USE AND RECRUITMENT OF KEY WOODY SPECIES IN SEMI-ARID AREAS OF NORTHEASTERN ETHIOPIA: INFLUENCE OF MANAGEMENT PRACTICES

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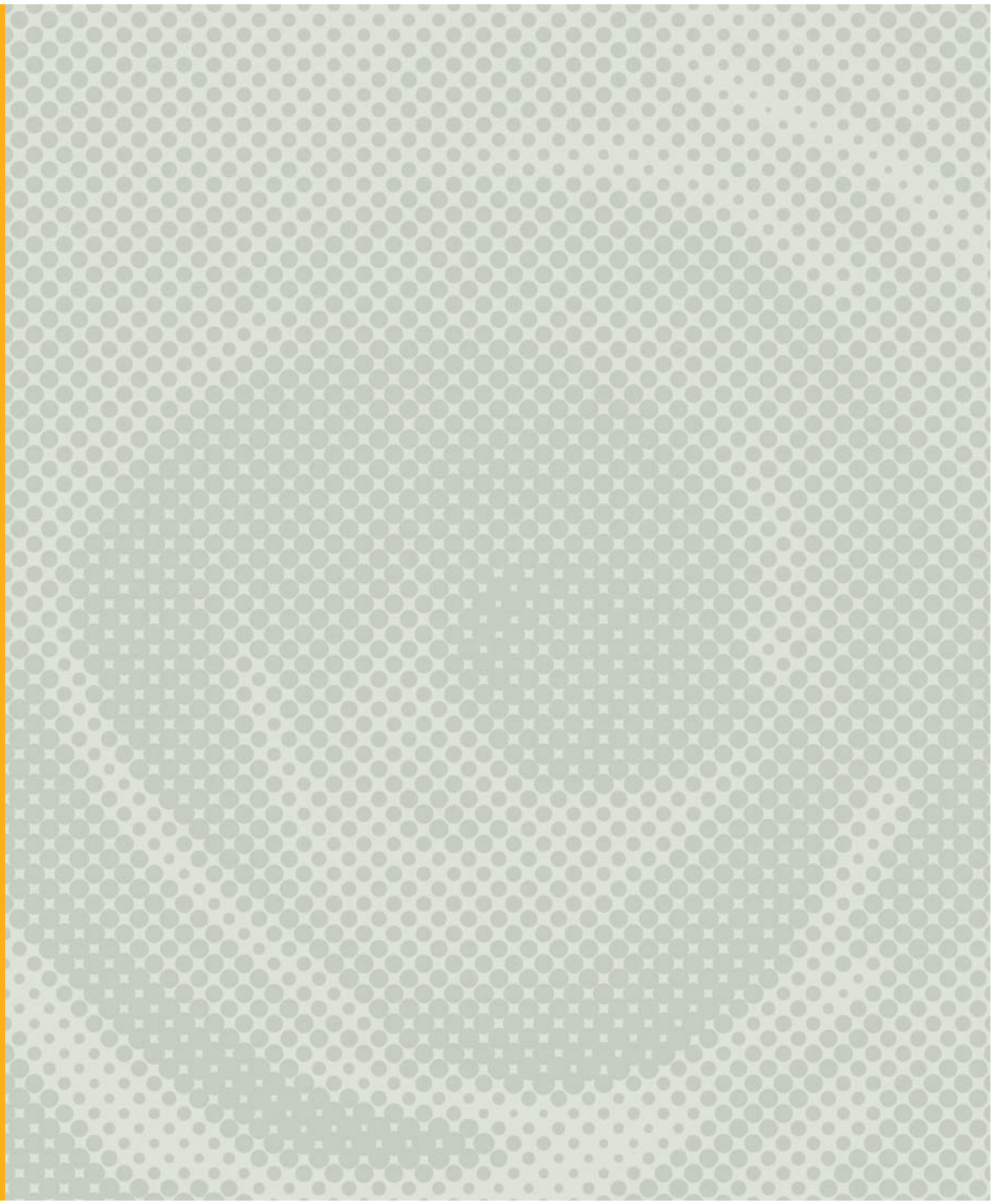

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Use and recruitment of key woody species in semi-arid areas of northeastern Ethiopia: influence of management practices

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Declaration

I, Seid Mohammed Ali, hereby declare to the senate of Norwegian University of Life Science (UMB) that this thesis is product of my original research work and all other sources are duly acknowledged. This work has not been submitted to any other university for a ward of academic degree.

Signature:_____

Seid Mohammed Ali

May 2008, Ås, Norway

Main Advisor: Dr Stein Ragnar Moe: _____

Acknowledgment

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Dedication

To my mother: Helwo Abdullah Hussein and my brother Abdulmenan Mohammed Ali.

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Abstract

Triggered with expanding population and their demand for natural resources, deforestation has been a national problem in Ethiopia threatening woody plants with extinction. To take conservation measures and ensure sustainable utilization of woodland resources, information on sources of disturbance, regeneration status and uses of woody plants are essential prerequisites. The current study was designed to: (1) document traditional ecological knowledge of Afar pastoralists on uses, status and threats of woody species and (2) compare the species composition and population structure of woody plants between areas where grazing and browsing is excluded (exclosures) and open access areas. The study was carried out in Wukro and Aba'ala districts of northeastern Ethiopia and used both an ethno-botanical approach and quantitative ecological methods using *Z. spina-christi, C. gharaf*, *B. aegyptiaca*, *A. etbaica* and *A. tortilis* as key species. A total of 66 woody plants used for browse (n = 59), medicine (n = 16), firewood and construction (n = 37), food (n = 31) and hygienic and cultural purposes (n = 26) were identified by interviewees. All the five woody species selected by key informants were used for several purposes. Local people perceive that most woody plants including key species have declined both in abundance and distribution. Frequent drought, decline in rainfall and logging were considered as major causes for decline of woody species. Perception of local with regard to declining trend of multipurpose woody species was corroborated by field data. Both diameter and height based class distribution of key woody species in open access areas indicated abnormalities either in the form of flat diameter class distribution or extremely few numbers of mature trees implying declining population size. Species composition, diversity, and density of woody species were significantly higher in exclosures compared to open access areas suggesting rehabilitation of degraded lands. Results of the current study indicated that local people in the study area are reliable sources of management relevant information on use and dynamics of woody species. In light of increasing population, trends of change towards agro-pastoral production system and government policy which favors settlement, the importance of multipurpose woody species is enormous and hence further studies to help in their sustainable use are recommended.

Key words: Exclosure, population structure, woody plants.

1. Introduction

Woody species are major ecological features and a key resource to cope with dry and unpredictable conditions of the African drylands (Ward and Rohner, 1997; Lykke *et al*., 2004). Similar to the rural poor living in drylands of Africa, woody species are indispensable in the daily lives of Afar pastoralists and used as main sources of fodder, food, firewood, construction materials and medicine (Yayneshet and Kelemework, 2003; Diress *et al*., 2007). As a result, traditionally there are institutional and management arrangements to manage, conserve and use woody species (Yayneshet and Kelemework, 2003). Ecologically, woody species are essential for the stability of rangeland because of their role in nutrient cycling and protection of soil erosion by torrential rainfall and strong winds characterizing drylands (Herlocker, 1999). Microclimates created under and near woody plants usually have reduced solar irradiance and higher soil fertility which promotes the development of herbaceous plants and woody plants regeneration (Belsky *et al*., 1989).

Decline of woody species in drylands of Africa have been widely reported. For example, low recruitment of acacia species has been recorded in the Negev deserts, Israel (Ward and Rohner, 1997). Mature trees have substantially declined in hyper-arid areas of Egypt (Anderson *et al*., 2007). A general decline in woody species has been observed in a study conducted in three West African countries Senegal, Niger and Burkina Faso (Wezel and Lykke, 2005). In Ethiopia, deforestation driven by expanding population has been a national problem resulting in dramatic decrease of forest cover in highlands from 16% in early 20th century to 11.9% by 2005 (EFAP, 1994). Coupled with aggravating poverty and incidents of uncontrolled fire, deforestation has been accelerating in recent years (Kindeya, 2004). With present pace of deforestation, Lemessa and Perault (2001) have predicted complete lose of all the remaining forests in the coming two decades.

In Aba'ala (study site), population driven land-use changes was behind a shift in plant species composition and functioning of the ecosystem (Diress *et al*., 1999). Declining trend of *D. glabra*, a valuable woody species in Afar rangelands, has been reported recently (Diress *et al*., 2007). Besides its ecological consequence, a decline of woody species will have critical socio-economic impact on health, nutrition and income of Afar pastoralists. Therefore there is an urgent need to take conservation measures to reverse the down ward trend.

To mitigate land degradation, exclosures have been practiced widely in northern Ethiopia and initial encouraging results had been reported (Emiru, 2002; Asefa *et al*., 2003; Mengistu *et al*., 2005). However despite initial positive socio-economic and ecological contributions of exclosures, recent studies have cast doubt with regard to the effect extended protection of exclosures. Extended protection of exclosures could expose seedlings of woody species to detrimental inter- and intra specific competition (Masresha, 2003), hamper seedling germination due to absence of pre-sowing treatment in the form of livestock ingestion (Mekruia *et al*., 1999) and can even cause degradation of woody species naturally dependent on perturbation (Oba, 2006). Therefore, prior to exclusion of all forms of interference, studies aimed at generating empirical information on sources of disturbance, regeneration status and uses of woody plants are required. In this regard, information on population dynamics is essential to understand and predict the responses of a system to disturbance (Goldberg and Turner, 1986). Moreover follow up studies on status of exclosures would contribute to clarification of the effect of extended protection on woody plants and help in making informed decision on the future fate of exclosures.

With the exception of a study on *D. glabra* (Diress *et al*., 2007), no systematic and scientific studies have been made on population dynamics of woody species in northeastern Ethiopian rangelands. Hence documented information on population dynamics of woody species is lacking. However, a thorough study of population dynamics of woody species require long term scientific data on vegetation change which are not commonly available. Under this constraint, population structures gathered from single survey are usually used to infer status of population dynamics (Lykke, 1998). Knowledge of population structure of woody species provides an insight into the availability and survival of woody species of concern (Omeja *et al*., 2004). Sufficiency of population structure in giving preliminary indication of population dynamics of woody plants and pointing out impact of extractive activities or land-use change has been proved adequate (Hall and Bawa, 1993; Obiri *et al*., 2002). Lykke (1998) has recommended a combined approach in which both interviews of local communities and population structure of woody species are used to assess vegetation change as these methods enlighten different aspects of the problem. Moreover, gathering information from local communities is essential to match conservation efforts with local priorities (Lykke, 2000).

This study was designed to investigate the recruitment status of key woody species and retrieve ethno-botanical knowledge from people in the study area. Specifically its targets were to (1) document ethno-botanical knowledge of the Afar pastoralists covering the uses, status and threats of woody species, (2) investigate the species composition, density and diversity of woody plants, (3) compare the recruitment potential of selected woody species between exclosures and open access areas and lastly (4) determine population structure of the selected woody species and compare the result with local peoples perceptions.

2. Materials and Methods

2.1. Study area

The study sites were located in Aba'ala (13 15'-1330'N and 3939'-3955'E) and Wukro (1339'-1347'N and 3930'-3934'E) districts of northeastern Ethiopia (Figure 1). Both are characterized by a semi-arid climate receiving bi-modal rainfall with average annual rainfall not exceeding 500mm (Hunting and MacDonald, 1976; Yayneshet, 2008). For both sites, the long summer rainy season starts between June and September with a short rainy season between March and April (Segel and Lamb, 2005; Seleshi and Camberlin, 2006).

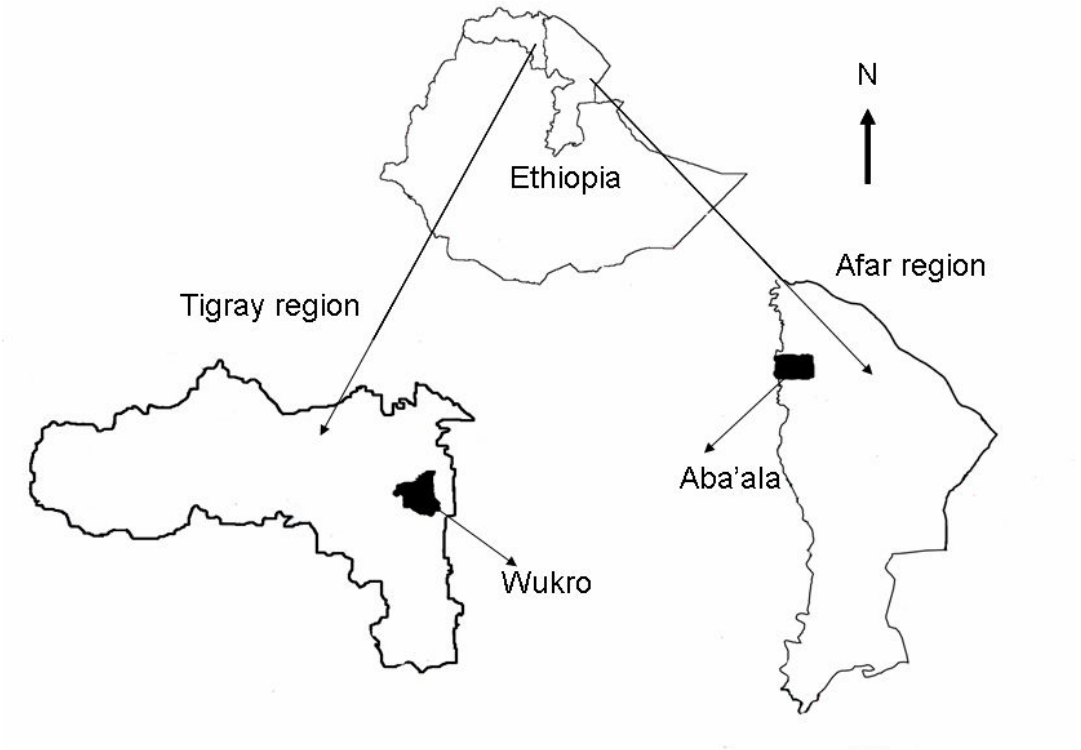

Figure 1: Map of study area

The vegetation of Aba'ala can be described as wooded bush-land dominated by *A. etbaica* (Hunting and MacDonald, 1976). Other widely observed acacia species in Aba'ala with often poor understory cover are *A. nubica, A. tortilis,* and *A. mellifera* (Diress *et al*., 1999). Plant formation of Wukro has been taken as typical of East African montane forest which is characterized as mesophyllic deciduous woodland, mixed evergreen and deciduous open woodland (Le Houérou 1989; Feolil *et al*., 2002). The woody component of Wukro is also dominated by *A. etbaica* (Yayneshet, 2008). In Aba'ala, the dominant soil type is sandy soil developed from alluvial deposits resulting from flood coming from nearby upland areas. Most of the hills and ridges of Aba'ala are often exposed rocks and dominated by gravel (Hunting and MacDonald, 1976). The dominant soil types of Wukro include Cambisols, Leptosols, and Regosols (FAO, 1998).

In Aba'ala, the community mainly depends on both pastoral and agro-pastoral production systems for their livelihood. Camels and goats are the main livestock species while agro-pastoralists mainly keep cattle besides crop production (Diress *et al*., 1999). Settlement and involvement in agriculture dates back to the early 1960s, when neighboring Tigrian highlanders started to develop crop production (Diress *et al*., 1999). The experiences from acute drought of 1984/85 also caused major transformation of some pastoralists into agro-pastoralists (Diress *et al*., 1999). The livelihood of the local people in Wukro depends on subsistence highland mixed farming, in which livestock husbandry and crop productions play a major role (Emiru, 2002).

2.2. Methods

2.2.1. Interview

Five pastoral and agro-pastoral settlements were selected for interview; Adiharemele, Asengola, Irkudi, Gelaiso and Dinemelle from the Aba'ala district. With the help of local leaders, 60 informants, four of them females, were randomly selected from the five settlements and interviewed independently. All informants were born and had been living in Aba'ala through out their life. Interviews, which lasted on average from 1-2 hrs, were made in Afar language with the help of experienced translators. Respondents were asked to list woody plants they prefer for livestock fodder, firewood and construction purposes, traditional treatment of both human and livestock diseases, their food value and cultural purposes Respondents were also asked to qualify current occurrence of woody plants they mentioned relative to their past abundance (20-50 years

depending on the age of interviewee) as disappeared, declining, not changed, increasing or new arrival and point out threats these species had faced.

Prior to individual interviews, discussions were made with key informants to get pre-information about woody plants of the study area and select key woody plants to focus on during the interviews and quantitative data collection. As the aim of the study was to focus on the most important woody species, free listing techniques in which informants list all the species they first come to think about were used.

2.2.2. Field sampling and data collection

Field sampling was conducted in study sites differing in their land use practices (open access areas, partially exclosure, and exclosure) from Aba'ala and Wukro districts. A total of 65 plots of 0.04 hectare each were selected for this study. At Aba'ala, 20 and 15 plots were selected from open access areas and partially exclosures land uses respectively. Thirty plots, 15 each, were selected from 58 ha exclosure and 52ha open access areas of Wukro. At each site, the first plot was selected randomly from the topographic maps while consecutive plots were marked at every 300m in four direction of the pre-selected plot. Exclosures are sites usually chosen with consent of the community and protected from all forms of interference through out the year. Open access areas as their name suggest are open areas where all forms of extractive uses still go on. Only oxen used for farming purpose are allowed in partial exclosure of Aba'ala for a period of less than three months and the site is protected from all other forms of disturbances.

Detailed measurements were made for five woody species (*A. etbaica, A. tortilis, B. aegyptiaca, C. gharaf* and *Z. spina-christi*) selected by key informants in each plot. For these key woody species, measurements included: number of individuals, diameter at breast height (dbh), maximum canopy diameter, canopy diameter perpendicular to the maximum diameter and tree height. For trees with multiple trunks, the tallest trunk was measured. In addition, the number of all other woody species present was recorded in each plot. Then, vegetation attributes such as density, frequency and crown cover were calculated from the above measured parameters.

In this study, trees were defined as woody plants with height > 130cm and dbh >2.5cm. Saplings were defined as woody plants with height ranging between 50cm and 130cm and dbh <2.5cm. Seedlings were defined as woody plants with height <50cm and dbh<2.5cm. Seedlings were sampled using three nested subplots of 5m by 5m randomly chosen in the main plots. All

landscapes sampled were photographed and the locations of plots marked using GPS (Global Positioning System) to help in future monitoring. Specimens of unidentified plant species were collected and sent to Addis Ababa University National Herbarium for identification. Nomenclature of plant species follow published volumes of the flora and fauna of Ethiopia and Eritrea (Hedberg and Edwards, 1989; Hedberg *et al*., 1995).

2.3. Data analysis

Data from the interviews were grouped into classes according to major themes of inquiry. According to the method of informants consensus (Martin, 1995; Alexiades, 1996), the importance of each specified species was calculated directly from the number of informants who mentioned them. Following Lykke (2000), only woody species mentioned by at least two informants were enrolled into final list of species and considered for the final analysis. Perceptions of interviewees form Aba'ala on population trend of woody plants were compared with population structures of respective species. Spearman rank correlation was used to identify the association between use groups and perception of interviewees on trends of woody population.

Data on density and cover of *A. etbaica* were transformed using Johnson transformation to conform to normality (Minitab Inc., 2006). General linear model, two-way t-test and Kruskal-Wallis test were used to compare species diversities of woody plants, mean densities and cover of *A. etbaica*. The Shannon-Weiner diversity index (Shannon and Wiener, 1963) using the formula given by Magurran (1998) was calculated as $H' = -\sum PilnPi$ where Pi is the proportion of individuals for the i^{th} species and *ln* is the natural logarithm. Significant differences were declared at $P<0.05$. All statistical analysis was performed using Minitab 14 (Minitab Inc., 2006).

3. Results

3.1. Use of woody species

A total of 66 woody plants used for browse, medicine, firewood and construction, food, hygienic and cultural purposes were identified by interviewees (Appendix 1). Over 80% of these species have at least two uses while more than half of them (n=38) are used for several purposes. Only 13 woody plants were single use species. Sixty woody plants from 27 families were used for browse purpose (Figure 2). Most of species used for fodder purpose were from the Tiliaceae, Fabaceae, Capparaceae and Salvadoraceae families. *G. tenax*, *G. kakothamnos*, *G. ferruginea*, *G.*

villosa and *A. mellifera* were among the woody plants highly preferred for their fodder value (Table 1).

Thirty-eight woody plants from 17 different families were used as medicinal plants (Figure 2). Most of the medicinal woody species belong to Capparaceae, Balanitaceae, Fabaceae and Salvadoraceae families. *B. rotundifolia*, *B. coriaceae*, *B. aegyptiaca*, *S. persica and Z. spina-christi* were among the frequently reported medicinal woody species (Table 1). *B. rotundifolia* was mentioned by almost all respondents and used mainly to treat malaria.

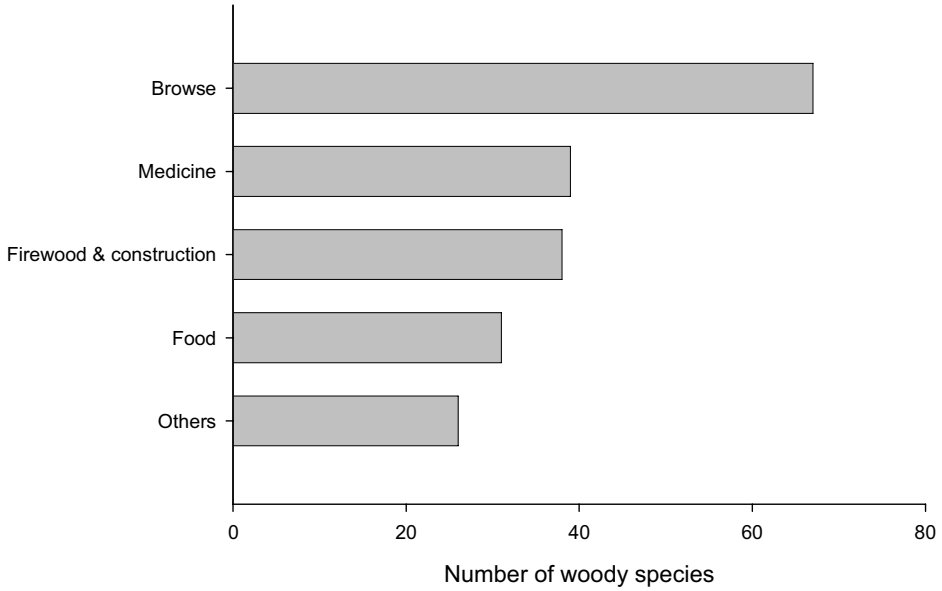

Figure 2: Number of woody plants used for different purposes by Afar pastoralists (n = 60) of northeastern Ethiopia.

Thirty-seven woody species from 15 different families were used for firewood and construction purposes (Figure 2). Most of woody species used for firewood and construction purpose were from Fabaceae, Tiliaceae, Rhamnaceae and Balanitaceae families. *A. etbaica*, *A. tortilis*, *A. nilotica*, *M. kummel* and *B. aegyptiaca* were among the most frequently reported woody species preferred for this purpose (Table 1).

Thirty-one woody species from 15 families were identified as human food (Figure 2). Members of Tiliaceae, Salvadoraceae and Balanitaceae families were highly preferred for their food value. For the majority of edible woody species, fruits are the parts eaten while for some woody plants their bark, leaves or (and) roots are used as food. *G. tenax*, *C. gharaf*, *D. glabra*, *G.*

ferruginea, *G. villosa* and *Z. spina-christi* are the most frequently reported edible woody species (Table 1)

Table 1: The ten most frequently reported woody species used for different purposes by Afar pastoralist (n = 60) of northeastern Ethiopia (Ranked based on number of reports). The number of people who mentioned each species is given in parenthesis (see also appendix 1)

Browse	Food	Medicine	Firewood and construction	Others
G. tenax (42)	*G. tenax* (43)	*B. rotundifolia* (27)	*A. etbaica* (39)	*M. kummel* (22)
G. kakothamnos (34)	*C. gharaf* (38)	*B. coriaceae* (20)	*A. tortilis* (35)	*O. europaea* (22)
G. ferruginea (32)	*G. ferruginea* (34)	*B. aegyptiaca* (16)	*A. nilotica* (32)	*Commiphora sp.*(21)
G. villosa (31)	*Z. spina-christi* (32)	*Z. spina-christi* (9)	*M. kummel* (20)	*T. brownii* (20)
A. mellifera (31)	*G. villosa* (32)	*S. persica* (9)	*B. aegyptiaca* (19)	*D. ombet* (18)
M. kummel (28)	*M. kummel* (29)	*A. mellifera* (7)	*Z. spina-christi* (18)	*B. aegyptiaca* (15)
D. glabra (25)	*D. glabra* (29)	*C. rotundifolia* (7)	*A. mellifera* (9)	*B. coriaceae* (13)
C. gharaf (24)	*S. persica* (20)	*A. nilotica* (6)	*C. gharaf* (7)	*A. mellifera* (7)
S. persica (23)	*B. aegyptiaca* (18)	*A. .nubica* (5)	Commiphora sp.(7)	*Commiphora sp.* (5)
C. rotundifolia (23)	*G. kakothamnos* (14)	*M. kummel* (4)	*G. tenax* (6)	*E. schimperi* (4)

Others= woody plants used for hygiene, perfuming, handicrafts and cultural purposes
Note: The full scientific names of all woody species are given in annex

Respondents were also asked to list woody species used for cleansing, perfume, religious rituals, and craft purposes (Figure 2). Twenty-six woody species from 13 different families were used for these purposes. Among the most frequently reported woody species used for these purposes are *O. europaea*, *M. kummel*, *Commiphora sp.*, *T. brownii and D. ombet* (Table 1).

Use of key woody species

Z. spina-christi, C. gharaf, *B. aegyptiaca*, *A. etbaica* and *A. tortilis*, which were selected after discussion with key informants, are used for multiple purposes. For example, *Z. spina-christi* has edible fruits and used for a number of other beneficial applications including, use of its shade during conflict mediation, its leaves as fodder and to wash the dead before burial, branches for fencing, wood as fuel and for construction and the utilization of different plant parts in traditional medicine. Field observations revealed that plant products of other key woody plants such as timber, charcoal, firewood, and crafts are sold in the study area (Table 2).

Table 2: Reported uses of the five most important woody plants selected by key informants in Aba'ala, northeastern Ethiopia: Major uses are denoted with ++ (Hm= Human medicine, Ev= Ethno veterinary medicine, FW= Firewood, Con= Construction). *Z. spina-christi* was not included in the final analysis as it was encountered only twice in the field

Name of species	Food	Browse	Hm	EV	FW	Con	Others
Z. spina-christi	++	++	+	+	+	+	a, b, c, d, f, g, i
C. gharaf	++	+	+		+	+	d, e, f, l
B. aegyptiaca	++	+	+	+	+	++	d, f, h
A. etbaica		++	+		++	++	c, f, j, k
A. tortilis		++	+	+	++	++	c, f, k

a= new twigs used to treat snakebites, b= to wash the diseased before burial, c= to expel evil spells, d= to make household utensils, e= to make walking sticks, f= shade, g= used to soften their hairs by soaking the leaves overnight so it makes oily, h= as chewing gums, i= to treat wounds, j= to build livestock barns, k= to make "rufu"; a traditional ritual where the leaves of these woody plants are mixed with butter and sprayed on children believing that this will make children productive and honored by the community, l= to ignite fire

3. 2. Association and habitat preference of key woody species

Informants were of the view that *Z. spina-christi, A. tortilis, B. aegyptiaca,* and *C. gharaf* species usually grow together as they commonly prefer plain areas with ample moisture (Table 3). Other woody plants commonly associated with these key woody species were *S. persica, A. nilotica, G. tenax* and *A. nilotica*. However, *A. etbaica* is usually found on hilly sites and commonly associated with *G. tenax, G. ferrigineae, G. villosa, A. mellifera, and R. natalensis.*

Table 3: Community knowledge on distribution and habitat preference of key woody plants, northeastern Ethiopia

Name of woody species	Preferred habitat	Remarks
Z. spina-christi	Stream banks; sandy loams soils with enough moisture	Almost absent from plain areas and confined to stream sides. Alarmingly threatened
C. gharaf	Plain; sites with ample moisture	Coppices easily but threatened by farmland expansion
B. aegyptiaca	Stream banks, plain, farmlands, hill sided; sandy loams soils with enough moisture	Threatened by overuse to build local houses, especially household utensils and doors
A. tortilis	Stream banks, ex-livestock barns, plain	threatened by overexploitation for charcoal, firewood and construction purposes
A. etbaica	Hill tops, and hill sides: grows on relatively higher altitudes with enough aeration.	threatened by overexploitation for charcoal, firewood and construction purposes

3.3. Pastoralists' perception on trend of woody species population

The majority of respondents (70%) perceive that woody species have generally declined and no informant reported newly introduced woody species in study area (Figure 3).

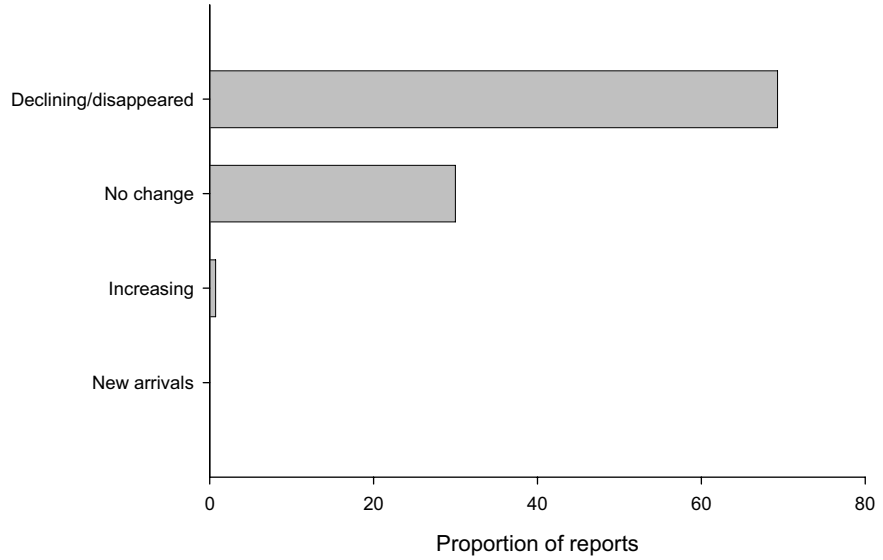

Figure 3: Perception of Afar pastoralists (n = 60) of northeastern Ethiopia on population trend of woody plants

Abundance of seven woody species including *E. africana*, *B. aegyptiaca*, and *C. purpurea* were reported to have declined by all respondents. The abundance of other seven woody species including *S. latifolia*, *T. camphorates* and *Z. pentandra* were consistently reported unchanged. Informants were inconsistent regarding population trend of 51 woody species and reported them both as unchanged and declining. However, when proportion of reports of decline and no change were compared for each species separately, 31 woody species were reported as declining by more than 70% of interviewees (Table 4).

Woody species highly preferred for their fodder, food, firewood and construction and cultural purposes such as *G. tenax*, *A. etbaica, B. rotundifolia* and *O. europaea* were perceived by the majority of interviewees as declining species. Moreover, multipurpose woody species used as key species in the current study namely *Z. spina-christi*, *A. etbaica*, *A. tortilis* and *C. gharaf* were reported among declining woody species by the majority of interviewees (Table 4). Only ten of the 51 differently categorized woody species such as *L. shawii*, and *B. edulis* were reported unchanged by the majority of informants. Moreover, significant correlation was found between declining woody species and species used for livestock fodder ($r = 0.781$, $P = < 0.000$),

as human food (r = 0.654, P = < 0.000), for construction and firewood purposes (r = 0.492, P = < 0.000) and for traditional medical purpose (r = 0.328, P = 0.025).

Table 4: Perception of Afar pastoralists (n = 60) of northeastern Ethiopia on population trend of 20 highly preferred multi-purpose woody plants. (See also Appendix 1).

Name of species	Proportion of interviewees who reported woody plants as	
	Declining/disappeared	Not changed
M. kummel	83.3	16.7
G. tenax	70.8	29.2
G. kakothamnos	76.9	23.1
A. nilotica	87.1	12.9
Commiphora sp.	86.2	13.8
G. villosa	64.1	35.9
C. gharaf	88.9	11.1
A. mellifera	66.7	33.3
G. bicolor	85.7	14.3
B. rotundifolia	68.0	32.0
G. ferruginea	48.6	51.4
A. etbaica	94.4	5.6
O. europaea	89.5	10.5
R. natalensis	80.0	20.0
'Boboita'	78.9	21.1
B. coriaceae	93.8	6.3
'Katoita'	92.9	7.1
Z. spina-christi	92.9	7.1
A. tortilis	83.3	16.7
T. brownii	83.3	16.7

3.4. Pastoralists' perception on causes for decline of woody species

Afar informants perceive that most woody plants in their surrounding have declined both in abundance and distribution. Factors attributed for the decline include logging of woody species to satisfy growing subsistence demand for fuel wood and homestead construction; frequent drought and shortage of rainfall which forbade establishment of seedlings of these woody plants; flood which takes seedlings of reverine woody plants and unskilled harvesting methods (Figure 5). Almost half of the respondents cite logging as a cause for the decline of woody species. It is interesting to note that quite few Afar pastoralists do consider over-browsing as a cause for decline of woody plants.

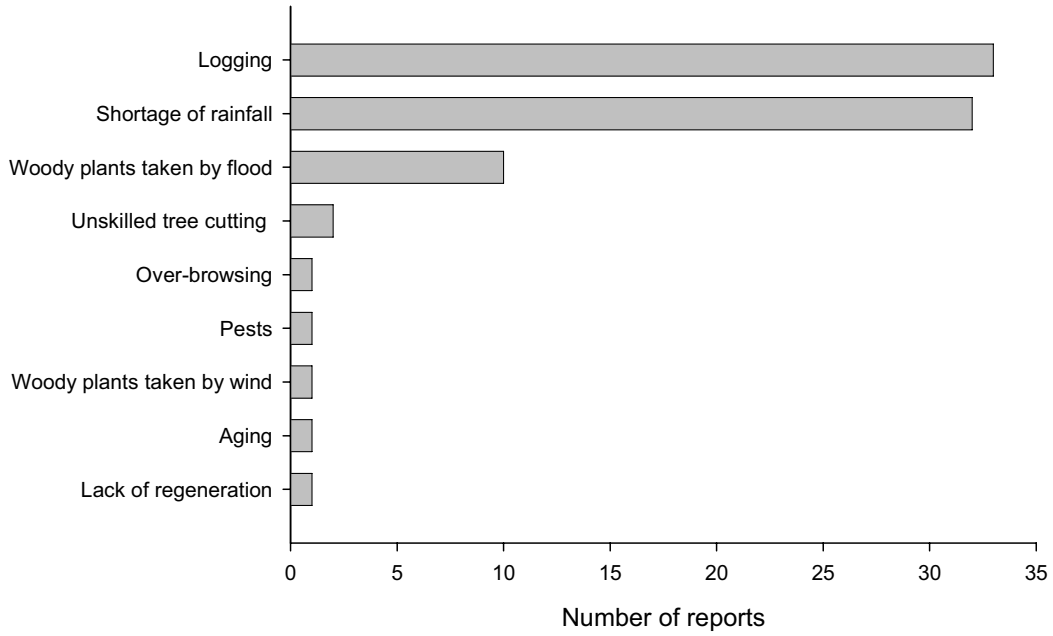

Figure 4: Perception of Afar pastoralists (n = 60) on factors behind decline of woody plants in the study area, northeastern Ethiopia.

3.5. Woody species composition and population structure

Fifty-three woody plants were recorded at both study sites, Aba'ala and Wukro (Table 4 and 5). A total of 37 woody species distributed among 19 families mainly from Tiliaceae, Fabaceae and Burseraceae were recorded in Aba'ala. Although more species were recorded at open access areas than in partial enclosures, there is no difference between the two land uses in woody plants diversity at Aba'ala ($P = 0.521$, $DF = 17$, $t = 0.65$).At Wukro, a total of 21 woody species from 12 families were recorded; five of which were common to both exclosure and open access areas (Table 6). Woody species diversity in exclosures were significantly higher than open access areas ($P = 0.013$, $DF = 20$, $t = -2.73$).

Table 5: List of woody species recorded at Aba'ala study site, northeastern Ethiopia, with their respective densities and frequencies.

Names of species	Open access areas		Partial exclosures	
	Density(No./ha) ±SE	Frequency[a]	Density(No./ha) ±SE	Frequency[a]
A. etbaica	457.7±143.0	51.1	969.3±131.0	100.0
A. mellifera	76.1±28.8	51.1		
A. nilotica	115.0±24.2	62.2		
A. tortilis	47.2±9.3	57.8		
A. nubica	2.2±1.3	6.7		
Atoori[b]	33.3±13.0	17.8		
B. aegyptiaca	9.4.0±3.3	22.2		
B. coriaceae	0.6±0.6	2.2		
Bobo'ita[b]	60.0±15.3	37.8		
C. gharaf	277.2 ±26.7	80.0		
C. ovalis	8.3±2.75	22.2		
Commiphora spp1.	12.8±4.1	22.2		
Commiphora spp2.	163.3±32.7	46.7		
Commiphora spp3.	0.6±0.6	2.2		
D. glabra	0.6±0.6	2.2		
G. bicolor	0.6±0.6	2.2		
G. ferruginea	70.0±22.0	28.9		
G. kakothamnos	91.1±22.6	37.8		
G. tenax	16.7±6.7	17.8		
G. villosa	102.8±102.8	46.7		
H. macranthus	368±114.0	22.2		
M. angolensis	12.7±4.2	22.2		
Mi'idita[b]	83.9±23.4	44.4		
R. natalensis	1.7±1.7	2.2		
S. persica	3.9±2.4	8.9		
Z. spina-christi.	0.6±0.6	6.7		
C. edulis			142.2±43.1	86.7
Danshel[b]			50.3±39.9	13.3
E. schimperi			209.4±40.0	93.3
Harugaito[b]			45.3±45.3	6.7
L. camara			191.0±122	26.7
O. europaea			6.3±3.6	20.0
R. vulgaris			226.6±45.5	100.0
Shokorba[b]			43.8±42.1	20.0
Shoha[b]			10.9±9.4	13.3
T. camphorates			466.0±132.0	53.3
L. abyssinica			436±112.0	86.7

a= Proportion of quadrates (%) in which the species was found b= unidentified woody plants

The density of all woody plants for open access areas and partial exclosure of Aba'ala were about 1587.8 and 2910.0 No./ha respectively while the figures for open access and exclosure of Wukro were about 1663.3 and 3058.0 No./ha respectively (Table 4 and 5).

Table 6: List of woody species recorded at Wukro study site with their respective densities and frequencies, northeastern Ethiopia.

Names of species	Open access areas		Exclosures	
	Density(No./ha) ±SE	Frequency[a]	Density(No./ha) ±SE	Frequency[a]
A. etbaica	1121.7±307.0	100.0	937.3±167.0	100.0
A. saligna[b]			36.7±18.1	33.0
C. edulis			16.7±12.4	13.0
D. angustifolia			1.7±1.7	6.7
Dikindik[c]			13.3±13.3	6.7
E. cymosa			6.7±5.0	5.0
E. schimperi	35.0±31.5	13.3	21.7±8.0	40.0
Eucalyptus sp.[b]			28.3±28.3	20.0
Hereg[c]			5.0±5.0	6.7
J. abyssinicum	3.3±2.3		8.3±6.8	13.3
L. abyssinica	493±233	53.3	1578.3±336	86.7
M. senegalensis			21.7±13.1	20.0
M. undata			11.7±11.7	6.7
Mebta'i[c]			3.3±2.3	13.3
Meseguh[c]			36.7±26.8	13.3
O. europeae			1.7±1.7	6.7
O. spinosa			133.3±63.9	53.3
R. glutinosa			106.7±106.7	13.3
R. vulgaris	3.3±2.3		185.0±159.0	46.7
S. singueana	6.7±3.8	33.3	66.7±32.1	53.3
Shoha[c]			8.3±8.3	6.0

a = Proportion of quadrate (%) in which species was found, c = unidentified woody plants, b = planted woody plants

Population structures of *C. gharaf*, *B. aegyptiaca*, *and A. tortilis* at open access areas of Aba'ala and of *A. etbaica* at exclosures and open access areas of both Aba'ala and Wukro were presented in Figure 5 and 6. *Z. spina-christi* was encountered only twice and therefore its population structure has not been included. In open access areas *A. etbaica, C. gharaf* and *A. tortilis* exhibit inverse J-shaped size class distributions (SCD) while the SCD of *B. aegyptiaca* is almost flat. In exclosure of Wukro and partial exclosure of Aba'ala, *A. etbaica* exhibits a hampered type of population structure and has low numbers of individuals in the lower diameter classes. Population structure of key woody species revealed a decrease at higher diameter classes especially at open access areas of both Aba'ala and Wukro.

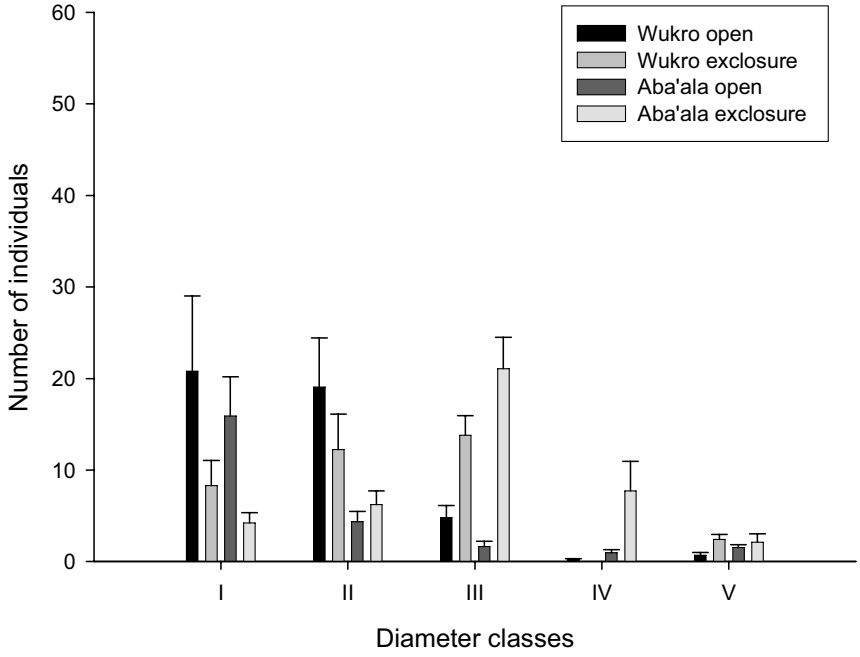

Figure 5: Population structure of *A. etbaica* in open access areas and exclosures of Aba'ala and Wukro, northeastern Ethiopia. The diameter classes (DC) are; DCI = dbh < 2.5cm Height (H) <50cm, DCII = dbh < 2.5cm and H = 50cm-130cm, the rest are all with H greater than 130cm and DCIII = dbh 2.5-7cm, DCIV = dbh 7-12.5cm, DCV = dbh > 12.5cm.

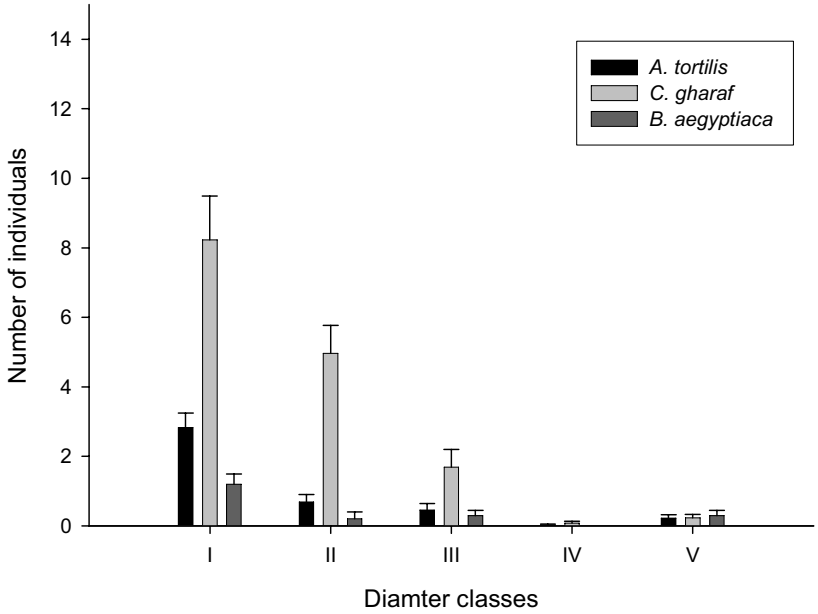

Figure 6: Population structure of *A. tortilis*, *C. gharaf* and *B. aegyptiaca* in open access areas of Aba'ala, northeastern Ethiopia. The diameter classes (DC) are; DCI = dbh < 2.5cm Height

(H)<50cm, DCII = dbh < 2.5cm and H = 50cm-130cm, the rest are all with H greater than 130cm and DCIII = dbh between 2.5-7cm, DCIV = dbh 7-12.5cm, DCV = dbh > 12.5cm.

Height based age class distribution of *C. gharaf, B. aegyptiaca* and *A. tortilis* at open access areas of Aba'ala and of *A. etbaica* at both Aba'ala and Wukro also suggested that mature trees of greater than 1.3m were represented in smaller proportion in open access areas (Figure 7and 8).

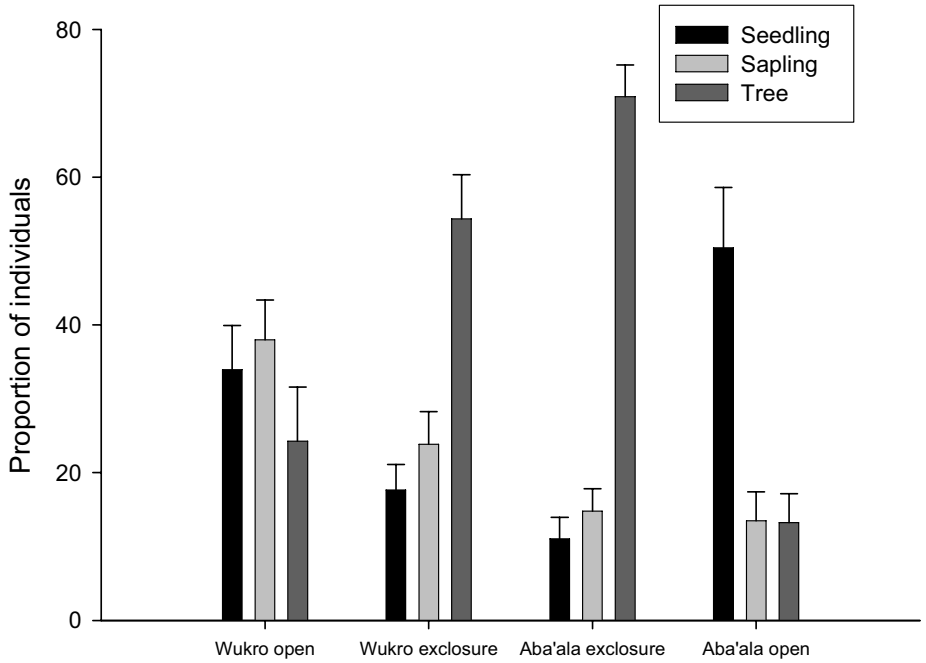

Figure 7: The proportion of different height based age classes of *A. etbaica* in open access areas and exclosures of Aba'ala and Wukro, northeastern Ethiopia: seedling (H < 50cm and dbh < 2.5cm), Sapling (H < 130cm and dbh < 2.5cm) and Tree (H > 130cm and dbh > 2.5cm).

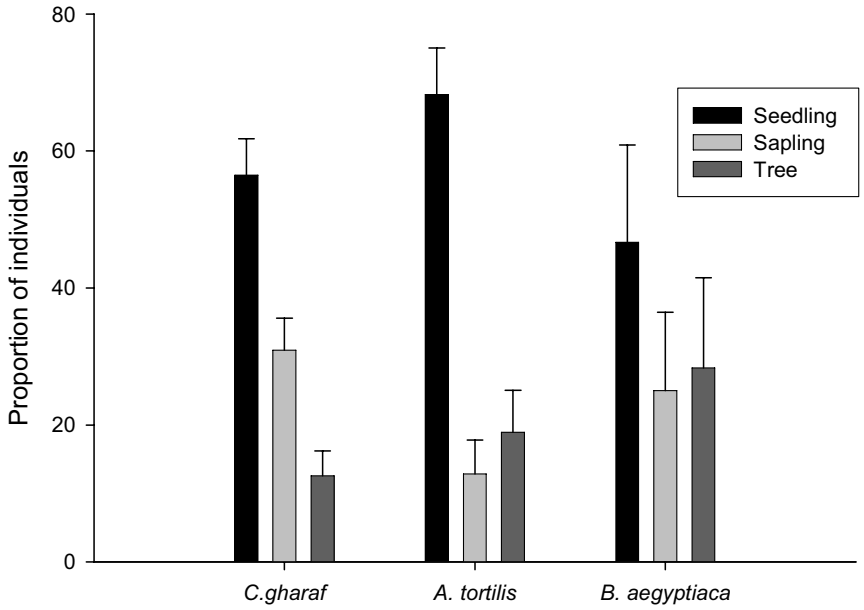

Figure 8: The proportion of different height based age classes of *C. gharaf, A. tortilis, and B. aegyptiaca* in open access areas of Aba'ala, northeastern Ethiopia: seedling (H < 50cm and dbh < 2.5cm), Sapling (H < 130cm and dbh < 2.5cm) and Tree (H > 130cm and dbh > 2.5cm).

A. etbaica is the only woody species common to all study sites and accounts for 22%, 33.2%, of woody plants density at open access areas and partial exclosure of Aba'ala and 28.6% and 67.4% at open access areas and exclosure of Wukro respectively. The mean covers of *A. etbaica* at open access areas and exclosure of Wukro were about 2675.0 and 1505.0 m^2/ha while the figures for open access areas and partial exclosure of Aba'ala were 443.0 and 3966.0 m^2/ha. With exception of exclosure at Wukro, *A. etbaica* is highest density woody species for rest of land use type at both Aba'ala and Wukro.

Generally, compared to open access areas exclosures had significantly higher cover of *A. etbaica* (F = 60.83, P = 0.000, DF = 2) but there was no difference between open access areas and exclosures in total densities of *A. etbaica* (F = 2.07, P = 0.135, DF = 2). Site has a significant effect on both cover (F = 10.13, P = 0.002, DF = 1) and density of *A. etbaica* (F = 6.29, P = 0.015, DF = 1). When seedling, sapling and tree densities were separately considered, generally exclosures had significantly higher tree densities while exclosures did not differ from open access areas in seedling densities (Table 7).

Table 7: The effect of exclosures compared to open access areas on densities (± SE) of different height based age classes of *A. etbaica* in Aba'ala and Wukro, northeastern Ethiopia.

site	Size classes	Land use type		t-value	H-value	DF	P
		Open access areas	Exclosures				
Wukro	Seedling	492 ± 194[a]	198 ± 60 [a]	-1.32		26	0.199
	Sapling	500 ± 146 [a]	304 ± 100 [a]	-1.10		26	0.281
	Tree	129 ± 32 [a]	420 ± 52[b]	4.75		26	< 0.000
Aba'ala	Seedling	300 ± 86 [a]	92 ± 24 [a]		1.17	1	0.279
	Sapling	74 ± 27 [a]	140 ± 35 [b]		4.48	1	0.034
	Tree	79 ± 24 [a]	722 ± 101 [b]		23.36	1	<0.000

NB. Values denoted with same letter did not differ significantly

4. Discussion

4.1. Use of woody species

Livestock production, especially of camels and goats, in the form of pastoralism is the main production systems in Aba'ala (Diress *et al*., 1999). In line with the production system, there is high dependency on woody species as the primary source of fodder. More than 90% of woody species mentioned during interview were used as livestock fodder. Locally, woody species are highly ranked fodder plants because of their availability in times of scarcity. In a related study conducted in central Ethiopia, more than 85% of Afar and Oromo pastoralists interviewed indicated browse species as their primary source of fodder (Abule *et al*., 2005) while 85% of woody species in semi-arid Borana rangeland had a forage value (Tefera *et al*., 2007). Elsewhere, woody species were found to account for 72% of livestock fodder in a study conducted in northwestern Namibia (Eisold *et al*., 2006)

More than half of woody species mentioned during interview were used as medicinal plants. Traditional medicine is the primary source of health in Ethiopia and over 80% of the populations still rely on traditional medicines for their health care needs (Abebe, 1996). Ethiopian pastoralists are highly dependent on traditional medicines as most of Ethiopian lowlands has been isolated from mainstream national development (Diress *et al*., 1999) and hence have a sparse coverage of health centers (Gamedo-Dalle *et al*., 2005). Respondents were hesitant to indicate medicinal plants for a number of reasons. The main ones being the interest to keep medicinal knowledge as a family secret, because of the belief which attaches the effectiveness of medicinal plants to the specific individual supposedly entitled to cut and prepare

the plant parts used and also because fear of misuse. Related studies on indigenous rural people found medicinal value to be largest plant use categories (Coe and Anderson, 1999; Rossato *et al*., 1999). However, in the current and another similar study conducted in southern Ethiopia (Gamedo-Dalle *et al*., 2005), medicinal value was the second most important category next to fodder.

Of all reportedly used woody plants, 44% were used as wild foods. Members of Tiliaceae, Salvadoraceae Balanitaceae and Burseraceae families were highly preferred for their food value. The Tiliaceae family was also found as the most important family containing edible woody species (Zemede and Tadesse, 2001; Gamedo-Dalle *et al*., 2005). Gamedo-Dalle *et al*., (2005) found the 13% of the woody plants encountered in Borana lowland was edible. The national estimate of edible higher plants is about 8% (Zemede and Tadesse, 2001). The higher proportion of woody species used as wild foods in the current study is the reflection of the important role of wild foods in the livelihood of local community in Aba'ala. Providing variety to the rather monotonous diets of people in drylands of Africa, wild foods increase vitamin intake of the rural poor and contribute to the improvement of their health (Becker, 1983; Jack, 1994; Lykke *et al*., 2004; Diress *et al*., 2007). A previous study in Aba'ala has reported use of fruits of *D. glabra* during drought periods and its potential role in food security (Diress *et al*., 2007).

A total of 37 woody species were used for firewood and construction purposes. Afar pastoralists solely depend on woody species as source of energy and to build local houses. Traditionally the use of charcoal was unknown to Afar pastoralists as they collect only dead wood for firewood and live in portable houses, 'senan eri' made of mainly grass thatches and *C. purpurea*. With increasing sedenterization, a more permanent local house, 'Genjeba', which needs durable woods, has been adopted. One respondent recalls that, as late as 1990's permanent houses were very rare. *A. etbaica*, *A. tortilis*, *A. nilotica*, *M. kummel* and *B. aegyptiaca*, which all have hard woods and are relatively resistant to termites, were preferred for firewood and construction purpose. Shortages of preferred species had forced local people to be less selective and even use aloe (non-woody species) and dried cow dung for cooking purpose. Related studies in Africa also found that shortage of preferred firewood plants has made rural people less selective and they use any firewood available in the village surroundings with the exception of those protected by traditional taboos (Lykke, 2000; Kristensen and Balslev, 2003).

Twenty-six woody species from 13 different families were used for cultural and hygienic purposes. Roots and branches of *S. persica* are highly preferred for tooth brushing and women use smokes of *T. brownii* for cleansing themselves and their clothes. Living in unpredictable environment with long dry seasons, woody plants are key resources for continued existence of people and livestock in drylands of Africa (Lykke, 1998; Lykke *et al*., 2004; Gamedo-Dalle *et al*., 2005; Eisold *et al*., 2006; Diress *et al*., 2007). The current study also confirmed the indispensable role of woody plants in the livelihood of local people in the study area.

4.2. Trend of woody species population

In the current study more than 70% of interviewees perceive that most of woody plants in their surrounding have declined both in abundance and distribution. Respondents recall that until some decades ago, woody species were relatively dense, wild fruits were abundant and there was enough dead wood to spare them from felling live trees for firewood purpose. All the major use groups (fodder, food, firewood and construction and medicine) were significantly correlated with woody species perceived to be declining. Highly preferred, multi-purpose woody species such as *G. tenax*, *A. etbaica, B. rotundifolia*, *Z. spina-christi*, *A. tortilis*, *A. nilotica* and *C. gharaf* were among woody species reported to have declined. Intensive uses of multipurpose woody species by local people have caused the decline in such species abundance and can potentially lead to local extinctions. Previous studies have attributed over exploitations to the decline of multipurpose woody species (Lykke, 2000; Gamedo-Dalle *et al*., 2005; Tabuti, 2007).

Local people consider frequent drought, decline in rainfall and logging as major causes for decline of woody species. Perception of local people was corroborated by a previous study in which aerial photos of Aba'ala of 1964 and 1994 were compared (Diress *et al*., 1999). The same study found a significant increase in cultivated land, settlement and bare grounds and a decline in vegetation cover from 87.88 to 75.52% (Diress *et al*., 1999). Similar to the view of respondents, the study ascribed clearance of natural vegetation for cultivation purpose as a cause for the decrease in vegetation cover (Diress *et al*., 1999). However, earlier study on three decade rainfall measurement of northern Ethiopia did not show any downward trend in the amount of rainfall (Hausken, 2004). Interestingly, quite few interviewees mentioned over-browsing as a cause for decline of woody species. This could be part of generally tendency of African people to ascribe vegetation change to climate minimizing the direct impact of human and livestock (Lykke, 2000).

4.3. Species composition and population structure of key woody species

The comparison made between exclosure and open access areas suggested that exclosure are higher in species composition, diversity, and density of woody species. Related studies conducted in exclosures of northern Ethiopia have reported similar results implying rehabilitation of degraded areas (Kindeya, 1997; Emiru, 2002; Kidane, 2002; Mengistu *et al*., 2005). Compared to previous study at Wukro in which 39 woody species were reported (Emiru, 2002), the current study recorded only 21 woody species implying decline of woody species at both exclosure and open access areas. The decline in number of woody species in open access areas of Wukro was apparently because of unabated human and animal interference since the last study was conducted. In the previous study, exclosure at Wukro was in active succession expressed in higher proportion of shrubs which raised total number of woody species (Emiru, 2002). Numerous shrubs reported in exclosure of Wukro previously (Emiru, 2002) have been replaced by fewer dominant woody species.

Population structures provide an insight into the availability and survival of woody species of concern and could be used to study the regeneration pattern of species (Lykke, 1998; Omeja *et al*., 2004). Analysis of population structures of *A. tortlis*, *A. etbaica* and *C. gharaf* at open access areas revealed larger number of individuals at lower diameter classes conforming to more or less inverse J-shaped size class distribution. However, population structure of *A. etbaica*, *A. tortlis* and *C. gharaf* in open access areas have been affected by selective logging of trees and all show extremely few individuals in larger diameter classes. Height based age class distribution of *A. etbaica*, *A. tortlis* and *C. gharaf* in open access areas also corroborate SCD and show lesser proportion of mature trees. Lower proportions of mature trees in open access areas were mainly because of selective logging of mature trees for different purposes hampering development to higher diameter classes. Although population structure of species *A. etbaica*, *A. tortlis* and *C. gharaf* imply absence of regeneration problem, continuous replacement of woody species could be hampered due to shortage of mature trees to replenish soil seed bank. In a related study conducted in acacia woodlands of Ethiopian rift valley, low densities of mature trees of woody species have been attributed for the poor representation respective species in the soil seed bank (Mekuria *et al*., 1999).

A. etbaica has a bell shaped type of population structure in exclosures with a higher frequency at middle class diameters. Related studies which studied population structure of

woody plants in northern Ethiopia reported an inverted J-shaped structure of *A. etbaica* in protected areas with higher proportion of lower diameter classes (Emiru, 2002; Mengistu *et al*, 2005). Effect of protection varies depending on vegetation type, status at the beginning of protection and duration of protection (Asefa *et al*., 2003; Oba, 2006; Yayneshet, 2008). The current bell shaped population structure of *A. etbaica* could be the reflection of normal successional trend in which lower diameter classes develop to higher diameter classes while seedling recruitment is minimized because of increasing intra- and inter-specific competition. Related studies have indicated failure of acacia sp. to regenerate under parent canopies and negative effect of perennial grasses which often colonize exclosures on seedling recruitment of *A. etbaica* (Mwalyosi, 1990; Masresha, 2003).

Less number of individuals in the lower size classes and missing individuals in higher classes of *B. aegyptiaca* are indications of absence of recent recruitment and selective logging by local people respectively. *Z. spina-christi* was also poorly represented in the regeneration as evidenced by its low density and could not even be included in population structure analysis. Because of low density of mature trees, both *B. aegyptiaca* and *Z. spina-christi* may have failed to produce enough seeds for regeneration which might explain their poor representation. Corroborating the field data, both *B. aegyptiaca* and *Z. spina-chisristi* have been perceived as declining woody species by majority of interviewees. Hence, it is necessary to prevent cutting of seed producing large trees and also to set mechanisms to regulate grazing or browsing pressure. Besides enhanced protection from unmanaged logging, *B. aegyptiaca* and *Z. spina-chisristi* may need intervention through artificial regeneration to improve their density and regeneration capacity.

In the current study, *A. etbaica* was the highest density woody species in both open access areas and exclosures. In related studies conducted in exclosures of northern Ethiopia, higher composition of *A. etbaica* in both exclosure and adjacent open access area had been reported (Emiru, 2002; Asefa *et al*., 2003; Mengistu *et al*., 2005). Coupled with its wide occurrence in ranges of environment and altitudes that extend from 1200 to 2000 m, the greater composition of *A. etbaica* in different land uses suggested that the species is highly tolerant to overuse and could serve as an important candidate for restoration (Masresha, 2003).

Higher proportion of mature tree of *A. etbaica* was recorded in exclosures compared to open access areas. Similar results had been reported in related studies (Emiru, 2002; Mengistu *et al*., 2005) and lower proportion of mature trees in open access areas were mainly due to the high level of interference in the form of selective logging. Poles of *A. etbaica* are widely used to make the pillars and beams of earthen houses in the study sites (Appendix 2). Elsewhere also studies have shown that uncontrolled logging usually destroys mature trees (Whitemore and Sayer, 1992; Chapman and Chapman, 1997) and could also interrupt the continuous replacement of woody species (Mastewal *et al*., 2006).

Previous studies conducted in exclosures of northern Ethiopia reported higher seedling densities of *A. etbaica* in exclosures compared to open access areas (Emiru, 2002; Mengistu *et al*., 2005). In the current study, there was no difference in seedling density between exclosures and open access areas. *A. etbaica*, as a pioneer species, is expected to dominate disturbed sites taking advantage of primary succession (Denslow, 1987). With colonization of exclosures by other species, inter- and intra- specific competitions increases affecting seedling recruitment of *A. etbaica* in exclosure areas. Related study had shown that perennial grass species, *Hyparrenia hirta,* which commonly colonize protected areas, out-compete seedlings of *A. etbaica* affecting their survival (Masresha, 2003). Regeneration of acacia sp. does not occur underneath the parent canopy (Mwalyosi, 1990). Higher cover of *A. etbaica* observed in exclosures may have partly responsible for lower proportion of seedlings in exclosures. Moreover, Mekruia *et al*. (1999) have indicated that seeds of legume require pre-sowing treatment to enhance germination. Seeds that have passed through digestive tracts of ruminants are said to germinate well without pretreatment. While seeds of *A. etbaica* in open access areas could get pre sowing treatment in the form of livestock ingestion, absence of livestock interference in exclosure inhibits this possibility and might have contributed to the lower seedling density observed in exclosure.

Results of the present study indicated that local people in the study area have closely witnessed vegetation change and they are reliable sources of management relevant information on plant use and dynamics of woody plants Perception of local with regard to declining trend of multipurpose woody species was corroborated by field data. Both SCD and height based class distribution of key woody species in open access areas indicated abnormalities either in the form of flat SCD distribution or extremely few numbers of mature trees implying declining population size. Locals also extended their wish for better management to divert declining trend of woody

species population and maintain tree species diversity. Moreover, empirical evidences generated by the current study show the potential role of exclosures in rehabilitation of degraded lands. However, results imply that extended protection could affect seedling recruitment of species if these species depend on interference for regeneration. Hence there is a need to make intensity and length of exclusion of perturbations area specific depending on the goal of exclosure and target woody plants of concern.

In light of growing population, increasing tendency towards agro-pastoral production system and government policy which favors settlement, the potential of multipurpose woody species in mixed farming is high and efforts to conserve them should be prioritized. The current study provides a list of multipurpose yet declining indigenous woody species. Prior to selection of these woody species for promotion of natural regeneration, reforestation or other forms of multiplication, further studies on their seed ecology (soil seed bank, seed dispersal, predation, germination, establishment and growth), appropriate silvicultural and management options and relevance and role of traditional institutions in current context in woodland reclamation need to be conducted.

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Appendix 1

Woody plant species used by Afar Pastoralists (n = 60) of northeastern Ethiopia and their perception on their ecological status. The list includes five use and three ecological status categories and the number of reports in each. Local Afar names and indication of total number of uses also included.

		Use group					Population trend		
Local names	Species name	Fodder	Edible	Construction and firewood	Medicine	Others	Increased	Decreased	Not changed
Adaito	*Salvadora persica* L.	23	20		9			14	16
Adihara	*Nicotiana glauca* Graham	2						1	1
Adlayto	NI	3							3
Adohadita	Commiphora sp.	19	1	7	3	21		25	4
Aebto	*Acacia tortilis* (Forssk.) Hayne	11		35	3			10	2
Afaramole	*Eleusine africana* Kenn.-O'Byrne	3						2	
Alaito	*Balanites rotundifolia* (Tiegh.) Blatt.	6	13	1	27	2		17	8
Alengalita	*Cadaba rotundifolia* Forssk.	23			7			9	6
As'era	*Dracaena ombet* Heuglin ex Kotschy & Peyr.		1	1		18		7	2
Asowta	*Enneapogon persicus* Boiss.	4						3	1
Atemeta	*Rhus natalensis* auct.	15	5	1	1	2		16	4
Atoori	NI	5			1			4	2
Aydeerayto	NI	3		5		1		8	
Boboita	NI	18	1	1	1	1		15	4
Bukesita	*Dichrostachys cinerea* (L.) Wight &Arn	6			1			1	2
Denenoita	*Boscia coriaceae* Pax	7		1	20	13		15	1
Dethara	*Euclea schimperi* (A.DC.) Dandy	8	1	1	4	4		9	5
Dewaito	*Grewia bicolor* Juss.	16	12	4				18	3
Ditita	*Grewia ferruginea* Hochst. ex A.Rich.	32	34	5	4		1	17	18

NI: Not identified (Others: woody plants used for hygiene, perfuming, handicrafts and cultural purposes)

Appendix 1: Continued

Local names	Species name	Use group					Population trend		
		Fodder	Edible	Construction and firewood	Medicine	Others	Increased	Decreased	Not changed
Dokhoita	*Combretum molle* R. Br. ex G. Don	7		1				3	5
Durfuta	*Eragrostis papposa* (Roem. & Schult.) Steud.	10						9	1
Ergermarto	*Seddera latifolia* Hochst. & Steud.	3			1				1
Gabita	*Adansonia digitata* L.	2	3					3	1
Gaboita	*Coccinia grandis* (L.) Voigt.	13	8					8	7
Germoita	*Acacia nubica* Benth.	18		2	6		3	8	10
Gersa	*Dobera glabra* (Forssk.) Poir	25	29	2	3			17	17
Gessalto	*Acacia nilotica* (L.) Willd. ex Delile	14	1	32	5	1		27	4
Hamayto	*Delonix elata* (L.)Gamble	3						1	2
Herugayto	NI	27						7	19
Heyukayto	NI	3			4			5	
Hibukto	*Tarchonanthus camphoratus* L.	2				1			2
Hidaito	*Grewia tenax* (Forssk) Fiori	42	43	6		1		34	14
Hidalisaito	*Lycium shawii* Roem. & Schult.	6	1		2			2	6
Hina (Galela)	*Indigofera coerulea* Roxb.				2			2	
Hivellita	*Grewia villosa* Willd.	31	32	3	3	2		25	14
Humurto	NI	1	7	1	2			5	3
Kaatoyta	NI	9	8	4	1			13	1
Korahi	NI		9					4	3
Kubriita	Commiphora sp.	7	2		1	5	2	10	1
Kusraito	*Ziziphus spina-christi* (L.) Desf.	15	32	18	9	2		13	1
Kutgeera	*Achyranthes aspera* L.	2			1				3

NI: Not identified (Others: woody plants used for hygiene, perfuming, handicrafts and cultural purposes)

Appendix 1: Continued

Local names	Species name	Use group					Population trend		
		Fodder	Edible	Construction and firewood	Medicine	Others	Increased	Decreased	Not changed
Leimaderto	*Cordia ovalis* R.Br. ex A.DC.	4	2		1			3	1
Madera	*Cordia gharaf* (Forssk.)Ehrenb. Ex Asch.	24	38	7		3		24	3
Melalebus	NI	3	1					2	1
Merkaito	*Acacia mellifera* (Vahl) Benth.	31		9	7	7		22	11
Mududeyta	NI	11						9	2
Nuhubto	NI	4		1	1	5		7	1
Numhila	*Cadaba farinosa* Forssk.	6	2	1				5	2
Oodaito	*Balanites aegyptiaca* (L.) Delile.	7	18	19	16	15		12	
Oylaayto	*Aerva javanica* (Burm. F.) Juss. ex Schult.	3		1	4			4	2
Sareiabo	*Terminalia brownii* Fresen.	4			3	20		10	2
Sekakto	*Acacia etbaica* Schweinf	14	2	39		2		17	1
Serakita	*Grewia kakothamnos* K.Schum.	33	13	3				30	9
Silien	*Cadia purpurea* (G. Piccioli) Aiton			6				6	
Sinklilisie	*Maerua angolensis* DC.	12		2				10	2
Solhis	NI				2				1
Sublayto	*Ficus sycomorus* L.	5	3			4		6	1
Sukuhto	*Acacia asak* (Forssk.) Willd.	11						8	3
Tekeble	*Acacia senegal* (L.) Willd.	14		1	2	1	1	10	3
Terarita	Commiphora sp..	2	9			1		8	2
Ubukto	NI	12		2				7	7
Udkahara	NI	2			3			1	3
Urufli	NI	8						3	5
Wegarto	*Olea europaea* - L.	13		4	3	22		17	2
Yaluito	*Mimusopi kummel*	28	29	20	4	22		35	7
Yamaru	*Blepharis edulis* Pers.	5						1	4

NI: Not identified (Others: woody plants used for hygiene, perfuming, handicrafts and cultural purposes)

Appendix 2: Pictures from the study area

Figure 9: Fruits of *C. gharaf* on the plains of Aba'ala, northeastern Ethiopia.

Figure 10: Pillars made of *A. etbaica* inside 'Genjaba', a common local house in Aba'ala, northeastern Ethiopia.

Figure 11: Traditional hair style of Afar youths using leaves of *Z. spina-christi,* Aba'ala, northeastern Ethiopia.


Figure 12: Bottomlands, Aba'ala, previously famous for their *C. gharaf* cover now degraded and here seen invaded with forbs, Aba'ala, northeastern Ethiopia.

Picture 13: Previous woodlands have been cleared to expand farmlands, Aba'ala, northeastern Ethiopia.