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Chapter · January 2022

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Chapter 11
Woody Species Composition, Diversity, Structure and Uses of Selected Church Forests in Central Ethiopia

Eguale Tadesse Kifle, Asia Khamzina, Yowhan Son, Florent Noulèkoun, Abdu Abdelkadir, and Wubalem Tadesse

Abstract The objectives of this study were to investigate woody species diversity, species richness, and identify endangered plant species of three church forests. The churches were located across three agro-ecologies. Transect lines and plots were established for woody species inventory. All woody species with a diameter at breast height of ≥5 cm were considered. Species richness, α-diversity, β-diversity, and Sørensen similarity were calculated. Results revealed the presence of 34, 17, and 27 woody species in Assela Teklehymanot (Church in highland agroecology), Etisa Teklehymanot (Chuch in mid-lowland agroecology), and Saramba Kidanemhret (Church in the lowland agroecology), respectively. The importance value index (IVI) indicated native tree species *Podocarpus falcatus* (IV = 164.59), *Croton macrostachyus* (IV = 80.28), and the exotic *Eucalyptus globulus* (IV = 199.06) are important in church 1, church 2, and church 3, respectively. Moreover, 9 IUCN Red List of Threatened Species recorded in the study. The conservation and additional enrichment planting with the indigenous woody species found in the respective church forests and from similar other areas by performing species-site matching is recommended.

Keywords Conservation · Diversity index · Endangered species · Species richness

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M. Kindu et al. (eds.), *State of the Art in Ethiopian Church Forests and Restoration Options*, https://doi.org/10.1007/978-3-030-86626-6_11

11.1 Introduction

Deforestation has been taking place since agriculture has the main livelihood source for humanity (Hance and Jeremy 2008). In Ethiopia, the main pressure on the forest remains to be land clearing for crop and cattle farming (Adam and David 2008). Deforestation of forest ecosystems has also been traced to economic incentives that make forest conversion appear more profitable than forest conservation in Ethiopia (Ref). In Ethiopia, deforestation is an ongoing issue that is causing extinction, changes to climatic conditions, desertification, and displacement of indigenous people (Rojahn 2006). The overall effect of such a loss and widespread forest degradation is a decline in environmental goods and services, including climate stabilization reduction, human well-being, and loss of biodiversity in general (Lamb et al. 2013).

Biodiversity is an attribute of an area and specifically refers to the variety within and among living organisms and is the total variety of life on earth comprising genes, species, ecosystems, and the ecological process as a whole (DeLong 1996). The diversity of woody species is central to total forest biodiversity since woody species deliver resources and habitats for almost all other species obtainable in the forest (Huange 2003). Ethiopia is an important regional center for biological diversity due to its wide range of altitude, diverse topography with high and rugged mountains, mountain ridges, flat-topped plateaus, deep gorges, notched stream gorges, and undulating plains (Teketay 2002; Zegeye et al. 2011). Moreover, the presence of a number of relic isolated forest trees, even on farmlands or patches of forests around churchyards and religious burial grounds in the country indicate the occurrence of well-diversified forests (Bekele 1993).

Church forests, befalling around more than 30,000 churches in Ethiopia, persevere vital biodiversity in a rather degraded landscape (Bongers et al. 2006; Cardelús et al. 2012). The value of these church forests in continuing to offer ecosystem services and serve as 'stepping stones' for restoration will depend on their long-term sustainability. Recent records show that populations of the tree species in the church forests are small, and decreasing in extent over time (Wassie 2002; Bingelli et al. 2003; Wassie et al. 2005).

Ethiopian churches and monasteries have a long-standing tradition of preserving and conserving their forests, including the many native plants and animals within them (Wassie et al. 2005; Bongers et al. 2006). Additionally, sacred groves as a whole can be particularly useful for conserving biodiversity by covering a wider variety of habitats than would be covered by a single large area (Bongers et al. 2006).

Ethiopian Orthodoc Tewahido Church (EOTC) has a long history of conservation of forest resources that encircle the churches besides its religious activities (Wassie et al. 2009). Church gardens are serving as in situ conservation and hotspot sites for biodiversity resources, especially for indigenous trees and shrubs of Ethiopia. The positive attitude to the resources sheltered by the church and the acceptance of the church tradition is also an opportunity for forest ecosystem conservation and restoration (Wassie 2002).

The EOTC conservation trend bases on its strong attachment to the words of God. The Bible teaches about environmental protection to be undertaken by human beings. For instance, in Genesis 2:15 it is written: "The Lord God took the man and put him in the Garden of Eden to work it and keep it." It is also written by the prophet Ezekiel 34:18 "Is it not enough for you to feed on the good pasture, that you must tread down with your feet the rest of your pasture; and to drink of clear water, that you must muddy the rest of the water with your feet?" (Ezekiel 34:18).

Studies of Church forest have focused mostly on those in northern parts of the country, Amhara and Tiogray regions. Few studies have been done on church forests in central Ethiopia. Based on this, the species composition, structure, and diversity of woody species were examined in central Ethiopia church forests. The aim of the study was towards the management and conservation of the church forests. Consequently, the objectives of the study were: (1) to investigate and describe woody species composition, structure, and diversity and the species richness of the selected church forests, (2) to explore the uses of woody species, and (3) to identify threatened (endangered) woody species in the study areas for future conservation.

11.2 Materials and Methods

11.2.1 The Study Areas

Three Ethiopian Orthodox Tewahdo Church forests have been selected for this study. Site I is Assela Teklehaymanot, located 175 km from Addis Ababa (AA). It has 25 ha church forest. Its elevation ranges 2521–2581 m a.s.l., which belongs to Dega (cool highland) agro-climatic zone. Site 2 is Etisa Teklehaymanot found 75 km far from AA and has an area of 23 ha. The elevation ranges 1800–2301 m a.s.l, which belongs to weyandega (midland) agro-climatic zone. Site 3 is Saramba Kidanemhret, found 200 km from AA and has an area of 22 ha. The elevation ranged 2164–2251 m.a.s.l. showing midland agro-climatic zone similar to Site 2 (Fig. 11.1).

11.2.2 Woody Species Inventory

To collect data on woody species, transect lines were laid 100 m apart along an altitudinal gradient based on altitudinal variations. The distance between consecutive plots within transect lines was also 100 m. The size of a plot was 20 m × 20 m following Gillison (2001). The number of plots on a transect line was determined by its length. Information such as elevation and geographical position was recorded at the center of each plot using a Garmin GPS receiver.

Site 1 had three transects. Transects 1 and 2 had 4 plots each and transect 3 had 3 plots. Hence a total of 11 plots were established at Site 1. Site 2 had only two

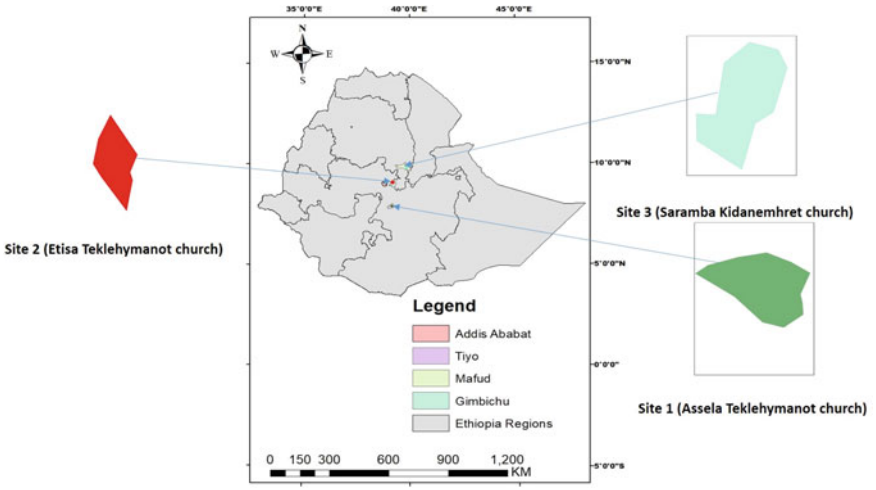

Fig. 11.1 Location of the study sites in central Ethiopia

transects. Transect 1 had 6 plots and transect 2 had only 1 plot. Therefore, the total number of plots on this site was 7. Site 3 had 2 transects. Transects 1 and 2 had 4 and 2 plots respectively. Hence, a total of 6 plots were established at Site 3.

Woody species encountered in the plots were surveyed and most identified in the field with the help of flora books on Ethiopia such as 'Flora of Ethiopia and Eritrea' (Edwards et al. 1995, 1997, 2000, 2003; Hedberg and Edwards, 1989; Hedberg et al. 2004, 2006), 'Useful Trees and Shrubs for Ethiopia' (Bekele et al. 2007). For the plant species difficult to identify in the field, voucher specimens were collected, pressed, and dried, and then taken to the herbarium laboratory of Addis Ababa University (Ethiopia) for identification.

All woody plants with a diameter at breast height, (DBH) $\geq$5 cm were measured using a caliper. For trees and shrubs that are forking at and below 1.3 m height, the DBH of each fork was measured and averaged.

11.2.3 Uses of Woody Species

A focus group discussion was undertaken after inventory of the woody species. The focus group discussants were provided with the list of woody species. Local names were used to grasp the indigenous knowledge of the local community. Finally, the group discussants have given the different uses of the woody species.

11.2.4 Data Analysis

The data were analyzed based on density, frequency, DBH, and basal area. The calculated indices were compared for the values of Shannon–Wiener, Simpson, and evenness indices among the three church forests. The analysis was performed using Generalized Linear Models (GLMs) with Gaussian distribution in SPSS software (v. 20) and Microsoft Excel 2010 for preliminary calculations.

The density and coverage area per ha were used as estimates of the relative standing yield of wood resources (Ludwig and Reynolds 1988; Kent and Coker 1992).

Relative density (RD), relative frequency (RF), and relative coverage (RC) were computed as:

$$\mathrm{RD} = \frac{\text{Number of species (ns)}}{\text{Total number of individuals in a sample}} * 100\% \tag{11.1}$$

$$\mathrm{RF} = \frac{\text{Frequency of species (nps/np)}}{\text{Total frequency of all species}} * 100\% \tag{11.2}$$

$$\mathrm{RC} = \frac{\text{Coverage area of species (Cs)}}{\text{Total coverage area (C)}} * 100\% \tag{11.3}$$

Finally, the importance value (IV) was calculated as in Ludwig and Reynolds (1988):

$$\mathrm{IV} = \frac{\mathrm{RD} + \mathrm{RF} + \mathrm{RC}}{3} \tag{11.4}$$

where—*nps* is the number of plots in which the species *S* appears and *np* is the total number of plots.

The church level wood resource was estimated in terms of the number of stems and basal area (coverage) (m^2) per ha for each church forest.

11.2.5 Diversity Indices

Because tree diversity can be measured at different levels, 3 biodiversity components were evaluated in this study in order to provide exhaustive biodiversity information: (i) α-diversity, as the mean species diversity of each study site; (ii) β-diversity, as both the difference in diversity among sites and among plots at each site; and (iii) effective species number, as the overall species richness at each study site (Cazzola Gatti et al. 2015). β-diversity was calculated by using Marczewski-Steinhaus index among plots of each study site (β-diversity within site) to evaluate internal small-scale diversity patterns.

Shannon diversity is the very widely used index for comparing diversity between various habitats (Clarke and Warwick 2001). The species diversity of the church forest in the selected forests was assessed using Shannon–Wiener diversity index (H'), Shannon evenness and Simpson's diversity index following Krebs (1989) and Magurran (2004).

β-diversity analysis was performed by computing the Marczewski-Steinhaus index to understand the dissimilarity between pairs of sites (i.e., β-diversity among sites). Because this measure considers only species presence and not species abundance data, it is not influenced by the dominance of certain species in the assemblage (Magurran 2013). Marczewski-Steinhaus index, the simplest of these diversity indices computes and compares the percentage similarity between two samples or communities (Marczewski and Steinhaus 1959, cited in Jakubowska 2011):

$$MS = \frac{c}{a + b - c} * 100 \tag{11.5}$$

where:

"*MS*" is the Marczewski-Steinhaus index, "*a*" is the total number of species in sample $\neq 1$, "*b*" is the number of species in sample $\neq 2$ and "*c*" is the number of species common to both samples.

11.3 Results

11.3.1 Woody Species Richness and Floristic Composition

The vegetation survey in the three church forests identified a total of 52 woody species (trees, shrubs, and lianas) belonging to 47 genera and 36 families. There were 34, 17, and 27 woody species in Site 1, Site 2, and Site 3 church forests, respectively.

In Site 1 there were a total of 27 families and 32 genera. The most represented family was Myrsinaceae having 3 woody species and 2 genera followed by Rosaceae (2 species and 2 genera), Euphorbiaceae (2 species and 2 genera), Cupressaceae (2 species and 2 genera), Fabaceae (2 species and 2 genera) and Oleaceae (2 species and 1 genus). The remaining 21 families had 1 species each and a total of 21 genera. The identified species were 56% trees, 41% shrubs, and 3% liana.

The importance value index in Site 1 indicated *Podocarpus falcatus* (Thunb.) R.Br. ex Mirb as the most important woody species (IV = 146.13) followed by *Maytenus arbutifolia* (A. Rich.) (IV = 105.47), *Rhoicissus tridentate* (L.f.) Wild & R.B. Drumm. (IV = 73.85), *Olinia rochetiana* A. Jussieu (IV = 71.26), *Juniperus procera* Hochst. ex Endl. (IV = 69.67) and *Rosa abyssinica* R. Br. ex Lindl. (IV = 69.23) (Appendix, Table 11.5).

In Site 2 17 species with 16 genera and 15 families were identified. The most represented families were Cupressaceae (with 2 species and 2 genera) and Moraceae

(with 2 species and 1genus). The remaining 13 families had 1 species each and a total of 13 genera. The species identified were 53% trees, 41% shrubs, and 6% liana.

The importance value in Site 2 indicated *Croton macrostachyus* Hochst. was the most important woody species (IV = 26.76) followed by *Ficus thonningii* Blume (IV = 26.10), *Juniperus procera* Hochst. ex Endl. (IV = 24.15), *Euclea divinorum* Hiern (IV = 23.05), *Allophylus abyssinicus* Hochst. Radlk. (IV = 21.12) (Appendix, Table 11.6).

In Site 3 the survey identified 20 families with 26 genera. The families represented most are Anacardiaceae (2 species and 1 genus), Asteraceae (2 species and 2 genera), Euphorbiaceae (2 species and 2 genera), Fabaceae (2 species and 2 genera), Myrsinaceae (2 species and 2 genera), and Oleaceae (2 species and 2 genera). The rest 14 families had 1 species each and 15 genera. The habit of the species surveyed was 70% shrubs and 30% trees.

The importance value in Site 3 indicated the planted exotic tree species *Eucalyptus globulus* Labil. was the most important woody species (IVs = 66.35) followed by indigenous species *Dodonea angustitolia* L. f. (IV = 35.66), *Olea europaea* L. (IV = 30.50), *Rhus vulgaris* Meikle (IV = 23.59), *Jasminum grandiflorum* L. (IV = 23.50) and *Carissa spinarum* L. (IV = 23.10) and *Premna schimperi* Engl. (IV = 22.78) (Appendix, Table 11.7).

11.3.2 Woody Species Comparison and Structure in the Church Forests

There were 5 woody species common to all three church forests. Those species were *Eucalyptus globulus* Labil., *Osyris quadripartite* Salzm. ex Decne., *Croton macrostachyus* Hochst., *Juniperus procera* Hochst. ex Endl. and *Olea europaea* L. A similarity analysis was also carried out to evaluate the resemblance between the church forests based on the presence of woody species. Evaluation was conducted using the Sørensen similarity index as described in Sørensen (1984) and Marczewski-Steinhaus index.

The similarity as calculated by Sørensen similarity index was 26.1% between Site 1 and Site 2, 29.9% between Site 1 and Site 3, and 26.7% between Site 2 and Site 3. Similarly, Marczewski-Steinhaus index was calculated to determine the similarity of woody species in the 3 church forests. As a result Site 1 and Site 2 church forests had 18.22%, Site 1 and Site 3 forests had 27% and Site 2 and Site 3 church forests had 22.22% similarities.

The density of trees and shrubs with DBH ≥5 cm in highland church forest (Site 1) was 1058 stems ha^{-1}. The density is very high in the lower diameter classes, especially from 5 to 20 cm. On the other hand, the density was low in the higher diameter classes above 40.1 cm. In Site 2 the total number of stems DBH ≥5 cm was 305 stems ha^{-1}. The highest density was similarly found in the lower DBH classes 5–20 cm. The density in the higher DBH classes (i.e., greater than 20.1 cm)

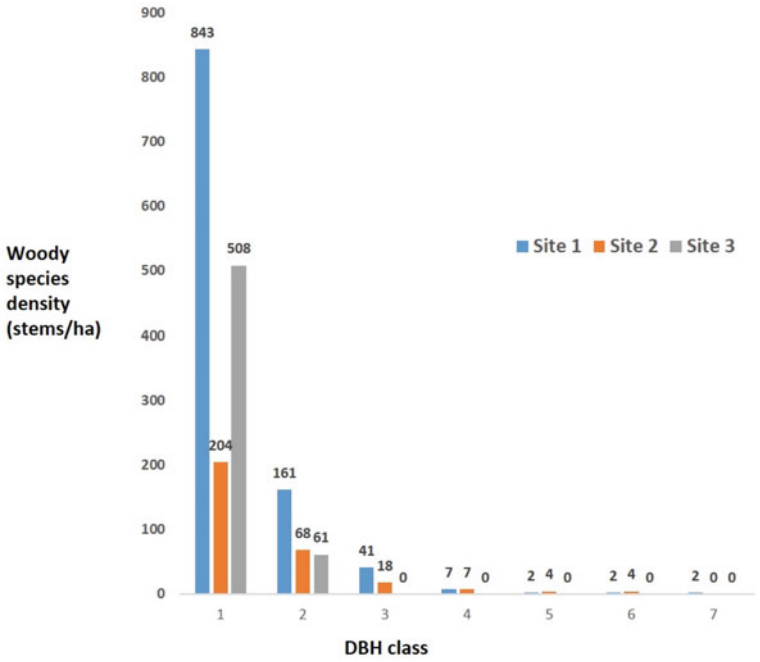

Fig. 11.2 Distribution of woody species density among DBH classes (1 = 5–10 cm, 2 = 10.1–20 cm, 3 = 20.1–40 cm, 4 = 40.1–60 cm, 5 = 60.1–80 cm, 6 = 80.1–100 cm, 7 ≥ 100.1 cm), in the study sites, central Ethiopia

was very small. In Site 3 the total density was concentrated only in the lower DBH classes (i.e., 5–20 cm) similar to Site 1. The density in the higher diameter classes (DBH >20.1 cm) was very small. In midland church forest (Site 3) the total density of woody species DBH ≥5 cm was 569 stems ha^{-1}(Fig. 11.2).

11.3.3 Woody Species Abundance and Diversity in the Church Forests

The results from the calculated Generalized Linear Models with Gaussian distribution revealed no significant variation in the mean Shannon–Wiener (H'), Simpson (D), and evenness indices among sites. The woody species richness and abundance of species in Site 1 was significantly higher than in Site 2 and similarly, in Site 3 was significantly higher than in Site 2 at p <0.05. Hence, Site 2 had a lower species richness and abundance (Table 11.1).

Table 11.1 Woody species richness, abundance, diversity, and evenness in the study church forests in central Ethiopia

Study site (forest)	Species richness	Mean species richness	Mean species abundance	Mean Shannon–Wiener diversity index	Mean Simpson diversity index	Mean species evenness (equitability)
Assela Teklehymanot (Site 1)	34	12.55 ± 1.41^{a}	106.55 ± 16.88^{c}	1.76 ± 0.08	0.74 ± 0.02	0.72 ± 0.03
Etisa Teklehymanot (Site 2)	17	4.71 ± 0.75^{b}	17.29 ± 12.38^{d}	1.19 ± 0.19	0.60 ± 0.07	0.81 ± 0.07
Saramba Kidanemhret (Site 3)	27	10.67 ± 1.86^{a}	71.79 ± 12.38^{c}	1.63 ± 0.32	0.67 ± 0.12	0.71 ± 0.12

Note Letters a, b, c, and d show the difference is significant at $p < 0.05$ i.e. similar letters indicate the difference is not significant at $p < 0.05$

11.3.4 Uses of Woody Species

The uses of the species included cultural medicine for both humans and livestock, human food, fodder, construction wood, and making house utensils among others. More than 41% of the woody species were used for human medication, livestock medication, and/or both, revealing the supreme importance of plant-based medicine. Of these 34 plant species, 14 were used predominantly for medicinal purposes. The rest of the species (58%) found in the highland forest site were used for various purposes such as tying and fastening material, fodder, and construction wood (Table 11.2).

In Site 2, 35% of the woody species were used for human medicine, livestock medicine, and both for human and livestock medicine. The rest 65% of the woody species in this site are used for different purposes such as for fodder, construction, charcoal making, and fire wood (Table 11.3).

The survey of Site 3 has shown that more than 22% of the woody species were used as human medicine livestock medicine and both human and livestock medicine.

Table 11.2 Number of woody species richness used for various purposes in highland church forest (Site 1, Assela Teklehymanot), central Ethiopia

Use type	Number of woody species
Human medicine	6
Livestock medicine	5
Livestock and human medicine	3
For tying	3
Fodder	3
Construction	4
Food	3
House utensils	3
Fire wood	4

Table 11.3 Number of woody species richness used for various purposes in the midland mixed lowland church forest (Site 2, Etisa Teklehymanot), central Ethiopia

Use type	Number of woody species
Human medicine	3
Livestock medicine	1
Livestock and human medicine	2
Tying	2
Fodder	2
Construction	2
Food	1
House utensils	1
Fire wood	2
Charcoal making	1

Table 11.4 Number of woody species richness used for various purposes in the midland church forest (Site 3, Saramba Kidanemhret), central Ethiopia

Use type	Number of woody species
Human medicine	2
Livestock medicine	2
Livestock and human medicine	2
Tying	1
Fodder	7
Construction	1
Food	2
House utensils	2
Fire wood	3
Charcoal making	2
For washing utensils	1
Fencing	2

Fodder was obtained from 26% of the species and fire wood from 11% of the mentioned species. The rest 41% of the woody species were used for various uses such as for tying, construction, food, house utensils, and fencing (Table 11.4).

Of the 17 woody species found in this midland church forest site, 6 (35%) species were predominantly used for medicinal purposes. Of these species, 2 are used for human medicine, 2 are used for livestock medicine and 2 are used for both human and livestock medicine.

11.3.5 Threat and Pressure on the Forests

The loss of biodiversity is the world's known crisis as observed from day to day events of our surroundings. There is also tangible evidence from science and public media about the issue. The loss is still increasing as seen from the present study's social survey. The present study might be one example regarding the study of some species in the church forests that were surveyed through ethnobotanical and vegetation census.

Most of the problems mentioned particularly habitat loss and overexploitation are most prevalent in the surrounding areas of the church forests whereas church forests maintain some species including most endangered ones. The present study identified 14 woody and herbaceous species listed by "The IUCN Red List of Threatened Species" (https://www.iucnredlist.org/) in the three sites. The identified woody species for the conservation priority are: *Cupressus lusitanica*, *Juniperus procera*, *Prunus africana*, *Erica arborea*, *Pinus radiata*, *Ekebergia capensis*, *Embelia schimperi*, *Ferula communis*, and *Ficus carica*.

11.4 Discussions

11.4.1 Woody Species Richness and Diversity

The significant difference observed in species richness and abundance between Site 1 and Site 2 may be attributed to the elevation differences. In the present study, opposite trend was found as compared to a study by Ren et al. (2006) that stated the number of species will decrease with increasing altitude. Other factors such as physiographic factors may impact soil moisture, chemical properties, and also physical properties such as drainage, porosity, and other characteristics which influence the distribution and diversity of plant species (Enright et al. 2005).

The identified highest floristic composition of woody species in the present study was comparable to other areas with more or less similar elevations. The floristic composition of Site 1 (2521–2581 m a.s.l.) showed a different family and species representatives from a similar study in Arsi Negele, Ethiopia (1557–1650 m a.s.l.) (Kedir et al. 2015) because of their elevation differences.

Comparisons of the recorded species richness of the present church forests with other Afromontane forests revealed that the level of the diversity in the forests was low maybe because of the small area of the church forests that ranged from 22 to 25 ha. For instance, in Ethiopia, the Yayu forest had 220 (Woldemariam et al 2008), Chilimo forest 90 (Woldemariam et al. 2000), Dakata forest 202 (Teketay and Bekele 1995), Jibat forest 58 (Bekele 1994), and the Harrena forest 128 species (Tadesse and Nigatu 1996). The lesser number of woody species richness in the present study might also be because of the deforestation of indigenous tree shrub species and replacement of the indigenous species by exotic ones such as *Eucalyptus* species that have more economic value for immediate needs. Church administration might need the immediate incomes from the sale of exotic fast-growing species to pay salaries to the church workers as stated by the group discussants.

The findings of this study were higher than that found from burial sites in Tehuledre district, Ethiopia which had 28 species from the whole representative sites (Seid and Santini 2017) while the present study identified 52 different woody species from the 3 church forests. It was also higher when compared to a study in Tanzania (Sitati et al. 2016) that recorded a total of 26 woody species.

There were only 5 woody species common to the 3 church forests of the present study. In a similar study of church forests in Ethiopia by Bongers et al. (2006), the species similarity in studied forests that are found above 2300 m a.s.l., was very small (only 4 species) in common, and for those found below 2300 m a.s.l. 9 species in common.

On the other hand, the results obtained from the present 3 study sites indicated DBH class distribution was concentrated in the lower diameter class especially 5–10 cm followed by 10.1–20 cm diameter classes. The general trend was shown in Fig. 11.2 approached an inverted J-shape. According to studies by Senbeta (2006), Yeneger et al. (2008), and Fisaha (2013), this pattern of diameter classes indicated good potential for reproduction and enrollment of the forest. Therefore, the diameter

class distribution in the present study showed a high potential for forest reproduction and staffing.

The basal area (coverage) calculated from the measured DBH also identified the highest coverage in Site 1 was *Podocarpus falcatus* (Thunb.) R.Br. ex Mirb. (6.66 m^2/ha) followed by the planted exotic species *Eucalyptus globulus* Labil. (1.11m^2/ha) and the other planted exotic species *Cupressus lusitanica* Mill. (0.75 m^2/ha). In Site 2 the highest basal area recorded for *Ficus thonningii* Blume (3.71 m^2/ha) followed by *Juniperus procera* Hochst. ex Endl. (2.04 m^2/ha) and *Croton macrostachyus* Hochst. (1.14 m^2/ha). In Site 3 the highest basal area was recorded for the planted exotic species *Eucalyptus globulus* Labil. (2.04 m^2/ha) followed by *Olea europaea* L. (0.46 m^2/ha) and *Myrsine africana* Linn. (0.17 m^2/ha). According to some studies (e.g., Bekele 1994) basal area is an important parameter for measuring the relative importance of plant species. Therefore, the woody plant species with a larger basal area in a forest was considered the most important species in that forest.

The woody species diversity in the present study was said to be lower (mean 1.56) as compared to similar studies in Ethiopia and elsewhere. For example in a study of church forests by Ayanaw (2016) the overall average Shannon–Wiener Diversity Index (H′) and the average evenness values for the entire forest were 2.88 and 0.79, respectively where the present study the highest Shannon diversity was 1.76 and the highest evenness index was 0.72 for Site 1 and less for the other 2 church forests. From a study in Tanzania (Sitati et al. 2016) the overall Shannon Wiener diversity index (H′) was 2.36 which was much higher than the present study's mean result (mean $H' = 1.56$).

11.4.2 Uses of Woody Species

The result of this study showed there are various uses of woody species. This is supported by a study in northern Ethiopia by Moravec et al. (2014), who explained that rural communities depend on plant resources for their domestic needs. Additionally, indigenous people all over the world are still using medicinal plants for treatment of various diseases (Akram et al. 2011; Ovesna et al. 2011).

In the present study, the representative life forms of the observed medicinal species are shrubs, trees, and climbers. Climbers have been mentioned in the list in Site 2 and Site 3. In Site 1 the number of medicinal shrubs and trees was equal while there are no climbers mentioned. A similar study by Moravec et al. (2014) recorded shrubs (21%) being used in traditional medicine in Tigray northern Ethiopia.

From the results of informal discussion and direct observation, there are no conservation activities to protect the different woody species that have varied uses. In contrast to the present study, studies in Mena Angetu district of western Ethiopia showed there was some conservation practice by the local people in cultivating 13.8 and 5.7% of the medicinal plants in home gardens by Tollosa and Moa (2018) and by Lulekal et al. (2008), respectively. Natural resources could be utilized best in a sustainable way if management activities are practiced (Yeneger et al. 2008). The

requirement of appropriate action to do such valuable activities is irrefutable and so is the involvement of the full range of societies and stakeholders in the conservation, production, and management as well as the use of medicinal plants (Schippmann et al. 2002). Woody plants, particularly trees, provide by far the largest number of products harvested. The various tree-based products contribute to rural household welfare in a range of ways, providing food and non-food goods, inputs into income generating activities, and inputs into agricultural production.

11.4.3 Threatened Species in the Study Area

Threatened species found in the present study sites indicate the requirement of conservation of these species with special concern. According to Borokini (2013), the highest rates of biodiversity in the world are found in tropical regions' developing countries that lack resources to manage all these species. Additionally, the species have widely ranged population, which are as a result of widely ranged trends of human mistreatment, growth forms, and varying bio-geographical distribution Borokini (2013). Thus, setting priorities for conservation efforts for these species is imperative. Those species whose population have reduced drastically, with a slight range of bio-geographical distribution, rampant species, and species those who belong to monospecific genera need more concern.

Those species requiring urgent conservation efforts are said to be threatened or endangered (Borokini 2013). Based on this, the present study identified 9 different woody species listed as threatened. The identification of the species whether they are threatened or not in the present study was done using the website (www.iucnredlist.org). However, two of the 2 woody species (*Cupressus lusitanica* and *Pinus radiata*) identified as threatened in the present study are increasing in population in Ethiopia and hence their extinction is in doubt. The IUCN Red List is possibly the most useful worldwide list of species in danger of extinction (Lamoreux et al. 2003). Its usefulness is based on its reliance on a number of objective criteria (IUCN 2012).

In addition to extinction risk assessment, the Red List provides an excess of useful evidence on each species assessed, including dispersal-trends, threats, and management actions (Cardoso et al. 2016). Assessment of threatened species is done either as Critically Endangered (CE), Endangered (EN) or Vulnerable (VU). Extinct or non-threatened species are also assessed and listed (Cardoso et al. 2016). Hence, the identified plant species in the present study attract attention in the future conservation and management of the species.

11.5 Conclusion and Recommendations

Floristic composition and species richness in the church forests were optimum as compared to the surrounding degraded lands including cultivated lands but it was low

as compared to other similar studies in Ethiopia and elsewhere. Highland site (Site 1) was comprised of big size trees and other shrubs and lianas than the mixed midland and lowland and midland sites. There was a higher similarity of woody species between Site 1 (highland) and Site 3 (midland) sites (29.9%). All the three church forests have less than 50% similarities indicating the need to enrich the church forests by diversified woody species (specifically indigenous ones). The diameter distribution of the 3 church forests showed the density of woody species was concentrated in the lower diameter classes indicating the high possibility of forest reproduction and enrollment. The woody species diversity of the present study was lower as compared to many studies in Ethiopia and elsewhere but better as compared to studies in some burial sites in Ethiopia. The uses of the woody species in the study area indicated the value of the trees, shrubs, and lianas for traditional medicine, food, fodder, and other multiple uses. Some 9 woody species have been found threatened in the study area that attracts future concern to their conservation. In the present study sites, there was a tendency to replace the indigenous species with exotic planted species such as *Eucalyptus globulus* Labil. and *Cupressus lusitanica* Mill. Which might be another threat for the conservation of natural indigenous forests. Therefore, Conservation of the present stand by fencing and local rules and religious sanctions, additional enrichment planting with the indigenous woody species found in the respective church forests, giving priorities for the IUCN red-listed species, planting other indigenous woody species by undertaking species-site matching and using the plots established for data collection as experimental plots for the indigenous species is recommended. Generally, the present remaining forests in the 3 church forests can also be used as a seed source for future management of the church forests.

Acknowledgments The study was supported financially by Ethiopian Environment and Forest Research Institute (EEFRI) and Korea International Cooperation Agency (KOICA), KOICA-Ethiopia project.

My greater gratitude also goes to my major advisor professor Yowhan Son and my co-advisor professor Asia Khamzina for their unprecedented help and encouragement to accomplish the writing of my research dissertation.

Appendix

See Tables 11.5, 11.6 and 11.7.

Table 11.5 Top 10 woody species in Site 1 (Highlan d, Asela Tekle Hymanot), central Ethiopia

Woody species	Family	Origin	Importance value (RCs + RFs + RDs)/3
Podocarpus falcatus (Thunb.) R.Br. ex Mirb	Podocarpaceae	Ind	146.13
Maytenus arbutifolia (A. Rich.)	Celastraceae	Ind	105.47
Rhoicissus tridentate (L.f.) Wild & R.B.Drumm	Vitaceae	Ind	73.85
Olinia rochetiana A.Jussieu	Oliniaceae	Ind	71.26
Juniperus procera Hochst. ex Endl	Cupressaceae	Ind	69.67
Rosa abyssinica R. Br. ex Lindl	Rosaceae	Ind	69.23
Dovyalis abyssinica (A. Rich.) Warb	Flacourtiaceae	Ind	65.00
Schefflera abyssinica A. Rich. Harms	Araliaceae	Ind	64.98
Osyris quadripartite Salzm. ex Decne	Santalaceae	Ind	64.45
Nuxia congesta R. Br. ex Fresen	Stilbaceae	Ind	58.36

Note 'Ind' stands for Indigenous and 'Exo' for exotic

Table 11.6 Top 10 woody species in Site 2 (mixed midland and Lowland, EtisaTekle Hymanot), central Ethiopia

Woody species	Family	Origion	Importance value (RCs + RFs + RDs)/3
Croton macrostachyus Hochst	Euphorbiaceae	Ind	26.76
Ficus thonningii Blume	Moraceae	Ind	26.10
Juniperus procera Hochst. ex Endl	Cupressaceae	Ind	24.15
Euclea divinorum Hiern	Ebenaceae	Ind	23.05
Allophylus abyssinicus Hochst. Radlk	Sapindaceae	Ind	21.12
Eucalyptus globulus Labil	Myrtaceae	Exo	16.57
Calpurnia aurea (Ait.) Benth	Fabaceae	Ind	12.43
Carissa spinarum L	Apocynaceae	Ind	11.88
Ficus sur Forssk	Moraceae	Ind	11.39
Olea europaea L	Oleaceae	Ind	10.80

Note 'Ind' stands for Indigenous and 'Exo' for exotic

Table 11.7 Top 10 woody species in Site 3 (midland, Saramba Kidanemhret church), central Ethiopia

Woody species	Family	Origin	Importance value (RCs + RFs + RDs)/3
Eucalyptus globulus Labil	Myrtaceae	Exo	66.35
Dodonea angustitolia L. f	Sapindaceae	Ind	35.66
Olea europaea L	Oleaceae	Ind	30.50
Rhus vulgaris Meikle	Anacardiaceae	Ind	23.59
Jasminum grandiflorum L	Oleaceae	Ind	23.50
Carissa spinarum L	Apocynaceae	Ind	23.10
Premna schimperi Engl	Lamiaceae	Ind	22.78
Osyris quadripartite Salzm. ex Decne	Santalaceae	Ind	17.39
Maytenus gracilipes Welw. ex Oliv	Celastraceae	Ind	17.23
Croton macrostachyus Hochst	Euphorbiaceae	Ind	12.41

Note 'Ind' stands for Indigenous and 'Exo' for exotic

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