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VEGETATION STRUCTURE AND DENSITY OF WOODY PLANT SPECIES IN TWO WOODLAND AREAS OF AMHARA NATIONAL REGIONAL STATE, ETHIOPIA

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Abstract

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This study was conducted in Jawi and East Belesa districts of the Amhara National Regional State in Ethiopia. It has an objective of describing the vegetation structure in relation to different environmental factors in general and *Boswellia papyrifera,* which is economically important species in particular. Vegetation data were collected in both sites (Mosebit and Hamusit) using plots of 50 m x 50 m (0.25 ha). In total 15 sample plots were set up. In each plot, all trees with DBH (Diameter at Breast Height), i.e. at 1.3 m above the ground were measured using caliper. In each major plot four subplots (4 m × 4 m) were established. Tree height measured using Hypsometer (Vertex III). Data's on different environmental variables (slope, aspect and altitude) of each plot were also taken respectively using laser rangefinder Impulse 200 Standard, an electronic compass Map-Star Module II and GPS Juno™ ST handheld (Trimble, USA). A total of 58 woody species belonging to 22 families were identified from both sites. A total of 241 trees/ha and 292 trees/ha were found in Mosebit and Hamusit study sites, respectively. The seedling density result indicates 3656 seedlings/ha and 2469 seedlings/ha in Mosebit and Hamusit study areas, respectively. The density of *Boswellia Papyrifera*, which is economically important species were 140 and 127 tree/ha in Mosebit, and Hamusit study areas, respectively. The relative density of different tree species in different height and diameter classes were determined by altitude, aspect, and gradient of the study areas. The study result concludes that distribution of the species, relative density, height class and diameter class of species in the two sites is dependent on environmental factors. Finally, the findings indicate that the two woodlands harbor, economically important tree species. Therefore, giving due attention in conserving these wood lands is important from ecological, economical and conservation point of view.

Boswellia papyrifera, Belesa, density, environmental factors, Jawi, Woodlands

Ethiopia is located between 3° and 15°N latitude and 33° and 48°E longitude and covers a land surface (including water bodies) area of 1 127 127 km². Nearly, 71% of the country's total land area is covered by dry lands (Tamiere, 1997). With this land cover the total estimated area of drylands, 25 million ha (31%) is covered with woodland and bushlands (Tefera et al., 2005). Generally, the country is covered with an immense of different physiognomic vegetation types due to its altitudinal variations that ranging from 120 meters below sea level to 4,620 meters a.s.l.

Amhara National Regional State (ANRS), which accounts 15 % of the countries surface area, has a woodland resource of about 10,382 km² i.e. 6.1% of ANRS (ANRS, 2002). The woody vegetation resources that are indigenous to dry lands of the ANRS provide economical, environmental and social benefits to local communities. Woodlands are the main source of frankincense and gum, hardened resinous exudates obtained from trees of some Boswellia and Acacia species, respectively, are important products used in pharmaceutical industries (Limenih, 2003). These forests are often important source of fuel and construction wood for the local people, improve the hydrology and purity of water resources and they are a source of feed supply to the growing livestock population.

However, in recent years, area of woodlands are declining due to agricultural expansion through resettlement programmes, occurrence of frequent wildfire, overgrazing by livestock, and the demand for charcoal and fuel wood production (Eshete, 2002; Asfaw, 2006; Lemenih et al., 2007). The concerted action of these factors has affected the distribution, abundance and the structure of woodlands which impoverishes ecology of the area.

Studies made on the wood lands of the ANRS were few, and most are concentrated on Metema districts (Eshete, 2002; Asfaw, 2006; Limenih, 2007). Other wood lands of the region, which has great socio-economic, ecological and biodiversity conservation were not studied and documented, because of inaccessibility, security and other reasons. Studying such wood lands is very mandatory for sustainable management and utilization of the wood lands. This study focuses on the vegetation of two wood lands located in ANRS, namely Mosebit wood land and Hamusit Wood land. The paper has an objective of analyzing the population structure of the woody vegetation in general and *Boswellia papyrifera* in particular, in relation to different environmental factors.

MATERIALS AND METHODS

Study area

The study was carried out in Mosebit and Hamusit wood land areas. Mosebit is found in Jawi district, 280 km west of Bahir-Dar (the capital city of ANRS), of Amhara National Regional State (ANRS), Ethiopia. Geographically Mosebit is located at 36° 33' 26" E and 11° 36' 46" N. It has an altitudinal range of 1100–1300 meters a.s.l. where as Hamusit is found in East Belesa district, 220 km North East of Bahir-Dar. Geographically it is located at 38° 10' 01" E and 12° 31' 39" N. Hamusit has an altitudinal range of 1600 to 1900 meter a.s.l.

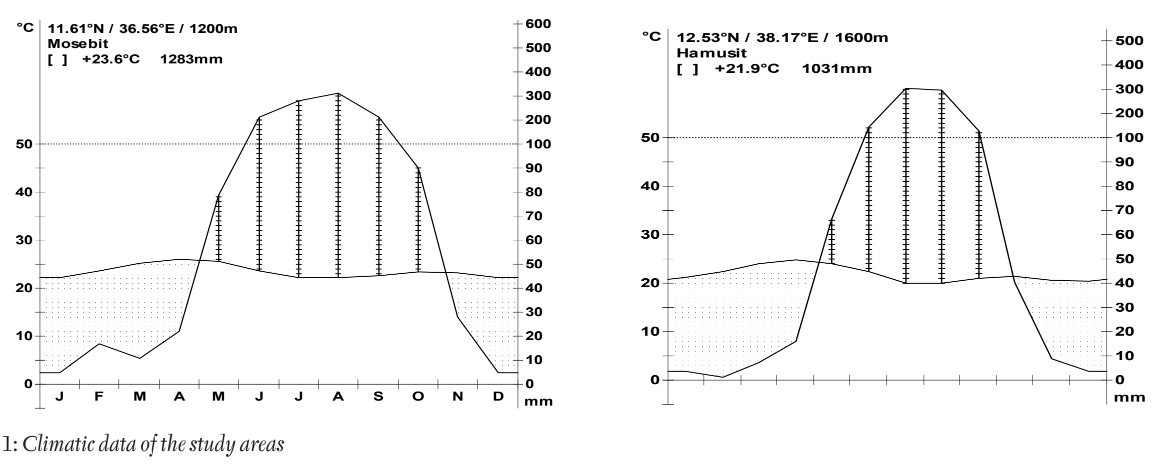
The climatic data were interpolated from Lieth et al. (1999) in Climate Diagram World Atlas. In the interpolation 20 meteorological stations closest to study sites were used. In both study sites there is a 9 months dry season. The rainfall pattern is unimodal, occurring from June to September. The mean annual temperature, total annual rainfall and total annual evapo-transpiration in Mosebit is 23.6 °C, 1283 mm, 1734 mm, respectively (Fig. 1). While, mean annual temperature, total annual rainfall and total annual evapo-transpiration in Hamusit is 21.9 °C, 1031 mm, 1616 mm, respectively (Fig. 1).

Sampling design and data collection methods

Sampling design

In both sites, natural dry woodlands were selected for the study. Vegetation data were collected in both sites using plots of 50 × 50 m (0.25 ha). Even though random sampling methods are recommended for spatial location of sample plots in vegetation studies, anthropogenic pattern of the land-use is not random (Sader and Joyce 1988; Helmer, 1999; Lawrence and Schlesinger, 2001) hence the total number and distribution of the sample plots in each study site varied with size and condition of the forest 5 and 10 plots were considered in Mosebit and Hamusit, respectively. More plots were sampled in Hamusit, where larger number of fragmented patches of woodlands exists and land is under higher human pressure.

The plots were laid out along line transects. The distance between consecutive plots along transect and the spacing between two adjacent transect lines were 500 m and 600 m, respectively. In each major plot four subplots (4 m × 4 m) were established. Subplots were laid at the corners of the major plots. An electronic compass Map-Star Module II was used for the alignment of transects. The aspect, altitude and location of each sample plot data were collected using an electronic compass Map-Star Module II and GPS Juno™ ST handheld (Trimble, USA), respectively.



1: *Climatic data of the study areas*

Vegetation data collection

Within the major plot, plant species were identified, and the Diameters at Breast Height (DBH) of all trees were measured using a caliper. In each major plot four subplots (4 m × 4 m) were established at the coner of the major plots. Height of trees was measured using Hypsometer (Vertex III). Woody plants of < 4 m height were measured using a folding marked pole. Number of individuals was also recorded in each plot. Data on number of species and number of seedling (height < 1.0 m) for all trees, shrubs and climbers were collected in each subplot. Voucher specimens of plant species were identified using field manual floras of Ethiopia (Woldemichael, 1989; Hedberg and Edwards, 1989; Edwards et al., 1995, 1997; Hedberg and Edwards, 1995; Bekele, 2007). Voucher specimens difficult to identify in the field were collected, pressed and identified in the National Herbarium of Ethiopia, Addis Ababa University.

Data analysis

Data collected from each major plot were used for structural analysis. The seedling data was also analyzed in a hectare base. The Importance Value Index (to know the distribution of species in the study area) (IVI), which is a sum of relative values of density, frequency and dominance, was also calculated for each species (Kent and Coker, 1994). Relative density of species in different height, diameter classes, altitudinal ranges, aspect and gradients were also analyzed using STATISTICA (data analysis software system) version 8.0 (StatSoft Inc. 2007, www.statsoft.com).

RESULT AND DISCUSSION

Result

Vegetation structure and density of woody plants

A total of 29 and 33 woody species belonging to 22 families were recorded in Mosebit and Hamusit woodlands, respectively. Among these species 51.8% were trees, 46.4% shrubs and 1.8% woody climbers.

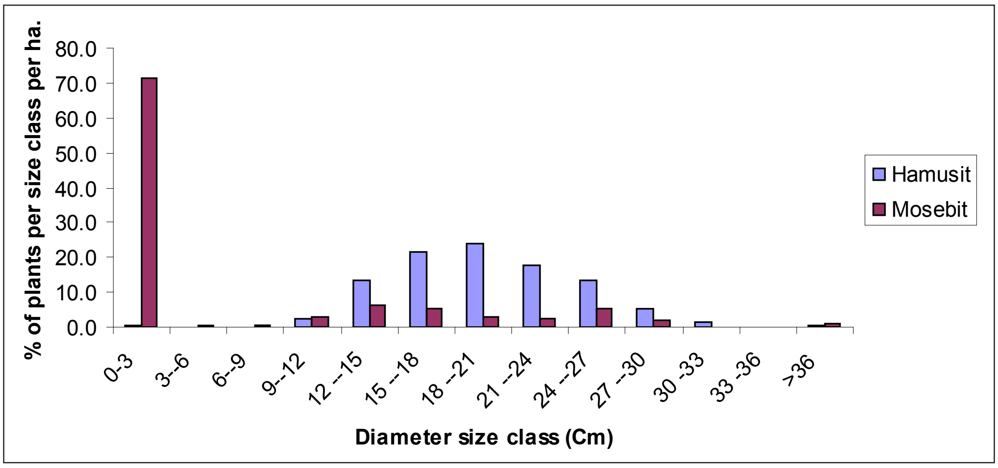
The density result found out a total of 241 trees and shrubs/ hectare in the study area of Mosebit, while the density of trees and shrubs per hectare in Hamusit was 292 trees/ hectare. The seedling (< 1 m height) density in Mosebit and Hamusit were 3656 seedlings/ha and 2469 seedlings/ha, respectively.

Combretum molle, Atriplex farinosa, Terminalia laxiflora and Sterculia setigera had 51.2 trees/ha, 31.2 trees/ha, 20 trees/ha, and 17.6 trees/ha, respectively in Mosebit study area. Endemic *Boswellia pirottae* classified as threatened' species (WCMC 1998), was found with a density of 10.4 trees/ha) in Mosebit study area. *Albizia amara*, *Cassia arereh*, and *Rhus ruspolli* had 75.6 trees/ha, 44 trees/ha and 10 trees/ha, respectively in Hamusit study area. The density of *Boswellia Papyrifera*, which is economically important species were 140 in Mosebit, and 127 in Hamusit study areas (Fig. 2).

The DBH structure result indicated that relative density of trees in the diameter class 1.0–3 cm is 32.3 % from a total of 23 species and 4% from a total of 4 species in Hamusit and Mosebit, respectively (Tab. I). In the higher diameter classes 33.1–36 cm and > 36.1 cm, relative density of trees in Hamusit were 0.4% and 0.5%, respectively. Similarly, the relative density of trees in the diameter classes of 33.1–36 cm and > 36.1 cm in Mosebit were 0.7% and 6.3%, respectively. Generally, the relative density of trees in Hamusit in the diameter classes of 3.1–6 cm, 6.1–9 cm, 9.1–12 cm, 12.1–15 cm, 15.1–18 cm,

I: *Relative density of species and number of species in different size diameter class of the study areas*

No	DBH Class (Cm)	Relative density of trees (%)		No of species	
		Hamusit	Mosebit	Hamusit	Mosebit
1	1.0–3	32.3	4.0	23	4
2	3.1–6	13.0	17.5	10	19
3	6.1–9	1.8	11.6	8	9
4	9.1–12	1.6	16.6	5	15
5	12.1–15	6.9	10.3	6	10
6	15.–18	11.5	10.3	9	9
7	18.1–21	11.4	6.3	5	10
8	21.1–24	9.5	6.6	5	9
9	24.1–27	7.0	5.6	4	6
10	27.1–30	3.0	2.6	3	5
11	30.1–33	1.1	1.7	4	5
12	33.1–36	0.4	0.7	2	2
13	>36.1	0.5	6.3	2	8



2: *The diameter frequency distribution of B. papyrifera plants at both study sites*

18.1–21 cm, 21.1–24 cm, 24.1–27 cm, 27.1–30 cm and 30.1–33 cm, were 13%, 1.8%, 1.6%, 6.9%, 11.5%, 11.4%, 9.5%, 7%, 3% and 1.1%, respectively. Similarly, the relative density of trees in Mosebit in the diameter classes of 3.1–6 cm, 6.1–9 cm, 9.1–12 cm, 12.1–5 cm, 15.1–18 cm, 18.1–21 cm, 21.1–24 cm, 24.1–27 cm, 27.1–30 cm and 30.1–33 cm, were 17.5%, 11.6%,16.6%, 10.3%, 10.3%, 6.3 %, 6.6%, 5.6%, 2.6% and 1.7 %, respectively

The diameter class distribution result of *B. papyrifera* (Fig. 2) showed that a dominance of trees between 12.1 and 27 cm diameter classes, and absence of trees of the species in lower diameter classes (< 9 cm) in Hamusit. Where as in Mosebit the highest number of individuals (up to 100 stems per hectare) was recorded in the lower diameter classes (less than 3 cm) (Figure 2).

Height class result distribution found out the highest density of trees in the classes of 0.1–2 m in Hamusit, and 4.1–6 m in Mosebit, which were 41.8% and 22.8%, respectively. In the height classes of 2.1–4 m, 4.1–6 m, 8.1–10 m, 10.1–12 m, and 16.1–18 m, the relative density of trees in Hamusit were 12.7%, 22.1%, 18.9%, 3.8%, 0.5% and 0.1%, respectively. While in Mosebit, the relative density of trees in the height classes of 0.1–2 m, 2.1–4 m, 6.1–8 m, 8.1–10 m, 10.1–12m, 12.1–14 m, 14.1–16m, 16.1–18 m and >18.1 m were, 4%, 18.9%, 15.2%, 22.2%,8.3%, 4.6%, 2%, 1 % and 1%, respectively. In Hamusit the number of identified species in the height classes of 0.1–2 m, 2.1–4 m, 4.1–6 m, 6.1–8 m, 8.1–10 m, 10.1–12 m, and 16.1–18 m were, 27, 15, 7, 7, 5, 4 and 1, respectively (Tab. II). While in Mosebit, the number of identified species in the height classes of 0.1–2 m, 2.1–4 m, 4.1–6 m, 6.1–8 m, 8.1–10 m, 10.1–12 m, 12.1–14 m, 14.1–16 m, 16.1–18 m and > 18.1 m were, 4, 20, 16,16, 15,9, 6, 3,3 and 3, respectively (Tab. II).

Environmental variables and density of trees

Density of species in relation to Altitude

The relative density of trees in the altitudinal ranges of 1600–1699, 1700–1799, 1800–1899, were 12.9%, 4.93 %, and 82.88%, respectively in Hamusit study site (Tab. III). Where as the relative density of trees in Mosebit study site in the altitudinal ranges of 1100–1199, 1200–1299 and 1300–1399 were, 21.19%, 68.87%, and 9.93 %, respectively. Like wise the relative density of seedlings in the study area of Hamusit within altitudinal ranges (meter a.s.l) of 1600–1699, 1700–1799, 1800–1899 were 27.22%, 6.96% and

II: *Relative density of trees and number of species in different size height class of the study areas*

Height Class (m)	Relative density of trees (%)		No of species	
	Hamusit	Mosebit	Hamusit	Mosebit
0.1–2	41.8	4.0	27	4
2.1–4	12.7	18.9	15	20
4.1–6	22.1	22.8	7	16
6.1–8	18.9	15.2	7	16
8.1–10	3.8	22.2	5	15
10.1–12	0.5	8.3	4	9
12.1–14	–	4.6	–	6
14.1–16	–	2.0	–	3
16.1–18	0.1	1.0	1	3
>18.1	–	1.0	–	3

III: *Relative density of trees and seedlings and number of species with respect to altitude*

Hamusit				Mosebit			
Altitude	Relative density of trees (%)	Relative density of seedlings (%)	No of Species	Altitude	Relative density of trees (%)	Relative density of seedlings (%)	No of species
1600–1699	12.19	27.22	18	**1100–1199**	21.19	31.03	15
1700–1799	4.93	6.96	4	**1200–1299**	68.87	41.38	24
1800–1899	82.88	65.82	29	**1300–1399**	9.93	27.59	12

IV: *The relative density of trees and seedlings respect to altitude, which are common species in both study areas*

No.	Species	Mosebit						Hamusit					
		Altitude (m.a.s.l.)						Altitude (m.a.s.l.)					
		1100–1199		1200–1299		1300–1399		1600–1699		1700–1799		1800–1899	
		Tree	Seed ling	Tree	Seed ling	Tree	Seed ling	Tree	Seed ling	Tree	Seed ling	Tree	Seed.
1	*Boswellia papyrifera*	7.62	1.71	4.64	1.71	0.33	-	2.33	-	2.19	-	38.90	-
2	*Sterculia setigera*	7.62	-	3.64	0.85	0.99	-	0.14	-	-	-	0.14	-
3	*Dichrostachys cinerea*	2.65	0.85	4.64	9.40	-	-	0.14	0.63	-	-	-	-
4	*Acacia nilotica*	7.62	-	0.33	0.85	-	-	-	-	-	-	0.14	-
5	*Grewia. bicolor*	2.65	-	0.66	1.71	-	-	0.14	-	-	-	0.55	1.3
6	*Stereospermum kunthianum*	0.99	0.85	1.66	0.85	-	16.24	-	1.27	-	-	-	-
7	*Grewia. ferruginea*	-	-	0.33	-	-	-	-	-	-	-	0.14	-
8	*Combretumcollinum*	-	-	-	-	0.33	-	-	-	-	-	0.14	-

65.82%, respectively. Similarly, in Mosebit study area the relative density of seedlings in the altitudinal ranges (meter.a.s.l) of 1100–1199, 1200–1299, 1300–1399 were, 31.03%, 41.38% and 27.59%, respectively. In the study site of Hamusit, the number of species in the altitudinal ranges of 1600–1699, 1700–1799, and 1800–1899 were, 18, 4 and 29, respectively. Where as the number of species found in Mosebit, in the altitudinal ranges of 1100–1199, 1200–1299, 1300–1399 were, 15, 24 and 12, respectively (Tab. III).

The relative density of trees, which are found common to both study sites, at different altitudinal ranges result analyzed and found in Table. IV. *B. papyrifera* in Mosebit at altitudinal ranges (meter a.s.l) of 1100–1199, 1200–1299 and 1300–1399, were 7.62%, 4.64%, and 0.33%, respectively. While the seedling density in the altitudes of 1100–1999 and 1200–1299 were 1.71%, for both. While, in the study site of Hamusit, the relative density of *B. papyrifera* in the altitudes (meter. a.s.l) of 1600–1699, 1700–1799, 1800–1899 , were 2.33, 2.19, and 38.90, respectively. In this study site there were no seedlings of the species, The relative density of *S. setgera* tree in Mosebit, in the altitudinal (meter.a.s.l) ranges of 1100–1199, 1200–1299, 1300–1399 were, 7.62, 3.64, and 0.99, respectively (Tab. IV). While in Hamusit study site it had a relative density of 0.14% and 0.14% in the altitudes of 1600–1699 and 1800–1899, respectively. *D. cinerea* in Mosebit had a relative density of 2.65% and 4.64% in the altitudes of 1100–1199 and 1200–1299, respectively. The seedling density of this species in the respective altitudes of 1100–1199 and 1200–1299 in Mosebit were 0.85% and 9.40%, respectively. Like wise the relative density of *D. cinerea* in Hamusit in the altitudes of 1600–1699 were 0.14%, and the seedling density in this altitude was 0.63%.

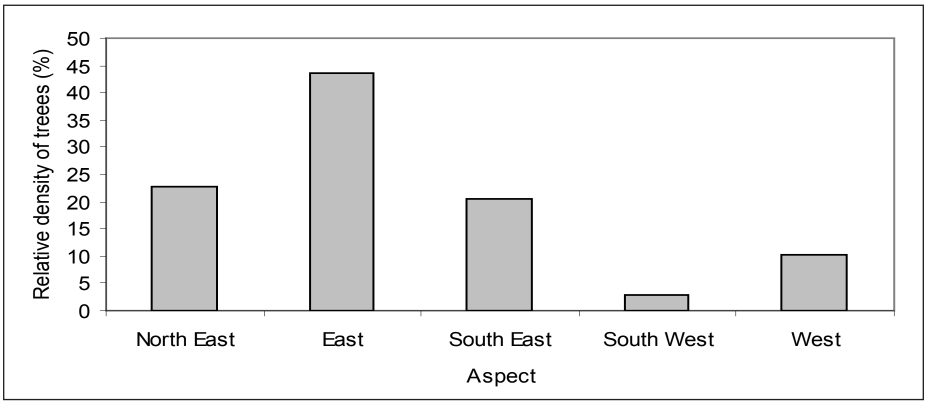
Density of trees and seedlings in relation to gradient

The gradient difference analysis result in the study area of Mosebit showed that the relative density of trees were 17.55%, 9.93%, 14.24%, 58.28% in the gradients of 0–5%, 5.1–10%, 10.1–15%, 15.1–20%, respectively (Tab. V). The number of species in this study area in the gradients of 0–5%, 5.1–10%, 10.1–15%, 15.1–20%, were 16%, 12%, 9% and 23%, respectively. Similarly, the relative density of seedlings in gradients of 0–5%, 5.1–10%, 10.1–15%, 15.1–20%, were 36.2%, 27.59%, 6% and 30.2%, respectively. On the other hand the relative density of trees in Mosebit, in the gradients of 5.1–10%, 10.1–15%, 15.1–20%, 20.1–25%, 25.1–30% were,17.12%, 9.73%, 32.47%, 29.47% and 11.23%, respectively. Similarly, the relative density of seedlings in this study area were, 14.56%, 27.22%, 27.85%, 11.39%, 18.99% in the gradients of 5.1–10%, 10.1–15 %,15.1–20%, 20.1–25%, and 25.1–30%, respectively. The number of species in the different gradient classes of Hamusit was 7, 4, 19, 17, and 16 in the gradients of 5.1–10%, 10.1–15%, 15.1– 20%, 20.1–25% and 25.1–30%, respectively (Tab. V).

Density of trees and seedlings in relation to aspect

Aspect has its own detrimental role in the relative density of trees and seedlings of a species. The relative density of *B. papyrifera* tree in North East, East, V: *Relative density of trees and seedlings and number of species in relation to gradient*

Slop (%)	Mosebit			Hamusit		
	Relative density of trees (%)	Number of species	Relative density of seedlings (%)	Relative density of trees (%)	Relative density of seedlings (%)	Number of species
0.0–5	17.55	16	36.207			
5.1–10	9.93	12	27.586	17.12	14.56	7
10.1–15	14.24	9	6.034	9.73	27.22	4
15.1–20	58.28	23	30.172	32.47	27.85	19
20.1–25				29.45	11.39	17
25.1–30				11.23	18.99	16



3: *Aspect vs. relative density of trees and seedlings*

South East, South West and west directions were 8.818%, 18.023%, 2.326%, 1.84% and 4.55% respectively (Fig. III). Similarly, relative density of seedlings of *B. papyrifera* in the aspects of South east and South West were 0.733%. The relative density of *Boswellia Pirottae* in the aspects of North east, South East, and South West were, 0.291%, 0.678%, and 0.291%, respectively. While the relative density of seedlings in the aspects of North east, South East, and South West were 0.733. The total relative density of trees

VI: *Relative density, Relative frequency, Relative basal area and Importance Value Index of trees and shrubs in Mosebit Study area*

Species	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Important Value Index (IVI)
Combretum molle	21.2	100.0	11.8	133.0
Boswellia papyrifera	16.6	100.0	20.3	136.8
Atriplex farinosa	12.9	100.0	8.9	121.9
Terminalia laxiflora	8.3	80.0	7.2	95.5
Sterculia setigera	7.3	100.0	23.1	130.4
Pterocarpus lucens	5.6	100.0	9.6	115.2
Dichrostachys cinerea	4.6	20.0	1.1	25.8
Boswellia pirottae	4.3	60.0	2.5	66.8
Albizia schimperana	3.3	100.0	6.3	109.6
Acacia nilotica	2.6	40.0	0.5	43.2
Zizyphus mucronata	2.6	80.0	0.5	83.2
Stereospermum kunthianum	2.0	60.0	0.9	62.9
Grewia ferruginea	1.0	40.0	0.5	41.5
Gardenia ternifolia	0.7	40.0	0.2	40.9
Grewia bicolor	0.7	20.0	0.1	20.7
Lonchocarpus laxiflorus	0.7	20.0	0.2	20.8
Maytenus gracilipes	0.7	40.0	0.6	41.2
Ochna leucophloeos	0.7	40.0	0.1	40.8
Strychnos innocua	0.7	20.0	1.8	22.4

Species	Relative Density (%)	Relative Frequency (%)	Relative Dominance (%)	Important Value Index (IVI)
Ximenia americana	0.7	40.0	0.5	41.1
cacia polyacantha	0.3	40.0	0.0	40.4
Agauria salicifolia	0.3	40.0	0.1	40.4
Celtis africana	0.3	20.0	0.5	20.8
Clutia abyssinica	0.3	20.0	0.4	20.7
Dombeya torrida	0.3	20.0	1.9	22.2
Faidherbia albida	0.3	20.0	0.0	20.3
Piliostigma thonningii	0.3	20.0	0.0	20.3
Securinega virosa	0.3	20.0	0.0	20.4
Temak*	0.3	20.0	0.4	20.7

* not identified and it is mentioned local names

VII: *Relative density, Relative frequency, Relative basal area and Importance Value Index of trees and shrubs in Mosebit Study area in Hamusit study site*

Species	Relative Density (%)	Relative Frequency (%)	Relative dominance (%)	Important Value Index (IVI)
Boswellia papyrifera	43.4	100	77.531	221.0
Albizia amara	25.9	100	8.923	134.8
Cassia arereh	15.1	80	1.188	96.3
Rhus ruspolli	3.4	50	7.286	60.7
Gorgoro*	3.0	30	0.035	33.0
Combretum hartmannianum	1.5	40	1.784	43.3
Commiphora habessinica	1.1	40	0.687	41.8
Grewia bicolor	0.7	20	0.015	20.7
Erythrina abyssinica	0.4	10	0.100	10.5
Euphorbia candelabum	0.4	20	0.268	20.7
Karita*	0.4	20	0.072	20.5
Abina*	0.3	10	0.010	10.3
Acacia seyal	0.3	10	0.003	10.3
Boscia angustifolia	0.3	20	0.015	20.3
Capparis tomentosa	0.3	20	0.006	20.3
Cassia singueana	0.3	20	0.010	20.3
Clerodendrum myricoides	0.3	20	0.003	20.3
Limorna*	0.3	10	0.010	10.3
Otostegia integrifolia	0.3	20	0.004	20.3
Ozoroa insignis	0.3	20	0.019	20.3
Rhus natalensis	0.3	20	0.028	20.3
Sterculia setigera	0.3	20	0.788	21.1
Terminalia brownie	0.3	20	0.272	20.5
Acacia dolichocephola	0.1	10	0.002	10.1
Acacia nilotica	0.1	10	0.536	10.7
Combretum collinum	0.1	10	0.009	10.1
Commiphora africana	0.1	10	0.109	10.2
Dichrostachys cinerea	0.1	10	0.005	10.1
Dudina*	0.1	10	0.161	10.3
Grewia ferruginea	0.1	10	0.109	10.2
Pergularia daemia	0.1	10	0.001	10.1
Solanum indicum	0.1	10	0.001	10.1
Zizyphus spina–christi	0.1	10	0.009	10.1

* not identified and it is mentioned local names

in the North East, East, South East, South West and West aspects were 25.97%, 40.79%, 20.45%, 4.16% and 8.62%, respectively. Similarly, the total relative density of tree seedlings in the aspects of North East, East, South East, South West and West were 22.7%, 43.59%, 20.51%, 2.93% and 10.25%, respectively (Fig. 3).

Basal area and Important Value Index

The total basal area of the woodlands was 5.631 and 6.6425 m^2 per ha. in Hamusit and Mosebit woodlands, respectively. The species with the highest basal area were *Boswellia papyrifera, Albizia amara, Rhus ruspolli* and *Combretum hartmannianum* in Hamusit and *Sterculia setigera, B. papyrifera, Combretum molle* and *Atriplex farinosa* were in Mosebit study sites in descending order.

The Important value Index (IVI) in Mosebit study area ranges from 20.35–136.83 (Tab. VI). While it ranges from 10.1–221 in Hamusit study site (Tab. VII). *B. papyrifera* has an IVI value of 132.99 and 221 in Mosebit and Hamusit study sites, respectively. About 65 % of the species in Mosebit and 88 % of the species in Hamusit has IVI value of less than 50%.

Discussion

Vegetation structure and density of trees

The analysis result showed that the wood lands of Hamusit harbors more number of species than the wood lands of Mosebit. The density of trees/ha in Hamusit is more than Mosebit. *B. papyrifera* which is economically important species in Mosebit had hight number of trees (140 trees/ha) than in Hamusit wood land, which had 126.8 trees/ha. Few studies conducted in the wooded land of ANRS in Metema found out more or less similar results e.g Eshete (2002) found out 24 species, Asfaw (2006) identified 32 species and Eshete in his study in Tach armachiho districts (2002) recorded a total of 27 species.

The DBH structure result indicated that trees in the diameter class of 1.0–3 cm in Hamusit is eight times higher than in Mosebit. The number of trees identified in this diameter class was 23 and 4, in Hamusit and Mosebit, respectively (Tab. I). The highest density of trees in Mosebit is concentrated in the diameter classes of 3.1–6 cm, diameter. Eight species in Mosebit wood land had > 36.1 cm diameter, which accounts 6.3 %. Generally, as the diameter class increases relatively, the density of trees decreases in both study sites.

The absence of trees of *B. papyrifera* (Fig. 2) in Hamusit study site, in the lower diameter classes might be associated with anthropogenic factors. In this wood land there is great pressure of livestock population and cultivation problems which hampers the natural regeneration of the species. Moreover, tapping of the species for incense is common in this study area. And therefore, tapping may be one cause of the enviable seed set of the species, later resulting poor germination of the seeds.

A high individual in the lower diameter class (< 3 cm) and a few individuals in saplings (3–9 cm) in Mosebit may indicate that the species has the ability to produce sufficient quantities of seedlings, but has a problem of growing up to sapling stage. High number of seedlings might be associated with the set of viable seeds by the species since tapping is not practiced in this wood land. However, problems of seedling recruitment to sapling stage might be related with the occurrence of frequent fire which could be the cause of death of seedlings and /or in Mosebit, Graminoid species were dominating the lower strata, which serve as nurse plants for seedlings and protect soil erosion, but has an influence on occurrence of frequent fire and thus affect the growth of seedlings in to sapling stage.

This result is inline with the findings of Abuelgasim (2008) and Ogbazgahi, (2001), study result. The studies found out high number of seedlings and less number of saplings in which they reason out different causative factors. Several studies on population structure of *B. papyrifera* have been found similar results in Metema, Tigray, Eritrea and Sudan (Eshet et al., 2002 and Lemenih et al., 2007; Gebrehiwot, 2003; Ogbazghi, 2001 and Abuelgasim, 2008, respectively.

The height class structure distribution result indicated highest density of trees concentrated in the classes of 0.1–2 m in Hamusit, and 4.1–6 m in Mosebit, which were 41.8 % and 22.8 %, respectively. This indicates that in Hamusit wood land there are more saplings than in Mosebit wood land. The relative density of trees in the height classes of 0.1–2 m in Mosebit was 4 %. This result may indicate that there are more saplings in Hamusit than Mosebit wood land, which is associated with some expansive and unpalatable species. Observation also showed that there were more expansive and unpalatable species in Hamusit woodland. All in all as the height class increases the density of trees decreases, relatively. The number of identified species in the lowest height class in Hamusit wood lands was 10 times higher than the wood land of Mosebit.

Importance Values of species

The total basal area of identified species in Hamusit was lower than the woodlands of Mosebit (Tab. VII). S. *setigera, B. papyrifera, C. molle, P. lucens, A. farinosa and T. laxiflora* had the highest basal area in Mosebit in descending order, while in Hamusit *B. papyrifera; A. amara, R. ruspoli, C. hartmannianum, C. arereh* and *S. setigera* had the highest basal area in descending order.

The leading species in term of Important Value index was *B. papyrifera* followed by *A. amara, C. arereh, R. ruspolli, C. hartmannianum* and *C. habessinica* in Hamusit woodland (Tab. VII) and *B. papyrifera* followed by *C. molle, S. setigera , A. faninosa, P. lucens* and *A. schimperana* in Mosebit woodland (Tab. VI).

The IVI is considered to show greater ecological significance in plant distribution in a given ecosystem than absolute density (Fosberg, 1961; Lamprecht, 1989). It means that higher IVI value of a species indicates relatively better and significant distribution of the species in that ecosystem. *B. papyrifera* had higher IVI value in Hamusit than Mosebit. Where as other species that occurred in both sites, like *D. cinerea, A. nilotica and G. ferruginea* had higher IVI in Mosebit than Hamusit site. The result shows that *B. papyrifera* has got better distribution in Hamusit wood land than the wood lands of Mosebit. However, these species which are occurred in both study sites have got better distribution in *Mosebit* than *Hamusit* woodlands. Thus, the result may be associated with better climatic conditions for the regeneration and growth of *B. papyrifera* in Hamusit and Mosebit woodland, respectively.

Similar studies on woody plant population structure in wood lands done in similar agro-ecologies showed different results. Asfaw (2006) on his study in Metema recorded 319–435 stems ha^{-1}. While, Asmamaw (2008) in Sudan, were recorded 87–126 stems ha^{-1}. These variations in results may be attributed by intensity of human induced factors such as conversion of the woodland into other land use types, which could be the major factors that contribute for these variations.

In this study the density of *B. papyrifera* in Mosebit and Hamusit were 140 stems/ha and 127 stems/ha, respectively. In Eshete (2002), Asfaw (2006), Limenih (2007), in their studies in Metema found out the density of *B. papyrifera* as 87–175 stem ha^{-1}, 172 stem ha^{-1}, 64–225 stem ha^{-1}, respectively. Where as Ogbazghi et al (2006) in his vegetation study in Eritrea and Asmamaw (2008) in his study in Sudan, recorded the stem density of *B. papyrifera* as 80–270 stems ha^{-1} and 52–82 stems ha^{-1}, respectively.

Density of trees in relation to different environmental parameters

Relative density of trees, seedlings and species in relation to altitude

The relative density of trees, seedlings and the number of identified species in relation with altitudinal ranges in both wood land study areas showed a variation (Tab. III). In Hamusit study area the highest density of trees, seedlings and species concentrated in the altitudinal range of between 1800–1899 meter a.s.l, which were 82.88%, 65.82%, and 29 species, respectively. While the lowest density of trees, seedlings and species in this study area were found in the altitudes of 1700–1799. On the other hand in Mosebit study site, the highest density of trees, seedlings and number of species found in the altitudinal ranges of 1200–1299. All this results indicated that altitude plays a significant role in determining density of trees, seedlings and type of species.

With in the altitudinal ranges of both study sites, *B. papyrifera* had highest relative density of trees, between altitudes of 1800–1899 meter a.s.l, in Hamusit wood land (Tab. IV). This indicates that the species with additional factors may be favored with in this altitudinal ranges, than the others. This result is not inline with the findings of Ogbazghi (2002). Ogbazghi, (2002) found out the maximum density of the species between 1500–1600 m a.s.l.

In contrary with this finding, between altitudes of 1300–1399, 1600–1699, 1700–1799 and 1800– 1899, there were no seedlings of the species found. This result may indicate that altitude along with other environmental factors has impact on the regeneration and seedling growth of the species. *S. setigera,* has better relative density between altitudes of 1100–1199 in Mosebit study area. As the altitude increases, the relative density of *S. setigera* decreases, considerably. Generally, table IV, showed that altitude does not only have influence on the relative density of trees, shrubs and climbers, but also it determines the relative density of individual species.

Relative density of trees, seedlings and species in relation to gradient

The analysis result on the relation ship between relative density of trees and gradient shows a variation. In Mosebit study area, the highest relative density of trees and seedlings were recorded in the gradient of 15.1–20%, and 0.0–5% respectively (Tab.V). Similarly, in Hamusit the highest relative density of trees and seedlings recorded in the gradient of 15.1–20%. The lowest relative density of trees and seedlings in Mosebit, recorded in gradient of 5.1 –10%, and 10.1–15%, respectively. While in Hamusit, the lowest relative density of trees found in gradient of 10.1–15% and 20.1–25%, respectively. Over all these results indicate that gradient has a role in determining the relative density of trees, seedlings and number of species.

Relative density of trees, seedlings and species in relation to aspect

The relative density of trees in different aspects is described in Figure III. The highest relative density of trees and seedlings were found in East direction. Where as, the lowest relative density of seedlings and trees recorded in the directions of South west. These results indicate that aspect plays a very big role in determining plant density, which may be associated with sun light.

Similarly, the largest density of *B. papyrifera* tree and seedlings were recorded in the aspect of East direction. Where as, the lowest relative density of this species was recorded in the directions of South West. In the directions of North East, East and West directions seedlings of *B. papyrifera* were not recorded. All these results may indicate that aspect has an influence on the regeneration and growth of *B. papyrifera* species.

Summery: The study was carried out in Mosebit and Hamusit wood land areas, which are found in Jawi and east Belesa districts of Amhara National regional state, Ethiopia. The main objective of this paper is to analyzing the population structure of the woody vegetation in general and *Boswellia papyrifera* in particular, in relation to different environmental factors. Vegetation data were collected

in both sites using plots of 50 x 50 m (0.25 ha). The plots were laid out along line transects. The distance between consecutive plots along transect and the spacing between two adjacent transect lines were 500 m and 600 m, In each major plot four subplots (4 m × 4 m) were established at the corner of the major plots. Number of species and number of seedling (height < 1.0 m) for all trees, shrubs and climbers were collected from subplots. An electronic compass Map-Star Module II was used for the alignment of transects. The aspect, altitude and location of each sample plot data were collected using GPS Juno™ ST handheld (Trimble, USA). Woody plants of < 4 m height were measured using a folding marked pole. A total of 58 woody species belonging to 22 families were identified from both sites. A total of 241 trees/ha and 292 trees/ha were found in Mosebit and Hamusit study sites, respectively. The seedling density result indicates 3656 seedlings/ha and 2469 seedlings/ha in Mosebit and Hamusit study areas, respectively. *B. papyrifera* were found the dominant and economically important species in both study sites. The relative density of different tree species in different height and diameter classes were determined by altitude, aspect, and gradient of the study areas. The study result concludes that distribution of the species, relative density, height class and diameter class of species in the two sites is dependent on environmental factors. Finally, the findings indicate that the two woodlands harbor, economically important tree species. Therefore, giving due attention in conserving these wood lands is important from ecological, economical and conservation point of view.

SOUHRN

Struktura a hustota dřevinné vegetace dvou lesních oblastí narodního státu Amhara, Etiopie

Studie byla realizována v oblasti savanových lesů Mosebit a Hamusit, které se nacházejí v distriktu Jawi a východní Belesa národního státu Amhara v Etiopii. Hlavním cílem práce je populační analýza struktury vegetace v souvislosti s limitujícími faktory životního prostředí obecně a specifickým výskytem významného vlajkového druhu *Boswellia papyrifera*. Analytická data byla získána z obou zmíněných lokalit ze zkusných ploch o rozměrech 50 × 50 m (0,25 ha). Tyto zkusné plochy byly umístěny podél liniových transektů, přičemž vzdálenost mezi sousedními plochami činila 500 m, vzdálenost mezi liniemi 600 m. Na každé z ploch byly v rozích s pomocí elektronického kompasu Map-Star Module II vytyčeny také čtyři vzorníky o rozměrech 4 × 4 m pro detailní pozorování výskytu zmlazení dřevin. Pro dřeviny byla zaznamenávána jejich výčetní tloušťka v d1,3 m a výška s pomocí laserového dálkoměru Impulse 200 Standard. Údaje o různých proměnných životního prostředí (svah a nadmořská výška) každé měřené lokality byly zaznamenány pomocí GPS Juno ST™ (Trimble, USA). Celkem bylo zjištěno 58 druhů dřevin patřících do 22 čeledí. Celkem bylo zjištěno 241 stromů/1ha a 292 stromů/1ha v lokalitě Mosebit a Hamusit. Zjištěn & a acute; hustota semenáčků přepočítaná na 1 ha odpovídá 3656 a 2469 jedincům lokality Mosebit a Hamusit. Druh *B. papirifera* byl shledán dominantním a hospodářsky významným druhem obou sledovaných lokalit. Výsledky studie ukazují, že pro výskyt druhů a jejich relativní hustotu má velký význam také nadmořská výška a sklonitost terénu. Studie dokazuje, že významným faktorem pro ochranu prostředí těchto savanových lesů je vazba na funkční ochranný a hospodářský systém oblasti garantovaný státním dozorem a místní venkovskou samosprávou.

Boswellia papyrifera, Belesa, enviromentalni factory, Jawi, hustota, lesy

CONCLUSSION

The study results indicated high diversity of species in both wood lands. The woodlands also harbor economically, ecologically and environmentally important tree and shrub species. The density of species in the studied wood lands of each species varies in relation with different environmental variables as a determining factor. The IVI result, which shows the distribution of the species in the ecology of the wood lands were better describing the distribution of the species than using absolute density. Accordingly, *B. papyrifera* in both wood lands have better distribution than the other species. This indicates the importance of the species in that ecology. Moreover, the species is one of economically high value tree species in the provision of gums and resins, which is important for the livelihood of surrounding communities.

In the case of *B. papyrifera*, there were more seedlings and there were no saplings, in Mosebit. This indicates that the species may not have a problem of regeneration, but it has a short fall of growing up. On the contrary, in Hamusit wood land, the species has no seedlings and saplings. The problem in this area may be associated with grazing and tapping problems. In the case of Hamusit, tapping were a common practice where as in Mosebit it was not tapped. This can indicate that tapping of the species

may have an influence in having viable seed. Or else, in Mosebit, Graminoid species were dominating the lower strata, which serve as nurse plants for seedlings and protect soil erosion, but have an influence on occurrence of frequent fire and thus affect the growth of seedlings in to sapling stage.
All in all, the wood land is important for biodiversity conservation, livelihood of the local communities, and to avert desertification. Therefore, conservationists, environmentalists, ecologists and policy makers should give due emphasis to protect the wood land from the encroachment of humans for investment purpose, settlement, sedentary farming, moreover participatory woodland management and utilization plan should be developed to sustain the woodlands.
Finally, the inter-relation ship of *B. papyrifera* on the recruitment of seeds and growth of the species has to be investigated further.

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