi, Acanthus sennii, Capparis tomentosa, Clausena anisata, Clematis simensis, Dodonaea angustifolia, Maytenus arbutifolia, Bersama abyssinica,* and *Osyris quadripartita* (Figure 8(c)). The last (4^{th}) pattern was represented by only *Ficus sur* (Figure 8(d)) that occurred only in the medium DBH classes (10.1–20 cm and 20.1–30 cm). This may be due to low regeneration status of the species and removal of the matured individuals of the species for construction materials.

3.5.5. Basal Area. As calculated from DBH data, the total basal area (BA) of adult woody species of Gosh-Beret forest was $19.81 m^2ha^{-1}$. The normal value of the basal area in Africa is expected to be between 23 and $37 m^2ha^{-1}$ [23]. This could mean that the basal area of the study forest is lower than the normal value.

The basal area of Gosh-Beret forest was also compared with the basal area of other 5 dry evergreen Afromontane forest patches in Ethiopia (Table 9). The basal area of Gosh-Beret forest was higher than that of Yegof and Amoro forests, but it was lower than that of Tara Gedam, Alemsaga, and Gedo dry evergreen Afromontane forests. A lower basal area value would mean that the study forest is composed of shrubby and young tree species that revealed that the forest is either protected lately or still under anthropogenic pressure. *Albizia schimperiana* accounted for the highest basal area value ($8.99 m^2ha^{-1}$), followed by *Euphorbia candelabrum* ($2.23 m^2ha^{-1}$), *Croton macrostachyus* ($1.79 m^2ha^{-1}$), *Carissa spinarum* ($1.6 m^2ha^{-1}$), and *Calpurnia aurea* ($1.07 m^2ha^{-1}$) (Table 8).

3.5.6. Importance Value Index (IVI). Based on their higher IVI values, the five leading dominant and ecologically most significant woody species were *Albizia schimperiana* (61.88), *Carissa spinarum* (34.63), *Calpurnia aurea* (26.87) *Teclea nobilis* (24.66), and *Euphorbia candelabrum* (20.75) (Table 8), whereas species with the least IVI value was *Hibiscus macranthus* (0.18), followed by *Myrsine africana* (0.26), *Prunus africana* (0.54), *Ritchiea albersii* (0.56), and *Clerodendrum myricoides* (0.56). A high IVI value indicates that the species is most successful in regeneration and pathogen resistance and grows in the shade, and in comparison with other species, these species are least preferred by browsing animals and seed predators and have high attraction of pollinators that facilitate seed dispersal within the existing environmental conditions of the study area [44]. Thus, these species are the most dominant ones in the forest [39]. Such species may not need immediate conservation measures, but they need regular monitoring. On the other hand, species with a low IVI value would mean they are at the risk of local extinction that needs priority of conservation measures.

3.6. Regeneration Status of Gosh-Beret Forest Species. Composition and density of seedlings, saplings, and adults would indicate the regeneration status of the forest species. The density of adult individuals was greater than that of seedlings (0.97 : 1) and saplings (0.68 : 1), whereas the density of seedlings was greater than that of sapling (1.42 : 1). This

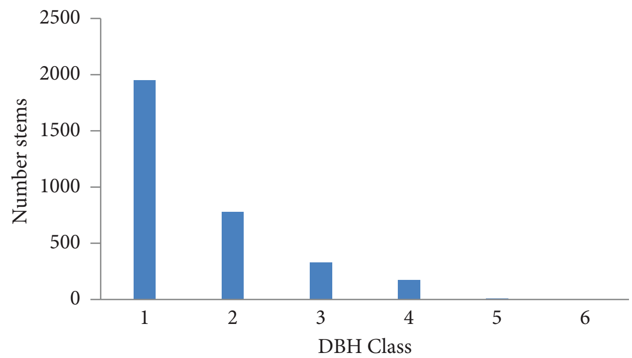

FIGURE 7: DBH classes with their density distribution of Gosh-Beret forest.

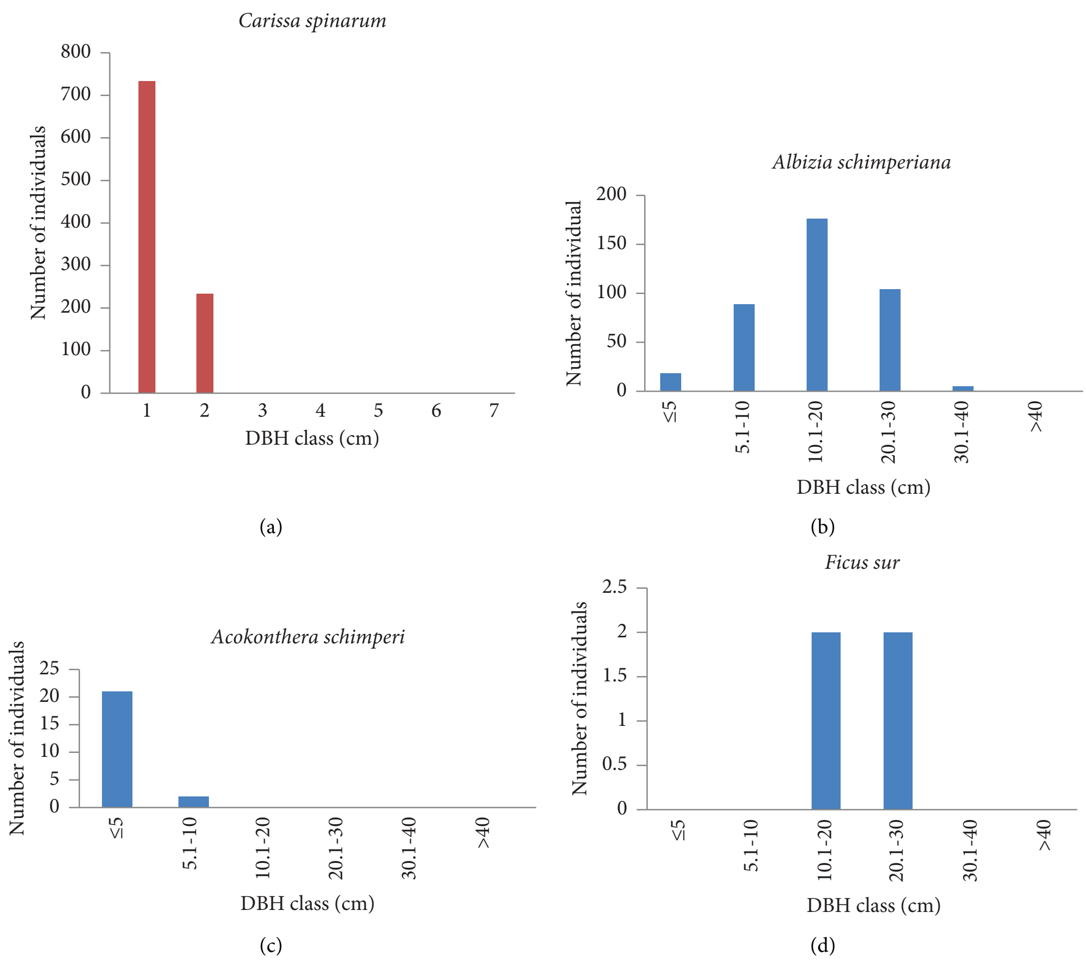

FIGURE 8: Population structures of four representative species by their DBH: (a) *Carissa spinarum*; (b) *Albizia schimperiana*; (c) *Acokanthera schimperi*; (d) *Ficus sur*.

implies that the forest is grouped under fair regeneration status. In some of South Gondar Zone Church forests, similar results were reported in [1], but some other authors [4, 28, 30, 31] reported good regeneration status in their study forest patches. The highest sapling density was recorded for *Carissa spinarum* (215.7 individuals ha^{-1}), followed by *Teclea nobilis* (192.8 individuals ha^{-1}) and *Calpurnia aurea* (142 individuals ha^{-1}). The highest density of saplings in *Carissa spinarum* might be due to special survival mechanisms having spines, and the plant by its nature cannot reach big trees that people do not use for charcoal and timber production.

Maytenus arbutifolia (460.8 individuals ha^{-1}) followed by *Calpurnia aurea* (122.5 individuals ha^{-1}), *Vernonia myriantha* (122.5 individuals ha^{-1}), and *Carissa spinarum* (120 individuals ha^{-1}) (Table 10) accounted for higher

Table 9: BA comparison of Gosh-Beret forest with other dry Afromontane forests.

Forests	Ba (m^2ha^{-1})	Author (source)
Yegof	15.85	[18]
Gosh-Beret forest	19.81	Present study
Amoro	18.5	[26]
Tara Gedam	115.5	[28]
Alemsaga	75.37	[17]
Gedo	35.45	[34]

Table 10: Density of adults, saplings, and seedlings (in ha^{-1} bases).

No	Species scientific names	Adult density	Sapling density	Seedling density
1	*Acacia abyssinica*	5.39	0.45	1.47
2	*Acanthus sennii*	4.41	11.80	80.80
3	*Acokanthera schimperi*	11.27	4.90	4.90
4	*Allophylus abyssinicus*	4.90	0.98	0.45
5	*Bersama abyssinica*	24.51	8.80	9.80
6	*Buddleja polystachya*	3.43	0.45	0.00
7	*Calpurnia aurea*	305.88	142.20	122.50
8	*Capparis tomentosa*	9.80	0.98	0.00
9	*Carissa spinarum*	474.02	215.70	120.00
10	*Clausena anisata*	8.33	5.90	7.40
11	*Clematis simensis*	4.90	0.00	0.00
12	*Clerodendrum myricoides*	0.98	0.98	0.98
13	*Clutia lanceolata*	1.47	12.70	11.80
14	*Cordia africana*	1.47	0.98	1.47
15	*Croton macrostachyus*	42.16	78.40	98.00
16	*Discopodium penninervium*	0.49	2.50	0.45
17	*Dodonaea angustifolia*	6.37	3.90	14.70
18	*Dombeya torrida*	8.82	0.00	0.00
19	*Dregea rubicunda*	4.90	0.98	0.00
20	*Ekebergia capensis*	4.41	0.00	0.00
21	*Entada abyssinica*	50.98	75.98	98.80
22	*Euphorbia candelabrum*	36.76	94.80	98.00
23	*Ficus sur*	1.96	0.00	0.00
24	*Grewia ferruginea*	4.41	0.00	0.00
25	*Hibiscus macranthus*	0.98	0.00	0.00
26	*Juniperus procera*	17.16	6.40	5.40
27	*Albizia schimperiana*	192.16	107.80	88.00
28	*Maytenus arbutifolia*	7.84	46.60	460.80
29	*Myrsine africana*	0.98	0.00	0.00
30	*Nuxia congesta*	6.86	0.00	0.00
31	*Olea europaea* subsp.*cuspidata*	14.22	1.96	0.98
32	*Otostegia integrifolia*	0.49	12.70	49.00
33	*Osyris quadripartita*	1.96	1.50	1.98
34	*Phytolacca dodecandra*	17.16	3.40	0.98
35	*Premna schimperi*	2.94	0.00	0.00
36	*Prunus africana*	1.47	0.00	0.00
37	*Ritchiea albersii*	0.98	0.98	0.98
38	*Rosa abyssinica*	6.86	2.90	2.50
39	*Teclea nobilis*	240.69	192.80	86.00
40	*Urera hypselodendron*	7.35	0.00	0.00
41	*Vernonia myriantha*	41.67	23.00	122.50
42	*Rhus glutinosa* subsp. *glutinosa*	0.00	3.90	0.45
43	*Brucea antidysenterica*	0.00	0.00	14.70
44	*Jasminum abyssinicum*	0.00	3.90	4.90
45	*Rumex nervosus*	0.00	3.90	3.90
46	*Solanecio gigas*	0.00	5.60	2.45
47	*Laggera tomentosa*	0.00	0.00	13.70

density of seedlings. The high dominance of *Maytenus arbutifolia* seedling might be due to human disturbance favoring the growth of this species by removing other woody species.

Laggera tomentosa, Brucea antidysenterica, and *Jasminum abyssinicum* were some woody species without adult individuals. These species were found in the juvenile stages and are newly regenerating. *Premna schimperi, Dombeya torrida,* and *Ekebergia capensis* were species which were not represented by seedlings and saplings. These species were not classified in any regeneration classes. Similar results were also reported by [1, 28].

Species that had poor regeneration status include *Buddleja polystachya, Capparis tomentosa,* and *Dregea rubicunda.* Some of the species that had fair regeneration status include *Acokanthera schimperi, Allophylus abyssinicus,* and *Bersama abyssinica.* Species that had good regeneration status include *Maytenus arbutifolia, Acanthus sennii,* and *Croton macrostachyus.* Tree species without juveniles need immediate conservation measures since they are at a higher risk of local extinction.

4. Conclusion and Recommendations

The result of the study revealed that the forest harbors considerable numbers of plant species that act as *in situ* conservation sites for some endemic as well as indigenous species of the country. The structural data analysis result, basal area, and DBH showed that the forest is composed of largely young individuals of tree and shrubby species, which revealed that either the forest is secondary forest or the forest is protected lately. The result from the analyses of IVI and regeneration status indicated that there are species which have very small IVI values and or low numbers or no seedlings that lead to the conclusion that the species are at risk of local extinction. The overall regeneration status of the forest showed that most woody species of the forest have fewer juveniles than adult plants that imply forest species are in fair regeneration status, which need management supervision.

Therefore, in order to ensure the sustainable utilization of the forest resources, the following recommendations are suggested:

(i) Immediate conservation measures are required for those species with very small IVI values such as *Hibiscus macranthus Myrsine africana*, *Prunus africana, Ritchiea albersii,* and *Clerodendrum myricoides* and species with low numbers of seedlings or species which lacked seedlings though safety net programs of the country.

(ii) Local people shall be encouraged about planting of indigenous and suitable exotic tree species in the agroforestry systems and waste lands in order to reduce the pressure on the natural forests via the green legacy initiative of the government

(iii) Continuous awareness enhancement is required to develop a sense of ownership in the local people, which ensures the long-term maintenance of the forests. This can be done during social gathering events and religious ceremony.

Data Availability

Some of the data used to support the findings of this study are available in the figure files (figures and tables) and the remaining data (figures and tables in Excel) are available from the corresponding author upon request.

Disclosure

The research was performed as part of the employment of the authors, which is considered one of the regular works of the employees for the employer organization, University of Gondar.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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