Diversity and Population Structure of Woody Species Browsed by Elephants in
Babile Elephant Sanctuary, eastern Ethiopia: an implication for conservation

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Abstract:

Babile Elephant Sanctuary (BES), in the semi-arid part of eastern Ethiopia, has long been known for comprising one of the globally threatened, ecologically isolated and possibly distinctive subsp. of elephant population (*Loxodonta africana orleansi*). Study on plant species diversity and population structure of woody species browsed by elephants in wet and dry seasons was conducted. A total of 75 quadrats, each 20 x 20 m, were laid out to make the inventory and 24 plant species composed of 16 genera and 13 families were identified. Out of these, trees and shrubs were represented by 50% each. Total density of the 24 woody species was 11,559 individuals ha^{-1}, with a mean density of 481.6 ± 282.5 (S.E.). The density of trees was 492 individuals ha^{-1} (4.3%) while that of shrubs was 11,066 individuals (95.7%). Total density of seedling and sapling was 3,377 individuals ha^{-1} (5.5% for trees and 94.5% for shrubs). The population structure of shrubs exhibited inverted J-shaped structure whereas trees exhibited inverted J-shaped, broken inverted J-shaped, U-shaped, bell-shaped and broken bell-shaped frequency distributions. These effects are highly associated with human-induced disturbances, due to population pressure. The result indicates that BES needs immediate rehabilitation measure in order to ensure the continuous survival of this, probably, distinctive elephant population.

Keywords: - *African elephant, Babile Elephant Sanctuary, rehabilitation, population structure, regeneration,*

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Introduction

Establishment of protected areas is vital for *in situ* conservation of diverse native species. These activities are undertaken for the purpose of education, research, and recreation. Moreover, these areas provide such essential items as fuelwood, building materials, forage, traditional medicines and wild foods. Up to now, no area has been formally protected in the country to conserve an ecosystem or habitat important for plant species although Ethiopia is known for its high diversity of plant species (Tadesse Weldemariam, 2003). Protected areas cover approximately 16.4% of the country's surface area (UNEP, 2003). There are 20 national parks, 3 sanctuaries, 2 wildlife reserves and 17 controlled hunting areas, 7 open hunting areas and 3 community conservation areas covering an area of about 65,531.4 km^2 (http://www.ewca.gov.et, accessed May 2011). However, except few, most of the protected areas exist on paper only and have declined in size and quality.

Babile Elephant Sanctuary (BES) is one of the protected areas in the semi-arid region of eastern Ethiopia, which has highly declined in size and quality. The sanctuary was established to protect the only known population of the isolated and ecologically distinct subspecies *Loxodonta africana orleansi* (Barnest *et al*., 1999). However, the home range of the elephants has shrunk by about 65.5% since 1976 due to mass influx of a large number of farmers and their domestic stocks from the east and north (Yirmed Demeke *et al*., 2006).

Although it has been designated as the largest sanctuary (6,984 km^2) in the country, there was no systematic ecological study conducted since its establishment. Moreover, even if the African elephants are known to be generalist and mega-herbivores (Wittemyer *et al.*, 2007), there is lack of information on the type of plant species browsed by elephants in the BES. As stated by Osborn (2004), even though elephants are considered to be unspecialized herbivores, they are often extremely selective in their food choice depending on availability, palatability and nutritional quality of forage materials. In addition, crops cultivated near protected areas are attractive to elephants as an alternative source of food, which has a potential to create humans-elephants conflict (Yirmed Demeke, 2008), and this is the major challenge in the BES (Anteneh Belayneh, 2006).

This study was carried out in the Erer Valley, which is the largest part of the Babile Elephant Sanctuary. This valley is the most extensive part of the sanctuary where it is currently subject to increasing settlement pressure. Both the human and livestock population have increased dramatically (Anteneh Belayneh, 2006). The Erer Valley, including Erer 'Guda' and Erer 'Xiqa' Valleys, had the densest vegetation stand in the entire sanctuary (Stephenson, 1976). Since the Erer Valley is a borderline between the eastern Hararge highlands to the west and the Ogaden lowlands to the south and east, conservation of such an area may prevent

the current rapid desertification process in the area. Moreover, it supports the Babile Elephant Sanctuary, which is the natural home for possibly endemic and highly endangered elephant subspecies known as *L. africana orleansi* (Barnest *et al.,* 1999).

Therefore, the objectives of this study were to: i) identify and document the woody plant species browsed by elephants; ii) analyze their density, population structure and regeneration status; and iii) identify the major anthropogenic factors that affect the sanctuary and recommend possible conservation measures.

Materials and Methods

Description of study area

Babile Elephant Sanctuary (BES), in the eastern lowlands of Ethiopia, is part of the Somali-Masai centre of endemism (Barnest *et al.*, 1999). The underlying rocks are mainly marine in origin and soils are characterized by cambisols, luvisols, nitosols, orthic solonchakes, fluvisols, vertisols and xerosols (Mohr, 1964). The sanctuary is situated at the semi-arid trans-boundary of Oromia and Somali Regions, at about 560 km from Addis Ababa. It is delimited with coordinates of latitudes $08^{o}22'30''$ - $09^{o}00'30''$ N and longitudes $42^{o}01'10''$ - $43^{o}05'50''$ E and its elevations ranges between 850 and 1,785 m a.s.l. (Stephenson, 1976; Yirmed Demeke, 2008).

When the sanctuary was established in 1970, it covered an area of about 6,984 km2 (Stephenson, 1976; IUCN, 1990) between the Eastern Hararge high mountain i.e. Mt. Gara- Muleta to the west and the Ogaden Desert to the southeast. Four main drainage river valleys (Fafem, Daketa, Erer and Gobelle) rise from Garamuleta-Harar-Gursum Highlands and extend southwards through the sanctuary to join Wabi Shebelle River Basin (Fig. 1). The vegetation of the sanctuary was represented by Acacia-Commiphora woodland, semi-desert scrubland and evergreen scrub ecosystems (Stephenson, 1976). More recent data indicated that the riverine species in the upper Erer Valley are comprised of Acacia robusta Burch., Tamarindus indica L., Oncoba spinosa Forssk., Acokanthera schimperi (A. DC.) Schweinf. and Capparis tomentosa Lam. (Anteneh Belayneh, 2006).

The largest and currently the major vegetation cover in the sanctuary is that of the Erer Valley, where this study was conducted. The Erer Valley lies about 25 kms southeast of Harar town. The area is a semi-arid plain surrounded by a chain of rocky hills (EHPEDO, 2004). The total area of the valley is estimated at 1,500-2,000 km2.

The Sanctuary is prized for hosting species of interest like the African elephant, Black-manned lion, Leopard, Hamadryas baboon and Menelik's Bushbuck, the only endemic subspecies for the sanctuary. Based on a direct count, Yirmed Demeke et al. (2006) had reported the presence of about 324 elephants in the sanctuary with indications that the number could rise to 400.

Climate

The BES is generally characterized by semi-arid climatic condition. The mean annual temperature is about 19.6 0C, ranging from a mean minimum of 11.9 0C to mean maximum of 27.2 0C. There is only a slight difference in temperature throughout the year, with the hottest months in April to June (maximum 29 0C) and the coldest months during October to December (minimum 7.80C). The mean annual rainfall is 702.9 mm year-1, with high variation from year to year, ranging from 451.7 to 1,115.9 mm year-1. Rainfall is bimodal occurring from March to April (short rain season) and June to September (long rain season)
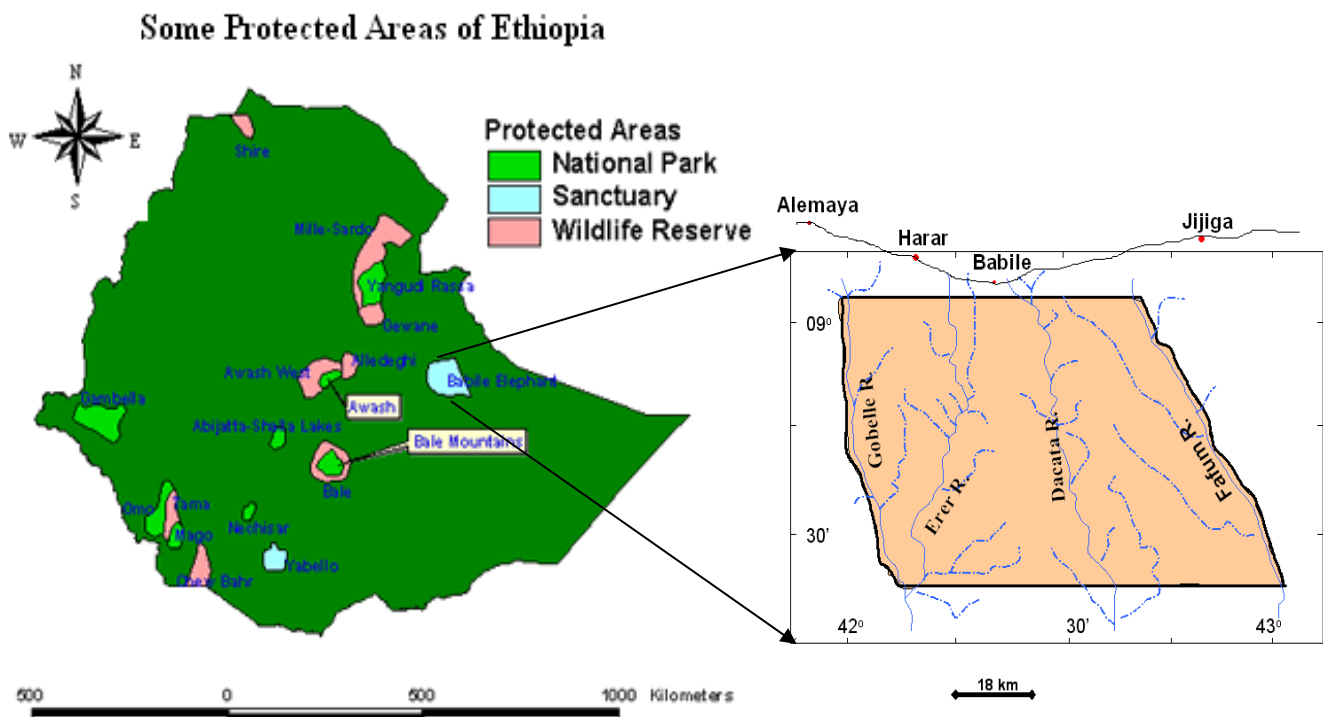(Source: National Meteorological Service Agency Data from 1965 to 2005).

Fig. 1. Map of the Babile Elephant Sanctuary (rivers & nearby towns) (source: http://www.ewca.gov.et, Yirmed Demeke, 2006, Anteneh belayneh, 2006)

September to October 2006 for the wet season feed preference and April to May 2007 for the dry season feed Preference. Participatory Rural Appraisal (PRA) technique and field observations were employed to gathering information on the woody species browsed by elephants. Elephant diet was studied by direct observations of elephants during feeding trials (Milewski and Madden, 2006),

indirectly by interviewing forty local residents and five sanctuary scouts. In addition, with the aid of binoculars, the tree species and the browsed plant parts were identified and recorded while elephants were browsing. After records were made, the plant was visited to verify the species and the browsed plant parts. A pre-tested and revised semi-structured questionnaire was administered in the local languages (Oromiffa and Somali language). Most of the interview was made in the field in order to avoid the risk of confusing the identity of plant species.

After the identification of plant species, which are browsed by elephants, data were collected for quantitative analysis on plot base. Since the study area has different formation types, stratified sampling design, as described by Krebs (1989) was used to collect data on vegetation. Twelve representative sites were selected by visual observation on the basis of homogeneity in floristic composition, and each site was sampled systematically. Among the selected sites, 5 were in the woodlands, 4 in the bushlands, and 3 in the riverine forest. A total of 75 sample plots were established which were proportionally distributed across the twelve representative sites by considering an estimated total size of each site. The size of the major plot for tree species was 20 x 20 m, as recommended by Kent and Coker (1992). In each sample plot, all tree species with diameter at breast height (DBH) $\geq$ 2.5 cm and height $\geq$ 1.5 m were recorded. With in the major plot of 400 m^2, five sub-plots of each 5 x 5 m (25

m^2) were set up. These plots were used to collect vegetation data of shrubs and climbers with diameter at stump height (DSH) $\geq$ 1.5 cm and height $\geq$ 0.5 m and the mean of these five subplots were used in the analysis.

Seedlings were recorded for analysis of regeneration status of trees within each 25 m^2 sub-plots. In this study all individuals with a height between 0.01 and 1 m were considered seedlings of trees, and both height and diameter measurements were taken (DBH< 2.5 cm and height < 1 m). Within each 25 m^2 sub-plots, five 1 x 1 m sub-plot was used to collect data on seedlings (below a height of 0.1 m) of shrubs and climbers.

The extent of external pressure on the sanctuary was assessed following a 5 point arbitrary scale of disturbance with a particular focus on agricultural activities, human settlement, logging, firewood and charcoal making, livestock browsing, fire and honey production where 5 is for highest threat, 4 for high, 3 for moderate, 2 for less and 1 for the least threat.

Plant species were recorded and voucher specimens of plant species were collected, pressed, dried, identified and deposited at the National Herbarium at Addis Ababa University, Ethiopia. The nomenclature of plant names in this study follows the published volumes of the Flora of Ethiopia and Eritrea (Hedberg & Edwards, 1989, 1995; Edwards *et al.*, 1995, 1997, 2000), and by comparing with authentic specimens at the National Herbarium.

Population structure, density, frequency and regeneration status of woody species browsed by elephants were analyzed using SPSS program version 12. Basal area (BA) was calculated by using the following formula.

$$BA = \Pi d^2 / 4 \text{ where } d \text{ is diameter at breast height}$$

Importance Value Index (IVI), i.e. the sum of relative dominance, density and frequency, of the woody species, which are browsed by elephants, was calculated following Kent and Coker (1992). IVI is useful to compare the ecological significance of species (Lamprecht, 1989).

Results and Discussion

Woody species browsed by elephants

A total of 24 woody species representing 13 families were identified as browsed by elephants. Out of these, 50% each were trees and shrubs. The total density of the 24 woody species was 11,560 individuals ha^{-1}. The mean density of the 24 woody species was 481.6 ± 282.5 (SE), with a range of densities between 6,842.7 (Opuntia ficus-indica) and 3.7 (Salvadora perisca) individuals ha-1. Shrubs accounted for 95.7% (11,067 individual ha-1) of the total population while trees had a share of only 4.3% (493 individuals ha-1). Elephants prefer the tree species for feed and spent most of the time in the woodlands and riverine forest. As stated by Barnes (1983), elephants preferentially utilized those trees that provide fruit (like, Balanites glabra, Balanites aegyptiaca, Berchemia discolour and Sclerocarya birrea and also spend most of the time under tree for shade (like, Acacia albida, Acacia robusta, Acacia tortilis (Coetzee et al., 1979). According to Kalemera (1989), plants shorter than 1m tend to be ignored. Other workers have found a preference of elephants for adult trees which may entail switching from stem and leaf browsing to bark stripping as height increases beyond 4 m (Barnes, 1983; Smallie and O'Connor, 2000). However, shrubs and climbers dominated the floristic composition of the sanctuary. The high pressure on the preferred browse trees may further lead to the decline in feed resources affecting survival of the elephants.

Basal area (BA) and Importance Value Indies (IVI) of woody species

The total basal area of the 24 woody species was 13.9 m^2 ha^{-1}. The highest proportion of mean basal area was accounted for *Acacia robusta* (7.01 m^2 ha^{-1}) followed by *Tamarindus indica* (2.46 m^2 ha^{-1}) and *Opuntia-ficus indica* (1.13 m^2 ha^{-1}) (Table 1).

Table 1. Important Value Indies (IVI) of the woody species at BES. (T = tree, Sh = shrub; Cl = climber)

Scientific name	Habit	Freq	Dens/ha	BA m²/ha	Rfre	Rden	Rdom	IVI
Acacia robusta Burch.	T	15	100.7	7.006	1.300	0.39	39.3	41.0
Opuntia stricta (Haworth) Haworth	Sh	57	3842.7	0.963	4.939	26.50	5.4	36.8
Tamarindus indica L.	T	5	15.7	2.462	0.433	0.06	13.8	14.3
Opuntia ficus-indica (L.) Miller	T	50	216.7	1.130	4.333	0.84	6.3	11.5
Acacia mellifera (Vahl) Benth.	Sh	50	1274.7	0.260	4.333	4.94	1.5	10.7
Acacia tortilis (Forssk.) Hayne	T	36	41.3	0.702	3.120	0.16	3.9	7.2
Balanites glabra Mildbr. & Schlecht.	T	33	33.7	0.369	2.860	0.13	2.1	5.1
Grewia ferruginea Hochst. ex A. Rich.	Sh	32	496.0	0.020	2.773	1.92	0.1	4.8
Kleinia squarrosa Cufod.	Sh	32	496.0	0.013	2.773	1.92	0.1	4.8
Balanites aegyptiaca (L.) Del.	T	28	31.0	0.262	2.426	0.12	1.5	4.0
Cryptostegia grandiflora Roxb. ex R. Br.	Sh	19	448.0	0.012	1.646	1.74	0.1	3.5
Grewia bicolour Juss.	Sh	20	410.7	0.015	1.733	1.59	0.1	3.4
Berchemia discolour (Klotzsch) Hemsl.	T	17	15.3	0.268	1.473	0.06	1.5	3.0
Dichrostachys cinerea (L.) Wight & Arn.	Sh	15	325.3	0.021	1.300	1.26	0.1	2.7
Acokanthera schimperi (A. DC.) Schweinf.	Sh	14	309.3	0.043	1.213	1.20	0.2	2.7
Acacia albida Del.	T	19	11.3	0.105	1.646	0.04	0.6	2.3
Acacia etbaica Schweinf.	T	10	7.7	0.072	0.867	0.03	0.4	1.3
Agave sisalana Perrine ex Engl.	Sh	6	122.7	0.038	0.520	0.48	0.2	1.2
Euclea racemosa Murr. ssp. *schimperi* A. DC.	Sh	4	154.7	0.001	0.347	0.60	0.0	1.0
Carissa spinarum L.	Sh	5	112.0	0.003	0.433	0.43	0.0	0.9
Oncoba spinosa Forssk.	T	5	7.0	0.073	0.433	0.03	0.4	0.9
Salvadora persica L.	T	5	3.7	0.038	0.433	0.01	0.2	0.7
Dodonoea angustifolia L. f.	Sh	4	74.7	0.003	0.347	0.29	0.0	0.7
Acacia nilotica (L.) Willd. ex Del.	T	5	8.7	0.020	0.433	0.03	0.1	0.6

Freq = Frequency; Dens = Density; Rfre = relative frequency; Rden = relative density, Rdom = relative dominance

These tree species alone accounted for about 76% of the total basal area of the 24 woody species browsed by elephants. *Acacia robusta, Acacia tortilis, Balanites glabra, Balanites aegyptiaca* and *Berchemia discolor* had the least relative densities. Even if the amount consumed was not assessed, these plants were considered as the top browsed species by elephants where most of the herds were observed to spend about 60% of the time out of the 16 feeding hours per day (Yirmed Demeke, 2008), and they are among the multipurpose woody species in the study area. Perhaps, it might be due to their relatively high dominance values in the sanctuary that they meet the high feed requirements of the elephants. However, if the current anthropogenic threat on these tree species continues, their density will decrease making it difficult to support the high feed demand of the resident elephants.

Trees and shrubs with IVI of more than 10 were *Acacia robusta, Opuntia stricta, Tamarindus indica, Opuntia ficus-indica* and *Acacia mellifera* (Table 1). These species can be considered as the most important species in the BES. Others, i.e. *Acacia tortilis, Balanites glabra, Grewia ferruginea, Balanites aegyptiaca* had relatively high IVI values, indicating their high ecological or importance value in the study area. Lower IVIs may indicate that the woody species are threatened and there is a need for immediate conservation measure(s).

According to the informant report, out of the ten top woody species browsed by elephants, *Acacia tortilis, Acacia nilotica, Acacia etbaica, Balanites aegyptiaca, Balanites glabra, Berchemia discolor, Oncoba spinosa, Salvadora persica* and *Tamarindus indica* accounted for only 1.4% of the total density, suggesting that they are highly threatened.

Population structure and regeneration status of woody species browsed by elephants

The population structure of shrubs exhibited an inverted J-shaped frequency distribution indicating healthy regeneration. The population structure of the tree species exhibited both healthy (Opuntia ficus-indica, Acacia tortilis and Acacia robust) and hampered regeneration (Acacia etbaica, Balanites glabra, Berchemia discolour, Oncoba spinosa, Salvadora persica, Tamarindus indica, Acacia nilotica, Balanites aegyptiaca and Acacia albida) (Fig. 2). The hampered regeneration may indicate selective removal/exploitation of the trees by the local people, poor regeneration and recruitment in the lower class and absence of regeneration at one particular time in the past.

Damage rates to vegetation can vary greatly by elephant density. Elephant densities of approximately 1 per km2 have been reported as causing damage of trees up to 4.7% (Anderson and Walker, 1974) and extensive damage up to 77.6% or more if elephant populations exceed 2 per km2 and

have localized concentrations (Mapaure and
Campbell, 2002; Jacobs and Biggs, 2002). The current elephant density in the BES is approximatly1 per 12 km2 in which the rate of damage could be less than 0.5%, and they do not have localized concentration (Yirmed Demeke et al., 2006; Yirmed Demeke, 2008) even if their home range look restricted to the Gobelle and Erer Valleys where their movement pattern have declined from Daketa and Fafum Valleys. Therefore, with this least density and no localized concentration in the sanctuary, the elephants may not be claimed as the major cause for the current destruction of the tree species.
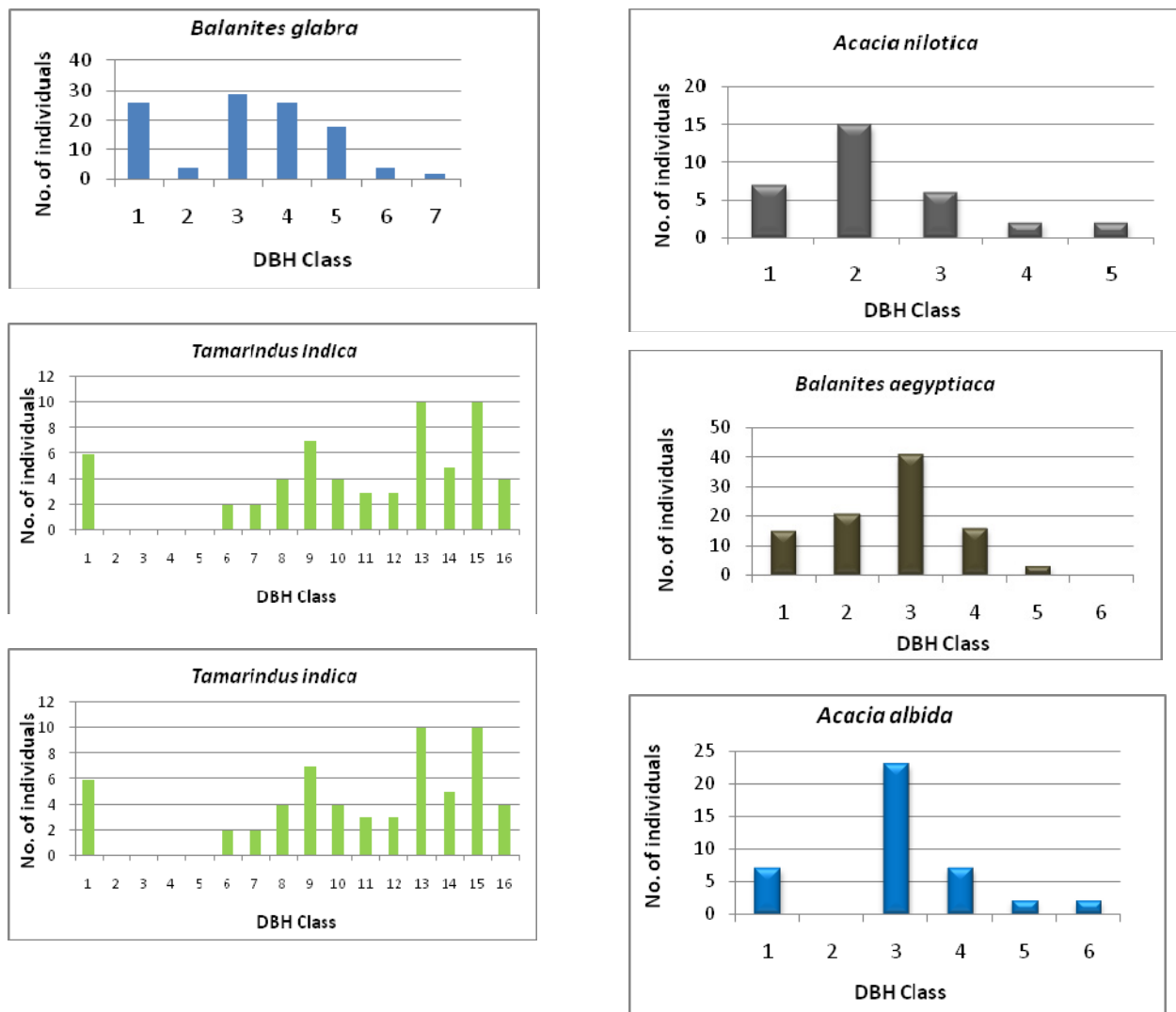

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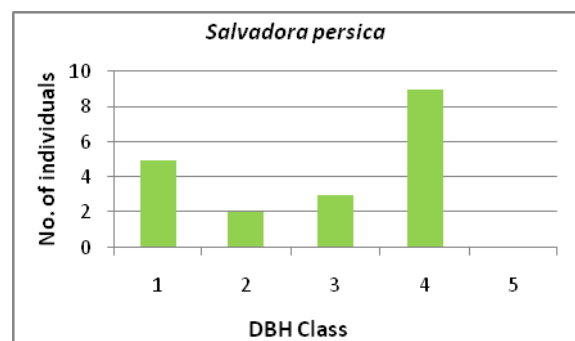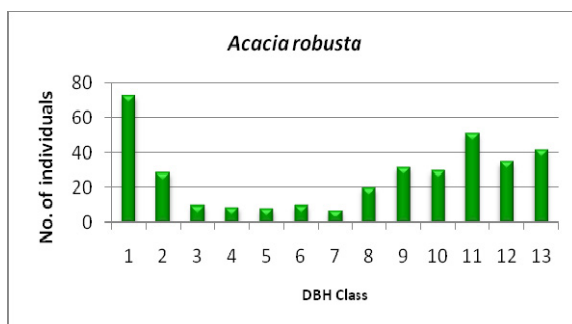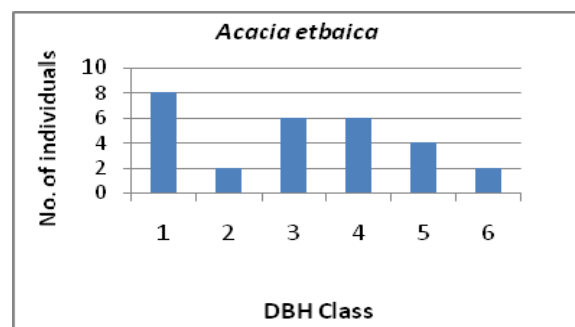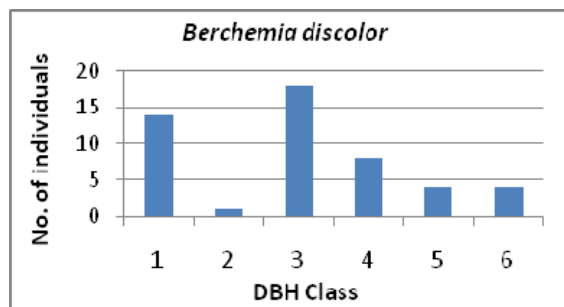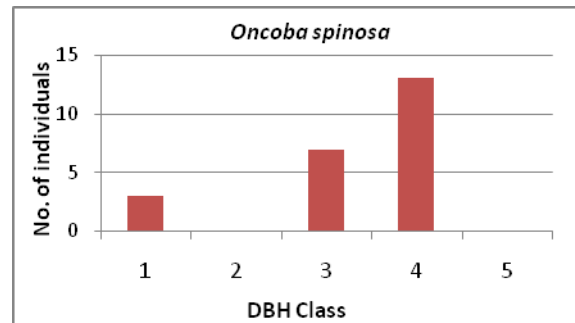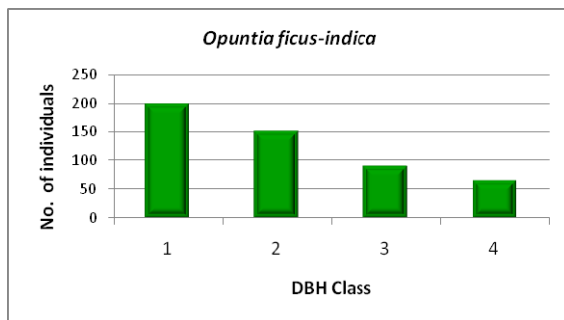
Fig. 2. Diameter class frequency distribution of tree species browsed by elephants (DBH class: 1 = 1-5(e) cm; 2 = 5(i)-10(e) cm, 3 = 10(i)-15(e) cm, 4 = 15(i)-20(e) cm, 5 = 20(i)-25(e) cm, 6 = 25(i)-30(e) cm, 7 = 30(i)-35(e) cm, 8 = 35(i)-40(e) cm, 9 = 40(i)-45(e) cm, 10 = 45(i)-50(e) cm…).

(i=inclusive; e= exclusive)

Rather there is a need to consider that most of these woody species are multipurpose and highly utilized by people in the study area. For example, *Acacia robusta* and *Tamarindus indica* had high IVI whereas, their population structure pattern indicated selective cutting and removal of medium-sized trees. Trees like *Acacia tortilis,*

Acacia etbaica, Berchemia discolour and Acacia nilotica had showed least number of individuals in their higher DBH class that might be due to more of anthropogenic impact rather that elephant destruction. According to Smallie and O'Connor (2000), very little destruction of vegetation was recorded by elephants in Venetia-Limpapo Natural Reserve in South Africa. Destruction of trees by elephants may occur sporadically, usually being a result of young bulls engaging in social displays

(Guy, 1976). In general, the population structure analysis showed more irregularities in which the regeneration of most important tree species is hampered, suggesting an urgent need for a conservation plan to promote sustainability of the woody vegetation resources in the BES

A total of 19 woody species were analyzed to know the regeneration status of trees and shrubs browsed by elephants. The total density of seedlings and saplings of these woody species was 3,377 individuals ha^{-1}.

Out of these, the density of seedlings of shrubs and climbers were 3,204 (94.5%) individuals ha^{1}, while the seedling and sapling of trees were 173 (5.5%) individuals ha^{-1}. Among the shrub species *Acacia mellifera* (342 individuals ha^{-1}), *Dichrostachis cinerea* (112 individuals ha^{-1}), *Grewia ferruginea* (112 individuals ha^{-1}) and *Grewia bicolor* (96 individuals ha^{-1}) exhibited better regeneration than other species (Fig. 3).
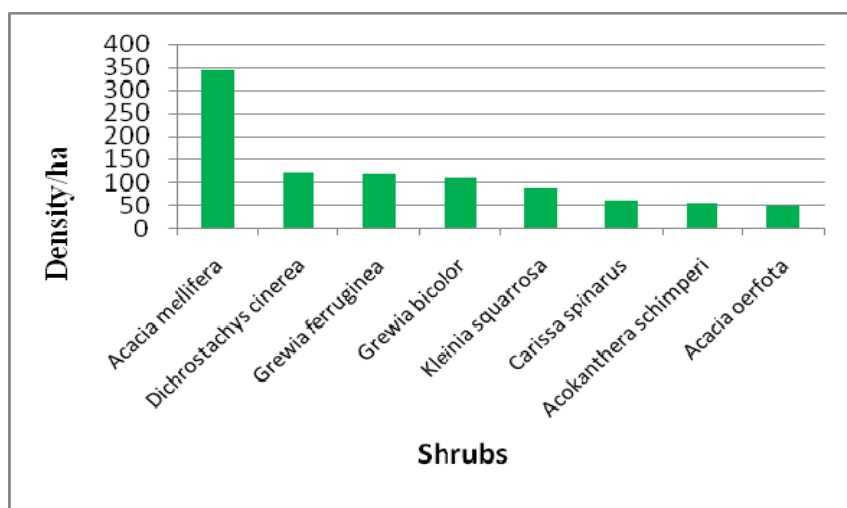

Fig. 3. Regeneration density per hectare for eight shrub species browsed by elephant

Highly browsed trees like *Acacia robusta* (47 individuals ha^{-1})*, Balanites aegyptiaca* (17 individuals ha^{-1})*,* individuals ha^{-1}), *B. glabra* (24 individuals ha^{-1}) and *Acacia*

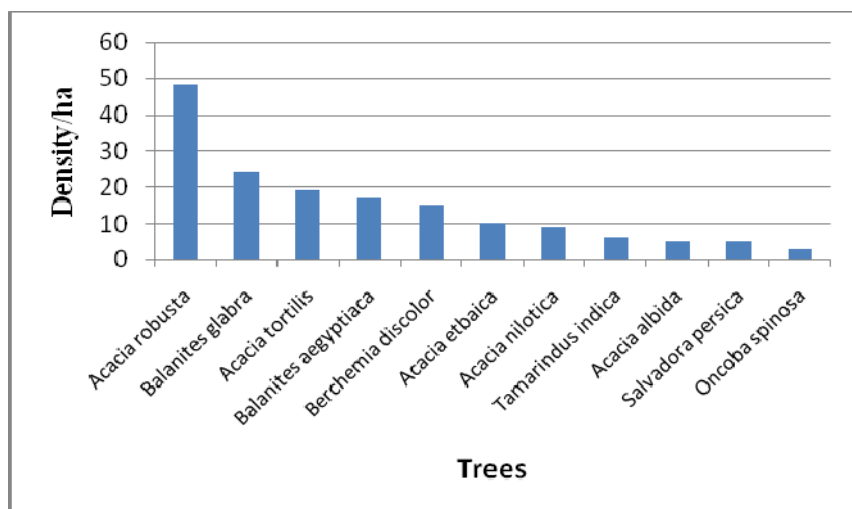*tortilis (*18 individuals ha^{-1}) show relatively better regeneration (Fig. 4).

Fig. 4. Regeneration density per hectare for eleven tree species browsed by elephants

The total regeneration status of woody species in the BES showed the dominance of shrubs and climbers. As stated by Mekuria Argaw *et al.* (1999), in Ethiopia, the uncontrolled removal of trees for various purposes is severely reducing the density of the species and affecting regeneration. The least regeneration count for tree species such as *Oncoba spinosa, Acacia nilotica, Salvadora perisca, Acacia albida* and *Acacia etbaica* could be due to the low density of mature trees in the standing vegetation or a poor seed dispersal strategy of the species. The relatively better regeneration of the top browsed trees such as *Acacia robusta, Balanites aegyptiaca, B. glabra* and *Acacia tortilis* might be attributed to the density of their mature trees, may be due to the presence of substantial amount of viable seeds in the soil and/or the wide dispersal of their seeds through ungulate faeces. In general, in the study area about 95% of the regeneration was recorded for shrubs and climbers. This result may indicate that the natural vegetation in the Erer Valley (the major part of the sanctuary) is moving towards shrubland/bushland since the population of trees is declining. Because the vegetation of upper and lower Erer Valleys were dominated by *Acacia* and *Acacia-Commiphora* woodlands (Stephenson, 1976; Demel Teketay, 1995) and that of Gobelle Valley by bushland/scrubland (Stephenson, 1976).

The major anthropogenic impacts in the BES

Temporary and permanent settlement, charcoal making, firewood collection, overgrazing, deliberate fire to clear the vegetation for agriculture, and selective tree cutting for construction were the main threats in the sanctuary. Agriculture scored 5 as a major threat to the sanctuary, followed by human settlement and overgrazing 4, charcoal making and tree

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cutting 3, invasive species 2, and honey collection 1.

Approximately, 400 ha of land along the Erer River have been used for agriculture illegally. A total of 31 small villages were counted in the sanctuary. Even during the data collection period, about 20 ha of woodland were cleared (burned) in the different part of the Erer Valley and prepared for agriculture illegally. However, crops cultivated near protected areas are attractive to elephants as an alternative source of food, which has a potential to create human-elephant conflicts (Yirmed Demeke, 2008). Similarly, due to an increasing practice of crop cultivation [such as, *Zea mays* L., *Sorghum bicolor* (L.) Moench and *Ipomoea batatas* (L.) Lam.] along the course of Erer River, crop-raiding became the common cause of human-elephant conflict in the sanctuary.

Within the four months data collection period (September to October 2006 and April to May 2007), about 735 sacks of charcoal and 625 bundles of firewood were produced, and 680 trees were cut for house construction in the Erer Valley. Invasive species like *Lantana camara* and *Parthenium hystrophorus* are the other threats to the sanctuary. *Lantana camara* was recorded in 43 of the 75 quadrats. In addition, the density of *L. camara* was 2,795 individuals per ha of which 1,035 individuals/ha were seedlings accounting to 37% of its total density.

The significant number of regeneration recorded for *L. camara* showed the severity of invasion in the sanctuary. If this trend continues, *L. camara* will be the major threat to the natural vegetation in the BES. The Northern or upper part of the Erer Valley is completely covered by *L. camara* in all the land features i.e. the riverbanks, field plains, and hillside areas (personal observation). The local communities have a practice of cutting *L. camara* from the base before it flowers and burn it on site afterwards. This shows how the local communities understood the negative effects of *L. camara* and the measure that they are taking to reduce its impacts in the study area. Perhaps, the invasion could be faster than the local communities control measure since the drainage pattern is from North to South direction in the sanctuary. Unless attention is given to the expansion of *L. camara*, it might dominate the vegetation in the study area.

Conclusion

Currently the natural vegetation of the BES is exploited in a destructive and unsustainable manner. The underlying root cause of deforestation and environmental degradation in the study area is an ever-increasing human population that caused influx of people from both highlands and lowlands of the surrounding area. In three years time, from 2005 to 2007, the numbers of small permanent and temporary villages established in the sanctuary increased from 23 to 31 (Anteneh Belayneh, 2006). As stated by Feyera Senbeta and Demel Teketay (2003), protected areas have hardly been managed in Ethiopia due to population pressure. Similarly, due to the

potential of the BES for agricultural activities, especially along the Erer River, people come from distant areas for shifting cultivation. Due to such agricultural expansion along the Erer River important multipurpose riverine tree species such as *Acacia robusta, Tamarindus indica, Oncoba spinosa* are declining. In addition, species of *Commiphora, Boswellia, Terminalia brownii* and *Berchemia discolor* are highly declining from the woodland vegetation of the sanctuary.

The BES, which is an important sanctuary for elephants, is not legally gazetted and, subsequently, the protection of the whole sanctuary will remain nominal. In addition, even if it could be gazetted, management plan that should carefully consider possibilities of sustainable utilization of the area by the local people should be considered like stated in the Bale Mountains National Park General Management Plan (BMNP GMP, 2007). As stated by Feyera Senbeta and Demel Teketay (2003), lack of integration of the local people living around such areas in the conservation efforts, and absence of law enforcement systems are the major constraints to the overall conservation efforts in Ethiopia.

It is important to emphasize that due to the accessibility of this particular habitat, it can be used as an outdoor classroom and research site. Moreover, the area can be used as an ecotourism site to attract visitors due to its biodiversity potential and topographic features. This can generate income that can be used to the benefits of the sanctuary and the local community if better management of the sanctuary is planned and implemented. In general, as part of the remaining vegetation cover and habitat of a wide variety of animals, including the only living representative individuals of the elephant subspecies (*Loxodonta africana*) in Ethiopia, and for the sake of long term benefit of the local communities, the Babile Elephant Sanctuary should be afforded the highest protection possible as a matter of urgency before it is too late.

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