



Review on Floristic Diversity and Threatened Plant Species in Babile Elephant Sanctuary in East Hararge, Ethiopia

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To cite this article:

Tahir Abdala, Yeneayehu Fenetahun. Review on Floristic Diversity and Threatened Plant Species in Babile Elephant Sanctuary in East Hararge, Ethiopia. *American Journal of Environmental Science and Engineering*. Vol. 1, No. 1, 2017, pp. 1-6. doi: 10.11648/j.ajese.20170101.11

Received: January 22, 2017; **Accepted:** February 7, 2017; **Published:** March 24, 2017

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*). As this review describe a total 55 plant species composed of 37 genera and 24 families were identified. Out of these, shrubs have accounted for 94.9% while trees constituted only 5.1% of the total density. Fabaceae, Tiliaceae and Capparidaceae are the most dominant family 1st, 2nd and 3rd dominant respectively. Browsing elephant, anthropogenic and invasive alian are the major threat of plant species in Babile elephant sanctuary. *Acacia robusta*, *Acacia senegal*, *Commiphora erythraea*, *Acacia nilotica*, *Balanites glabra*, *Acacia mellifera*, *A. tortilis* and *A. seyal* are the major useful plant and impacted species by human use, browsing elephant and invasive. Therefore, Future research should also focus on detailed assessment of current vegetation status in the Sanctuary; Rehabilitation by plantation especially the indigenous multi-purpose tree species that are highly threatened but still available in the valley should be given emphasis.

Keywords: African Elephant, Babile Elephant Sanctuary, Diversity, Threat

1. 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 fuel wood, 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 km² (<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.

BES, located in the semi-arid part of eastern Ethiopia, is

part of the Somali-Masai Centre of Endemism (Yirmed et al. 2006). This sanctuary is one of the protected areas in the country established to protect the only viable elephant population in the Horn of Africa. These elephants have been separated from other populations in Ethiopia for more than eight decades. Despite the establishment of the Sanctuary in 1970, their range of distribution has shrunk considerably. As a result of mass influx of a large number of farmers and their livestock from the east and north, the home range of elephants of Babile has shrunk by about 65.5 percent since 1976 (Yirmed et al. 2006). Moreover, a recent year 10,000 hectares of the north western part of the land given to a private company engaged in the cultivation of castor used for production of biofuel (Yirmed et al. 2006) is being described as a calamity to the already declining elephant population and other wildlife. Of the total 10,000 hectares of land granted to the company, 87.4% was proved to fall within the boundary of the Sanctuary, and of this 79.2% were within the present elephant ranges movement corridors and regular feeding grounds for elephants (Yirmed et al. 2006). Local communities around the area are highly dependent on vegetation for fencing, medicine, construction and fuel wood

(Anteneh and Feaven 2008).

2. Floristic Diversity

2.1. Plant Diversity

Biological diversity is defined as the total variability of all living organisms and the ecological complexes in which they occur often shortened to "Biodiversity". "Species diversity" refers to the number of species found within a given area. "Genetic diversity" refers to the variety of genes within a particular species variety or breed (WRI-IUCN- UNEP, 1992; IPGRI, 1993 "Plant diversity" refers totality and variability of all plants and their ecosystems.

The diversity of higher plant species increases as one move from the pole to the equator. According to Groombridge (1992), 40-100 tree species may occur in one hectare of tropical moist forest in Latin America, compared to 10-30 per hectare in North eastern America. The estimated number of Angiosperm species in the world and Ethiopia is 250,000 and 6000-7000 respectively. However, due to biotic and/or a biotic factors species and ecosystems are being lost (Tsidel, 1991). The recognition of this loss at a global level has led scientists and concerned groups to draw up world conservation strategy and the Convention on Biological Diversity held at the Earth Summit in Rio de Janeiro, Brazil in June, 1992. At the national level, Biodiversity Institute and National Conservation Strategy have been established. In addition, various government, non- governmental organization and Peasants Associations are involved in conservation practices (UNEP, 1995).

Diversity in ecological research could refer to species diversity, habitat diversity or genetic diversity indicating variability between species, habitat and individuals respectively (Spellberg, 1994). Species diversity could be viewed from different approaches in terms of alpha (α), Beta (β) and gamma (γ) diversity (Rosenzweig, 1995). Alpha diversity refers to the diversity of species within particular habitat or community. Beta diversity is a measure of the rate and the extent of changes in species along gradient from one habitat to another. It is diversity between habitats that measures the turnover rate. Gamma diversity on the other hand is the diversity of species in comparable habitat along geographical gradients and is independent of the two.

Diversity indices are simple mathematical expressions that summarize a lot of data recorded in one or sets of figures. Among the different coefficients widely used to compute diversity of a community are species richness, evenness and heterogeneity (Krebs, 1989). Species richness is the simplest concept of species diversity implying the number of species in a community. Heterogeneity is the measure of the probability of which two individuals randomly picked from a community belong to a different group or species (Hulbert, 1978). Evenness is the measure of equitability. It attempts to quantify the unequal representation of species in a community against a hypothetical community in which all species are equally common (Lloyd and Ghelardi, 1964).

Assessments of plant diversity have been frequently used to judge the success of conservation efforts (Hall and Willig, 1994) besides being a criterion for the identification of potential conservation sites. Therefore, it is important to assess the floristic composition and dynamics of the forest communities after protected area establishments in order to comprehend the conservation efforts made so far (Geilbach, 1975; Margules and Usher, 1981; Baskin, 1994).

2.2. Composition and Population Characteristics of Woody Plant Species in BES

A total Of the 55 woody plant species sampled in the riverine and woodland habitats, the impacts of elephants were recorded on 28 (50.9%) species belonging to 12 families. Out of these, 13 (45.8%) were trees and 15 (54.2%) shrubs. The total density of these 28 woody plant species was found to be 11,169.3 individuals/ha where the mean density was 399. Whereas the maximum density was 3,842.7 individuals/ha (*Opuntia ficus-indica*), the minimum density 3.7 individuals/ha was recorded for *Combretum molle*. The total density of trees was 558.7 individual/ha and shrubs 10,610.6 individual/ha. Furthermore, shrubs have accounted for 94.9% while trees constituted only 5.1% of the total density (Zelalem Wodu, 2007).

3. Threat of Plant Species in Babile Elephant Sanctuary

3.1. Impact of Elephant on Woody Plant Species

Consequences of the feeding and foraging behaviour of elephant populations are important for woody species, especially when developing conservation management options (Wiseman et al., 2004). Elephants spend 16 hours a day feeding, with peaks in the morning, afternoon, and around midnight. An elephant's diet requirement is usually met by forest-edge and woodland, and these habitats also provide the elephants with valuable shades (Croze, 1974). Elephant damage was not randomly distributed for riverine and woodland and habitats in Babile Elephant Sanctuary. Shrubs accounted for 94.9% of the total density of the 28 woody species impacted by elephants whereas trees only 5.1%. This is because shrubs are the dominant components of the floristic composition of the study area. As elephants prefer trees to shrubs (Croze, 1976), meeting the high feed demand of elephants of the BES could be a future challenge.

As many uncommon species were less frequently impacted than some of the more abundant species, any change in woody vegetation composition that might result from these impacts is likely to benefit species diversity in BES. Elephants are known to be physical ecosystem engineers with an ability to directly or indirectly control the availability of resources to other organisms (Cowling and Kerley, 2002). Pamo and Tchamba (2001) have also shown that elephants have varied effects on the vegetation; they can cause detrimental changes to some species, at the same time

increasing the abundance of other species. Whitehouse and Schoeman (2003) found that elephant foraging resulted in the reduction of plant biomass and abundance at Serengeti National Park. However, Midgley et al. (2005) contradicted these results by showing that the density of woody plants in the Addo Elephant National Park increased with elephant defoliation and attributed this to the fact that the removal of the canopy allows for coppicing to occur. In both of the riverine and woodland habitat types, the frequency of elephant damage varied according to the woody plant species and size classes. Density was calculated for woody species impacted by elephants, by calculating the average individual tree and shrubs, in terms of the number of individuals per hectare in both areas (Table 1). The highest density of shrubs is due to the domination of small sized shrubs in the floristic composition in both communities. *Opuntia stricta*, *Acacia brevispica*, *Kleinia squarrosa* and *Acacia mellifera* constitute about 50% of the total density. The most probable reason for the domination of these species may be specialization of the different species to different dispersal agents. Wind can carry light seeds with thin cotyledons, e. g. *Acacia mellifera* for a considerable distance (Tybirk, 1991). Some of the plant species may have a wide range of dispersal mechanisms and/or rapid reduction strategies. Cowling and Kerley (2002) also suggested that since most of the shrubs produce bird-dispersed fruits, they are able to recolonize areas successfully.

Table 1. Top dominant family and genera in BES.

No.	Family name	No. of species	genera	No. of species
1	Fabaceae	16	6	16
2	Tiliaceae	5	1	5
3	Capparidaceae	4	3	4
4	Balanitaceae	2	1	2
5	Rhamnaceae	2	2	2
6	Sapindaceae	2	2	2
7	Apocynaceae	2	2	2
8	Combretaceae	2	2	2
9	Acanthaceae	2	2	2
10	Burseraceae	2	1	2

Source: Zelalem Wodu, (2007) and Anteneh Belayneh, and Sebsibe Demissew, (2011).

Table 2. Plants highly impacted by elephants at BES, arranged alphabetically by genus (after Azene Bekele et al., 1993).

No.	Species	Level of Utilization
1	<i>Acacia brevispica</i>	Browsed, Uprooted, snapped stem
2	<i>Acacia bussei</i>	Severely damage, Preferred species
3	<i>Acacia etbaica</i>	Considerable damage, Debarked
4	<i>Acacia mellifera</i> Browsed	Favored species
5	<i>Acacia nilotica</i> Browsed	Browsed
6	<i>Acacia robusta</i>	Leaves browsed, Debarked
7	<i>Acacia seyal</i>	Browsed, Frequently uprooted, Ringbarked
8	<i>Acacia tortilis</i>	Browsed, Debarked
9	<i>Balanites aegyptiaca</i>	Well browsed
10	<i>Balanites glabra</i>	Browsed
11	<i>Berchemia discolor</i>	Fruits and leaves browsed, Branches broken
12	<i>Cadaba farinosa</i>	Browsed, Branches broken
13	<i>Carissa spinerum</i>	Browsed, Branches broken

No.	Species	Level of Utilization
14	<i>Combretum molle</i>	Well browsed
15	<i>Dichrostachys cinerea</i>	Heavily browsed, Branches broken
16	<i>Dodonaea angustifolia</i>	Heavily browsed
17	<i>Grewia ferruginea</i>	Severely browsed
18	<i>Kleinia squarrosa</i>	Pushed over Browsed
19	<i>Euclea schimperi</i>	Debarked, Browsed
20	<i>Grewia bicolor</i>	Browsed
21	<i>Oncoba spinosa</i>	Browsed, Branches broken
22	<i>Terminalia brownii</i>	Browsed

Source: Zelalem Wodu, (2007) and Anteneh Belayneh, and Sebsibe Demissew, (2011).

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 (Anteneh Belayneh, and Sebsibe Demissew, 2011).

3.2. Anthropogenic Impact on Woody Plant Species

Anthropogenic changes in vegetation over the past century need to be accounted for when assessing elephant impact. The harvesting and consumption of plant products from natural vegetation is known to account for a large proportion of the livelihood of people living close to such habitats. At the global level, socio-economic and political forces that determine the mode of development in many developing countries play an important role in the processes of vegetation degradation and destruction (Sindiga, 1995).

3.2.1. 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 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).

3.2.2. Use of Riverine and Woodland Resources

Woody plant species such as *Acacia mellifera*, *Acacia tortilis*, *Balanites glabra* and *Acacia senegal* were used for a variety of purposes in relatively large quantities and at higher frequencies. These species are relatively widespread at Babile Elephant Sanctuary. They represent some of the dominant and large woody plants on the sanctuary, the branches, bark, leaves and trunks of which can be used for a variety of purposes and in satisfactory quantities. Even

though they are used in relatively larger quantities, these plant species are still considered relatively available. This is because they are characterized by relatively large basal and crown cover and once the saplings grow fast beyond the browsing range of the local livestock, while their thorns discourage browsing by a variety of free-ranging domestic and wild ungulates that inhabit the rangelands (Mbuya et al., 1994).

The sapling *Acacia mellifera* is characterized by large multiple-stem stands, they easily out-compete other plant species, to the extent of dominating most of the landscape. It successfully colonizes degraded soils and sites due to its natural ability to fix atmospheric nitrogen, which is a limiting nutrient in such soils (ICRAF 1992, Moore et al. 1998). This species was also preferred because of its durability and high wood density. *A. mellifera* has the ability to recover quickly, especially if only the crown is harvested, and has short seed germination duration of 2–14 days and 50–80% seed viability (Mekuria Aragaw et al., 1999). *Balanites glabra* is also successful in the BES, partly because of its ability to survive in the alkaline soils (Brady and Weil, 1999). A large crown dominates the growth form of *Acacia tortilis*, with a deep and widespread root system which enables it to access water in the lower strata of the soil horizon. These potentially increase its ability to withstand dryland conditions. Its pods are widely consumed by a variety of domestic and wild herbivores, which facilitates the breaking of seed dormancy as well as enhancing germination rate and promoting high seed dispersal (Ensermu Kelbessa et al, 1992).

Table 3. Some of the important species used by human being and their main uses (Zelalem Wodu, 2007).

No.	species	Uses of them
1	<i>Acacia mellifera</i>	fencing, firewood, building and medicinal purposes
2	<i>Acacia tortilis</i>	Fencing And Firewood
3	<i>Acacia seyal</i>	Fencing And Firewood
4	<i>Acacia robusta</i>	Multiple Purpose Tree And Shrub
5	<i>Acacia senegal</i>	Multiple Purpose Tree And Shrub
6	<i>Commiphora erythraea</i>	Multiple Purpose Tree And Shrub
7	<i>Acacia nilotica</i>	Multiple Purpose Tree And Shrub

3.3. Expansion of Invasive Species (*Lantana Camara*)

The invasive species *lantana camara* was observed as the dangerous species for both plants and animals during the field observation of this study. *Lantana camara* is an angiosperm plant which origin of diversity is America. It is a small perennial shrub which can grow up to 2 meters in height and form dense thickets in a variety of environments. One of the highest problems of *Lantana camara* is that it breeds by both sexual and asexual reproduction. It is also true that Munir, A. (1996) reported that up to 12000 (twelve thousand) seeds per plant per year can be produced by each plant which are then eaten by birds and other animals which can spread the seed over large distances by facilitating the spread of *lantana camara*. This situation is creating a serious problem on plants and animals. This is due to its significance of being a dangerous weed found in a variety of environment including grass land, farm land,

forest margins and gaps in both natural and semi natural areas of forest. Therefore, *lantana camara* is considered as an invasive species by dominating other native fauna and flora. It prevents the growth of other trees and plants. This also matches with (Desalegn Desissa, 2003 and Sanders R. W., 2012). *Lantana* is a weed not used by the animals as fodder or human being for any productive purpose but it is rapidly covering mainly the grazing land of the sanctuary. It is also becoming a major threat to the grass land-the main feed source for the elephants. *Lantana camara* is also reducing the crop production. This invasive species is less prone to be eaten by elephants and livestock due to its toxicity. According to Desalegn Desissa (2003), this toxicity is also inhibits competing plant species. And it is the shelter for threatening wild animals like wild cats, hyena, warthog and others. According to their source people in the study area, *Lantana camara* was creating problems since it was introduced during 1980s.

4. Conclusion and Recommendation

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*). As this review describes a total 55 plant species composed of 33 genera and 24 families were identified. Out of these, shrubs have accounted for 94.9% while trees constituted only 5.1% of the total density. Fabaceae, Tiliaceae and Capparidaceae are the most dominant family 1st, 2nd and 3rd dominant respectively. Browsing elephant, anthropogenic and invasive alien are the major threat of plant species in Babile elephant sanctuary. *Acacia robusta*, *Acacia senegal*, *Commiphora erythraea*, *Acacia nilotica*, *Balanites glabra*, *Acacia mellifera*, *A. tortilis* and *A. seyal* are the major useful plant and impacted species by human use, browsing elephant and invasive. Therefore, the following recommendation needed for further conservation;

- Future research should also focus on detailed assessment of current vegetation status in the Sanctuary; Rehabilitation by plantation especially the indigenous multi-purpose tree species that are highly threatened but still available in the valley should be given emphasis.
- To use the area 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.
- Rehabilitating more impacted indigenous tree to maximize their regeneration status
- Babile Elephant Sanctuary should be afforded the highest protection possible as a matter of urgency before it is too late.
- To demarcate area from expansion of agricultural land and over grazing.
- To eradicate invasive through community mobilization and appropriate measure.

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