Wildlife Habitat Loss and Land Cover Change as Conservation Threat in Alatish National Park, Northwestern Ethiopia

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Abstract: The ecosystem of the Alatish National Park is an Ecotone between the Afromontane Region in Ethiopia and the Sudan-Guinea Savanna Region of Tropical Biome. The biological attribute of the park where the country opt to manage the resource sustainably are thought to be unique. However, the sustainability of its biological resources has faced profound threats. The aim of this study was to identify the threats of habitat loss and evaluate their effect on land cover change in the park. The result showed that fire induced by humans was the major threat of habitat loss. The nomads who intruded into the park from the Sudan side were not easily controlled by the Park scouts. The land cover change analysis revealed that woodland habitat of the Park was altered significantly. The land cover of the Park in 1999 showed that deciduous type of woodland was 46.55%, but it was reduced to 19.8% in 2013. On the contrary, wooded grassland habitat was increased from 35.4% to 64.5% of the land cover in 1999 and 2013, respectively. This indicates that threats of habitat loss remain unsolved after the establishment of Park. Therefore, urgent interventions by the federal government and international conservation foundations should be mandated to support the management effectiveness of the park office. These would enable the park office to control major conservation threats through the Ethio-Sudan Transboundary National Park collaboration and implementation of management strategies.

Key words: Fire, lowland, nomad, park office, woodland habitat, wild honey collection

1. Introduction

Biogeographically Alatish is known by its woodland vegetation and diverse fauna composition (Heckel *et al*., 2007; Mengesha and Bekele, 2008; Habtamu and Bekele, 2008; ANPMP, 2009; Tewabe *et al*., 2009 and Kruskop *et al*., 2016). According to White (1983), the flora of the western Ethiopian escarpment including Alatish National Park is considered as undifferentiated woodlands of Ethiopian type and it is linked most closely to the flora of the Sudanian-West African region. The vegetation of the Park could also be considered as a transition zone between the Afromontane region in Ethiopia and the Sudanian region in the

Sudan. As a result, the biological attributes of the park are thought to be unique. Demissew *et al*. (2005) also pointed out that the vegetation of western Ethiopia is higher in rank of local endemism compared to most Ethiopian regions.

Alatish has characteristic vegetation consists mainly of deciduous woodland with combretaceous trees, *Acacia* woodland and lowland bamboo (Demissew *et al*., 2005). Other vegetation types like wooded grassland, riverine forest and swamps also occurred. Thus, the Alatish area is classified into major ecosystem components or communities such as Riverine woodland, Seasonal Wetland/flood plains, mixed deciduous Woodland, Acacia, Bamboo and Wooded grassland ecosystems.

Alatish is a trans-boundary Park, adjacent to the Dinder National Park of the Sudan Republic that has huge potential to conserve rich wildlife resources. The Park harbors 20 large mammalian species, including threatened species like Elephant (*Loxodonata africana*), Leopard (*Panthera pardus*), and Lion (*Panthera leo*) (Mengesha and Bekele, 2008). It is also anticipated as a potential site to shelter critically endangered Tora hartebeest (*Alcelaphus buselaphus tora*) which has a historic biogeographic distribution range in Eastern Sudan, Northwestern Ethiopia and Northern Eritrea (Heckel *et al*., 2007). In addition to the presence of large mammals, 23 rodent species, 6 species of insectivores (Habtamu and Bekele, 2008), 21 bat species (Kruskop *et al*., 2016), 204 bird species (ANPMP, 2009), 23 fish species (ANPMP, 2009; Tewabe *et al*., 2009), at least 15 reptile species and a few amphibians (Ashagrie, 2015) are reported and inhabiting in the park. Habtamu and Bekele (2008) noted that some endemic rodent species of the Ethiopian highland forest and three shrew species were found in Alatish.

Conservation of Alatish National Park is beyond local interest. Marye *et al*. (2008) and ANPMP (2009) described that Alatish serves as a migratory route for Elephants, which traverse from the Dinder National Park in Sudan. Another regional opportunity of the park is that Alatish is watershed to the Nile Basin in Sudan. From Alatish various rivers like Gelegu, Ayma and Alatish drain into Sudan and these are important tributaries of the Nile. The Park was also demarcated by considering its role in conserving a healthy ecosystem such as preventing environmental risk that will occur due to the expansion of desertification, which may possibly extend to northwestern part of Ethiopia via the neighboring state around the Sahara region (Anonymous, 2006). In combating climate change, Alatish has significant potential in carbon sequestration (Vreugdenhil *et al*., 2012). According to these authors,

Alatish National Park has the largest carbon stock estimates (carbon sequestration potential), which is 20,132,576 tons of CO_2 within its vegetation source, among the national parks of Ethiopia.

Under category II protected area management criteria human habitation is not permit in a National Park (IUCN, 1994). In principle Alatish fulfill this criterion compared to the well known National Parks like Simen Mountains National Park, Awash National Park (Belay *et al*., 2012; Zerga, 2015), Abijata-Shalla National Park (Mulualem and Tesfahunegny, 2016) and Yangudi Rasa National Park (Wale *et al*., 2017). Alatish is free from local people settlement and agricultural activities inside the park. Despite this fact, previous studies reported that Alatish had been threatened by anthropogenic effect and its fauna biodiversity was declining (Heckel *et al*., 2007; Marye *et al*., 2008; Mengesha and Bekele, 2008; Menale, 2011; Ivlev *et al*., 2011). Thus, continuous monitoring on population status of wildlife, conservation threats and trends of land cover change are very important to quantify levels of habitat loss, evaluate management effectiveness and design conservation strategy that mitigate conservation challenges of the park. This study was aimed at identifying causes of habitat loss, quantifying land cover changes and providing insight for mitigating conservation threats of the park.

2. Materials and Methods

2.1 Description of the study area

This study was conducted in Alatish National Park (ANP), located in the Quara District of north Gonder Zone, northwestern Ethiopia. It is located between $11^0$47' – $12^0$32'N latitude, and $35^0$15'-$35^0$49'E longitude (Figure 1). Alatish is a flat plain lowland area with an elevation ranging from 528 to 654 meter above sea level with a few scattered mountain cliffs (Abraham *et.al.* 2008). It is far about 1123 km northwest of Addis Ababa and 324 km southwest of Gonder town. As the area had been delineated to be a priority forest conservation area since 1941 during Emperor Haile Selassie's I regime, it was gazetted as a park in 2006. The park has a total area of 2600 km^2. It shares boundaries with Sudan (Dinder National Park) to the West, Benshangul Gumuz National Regional State of Ethiopia the South, and 7 peasant associations of Quara Woreda to the East (Anonymous, 2006).

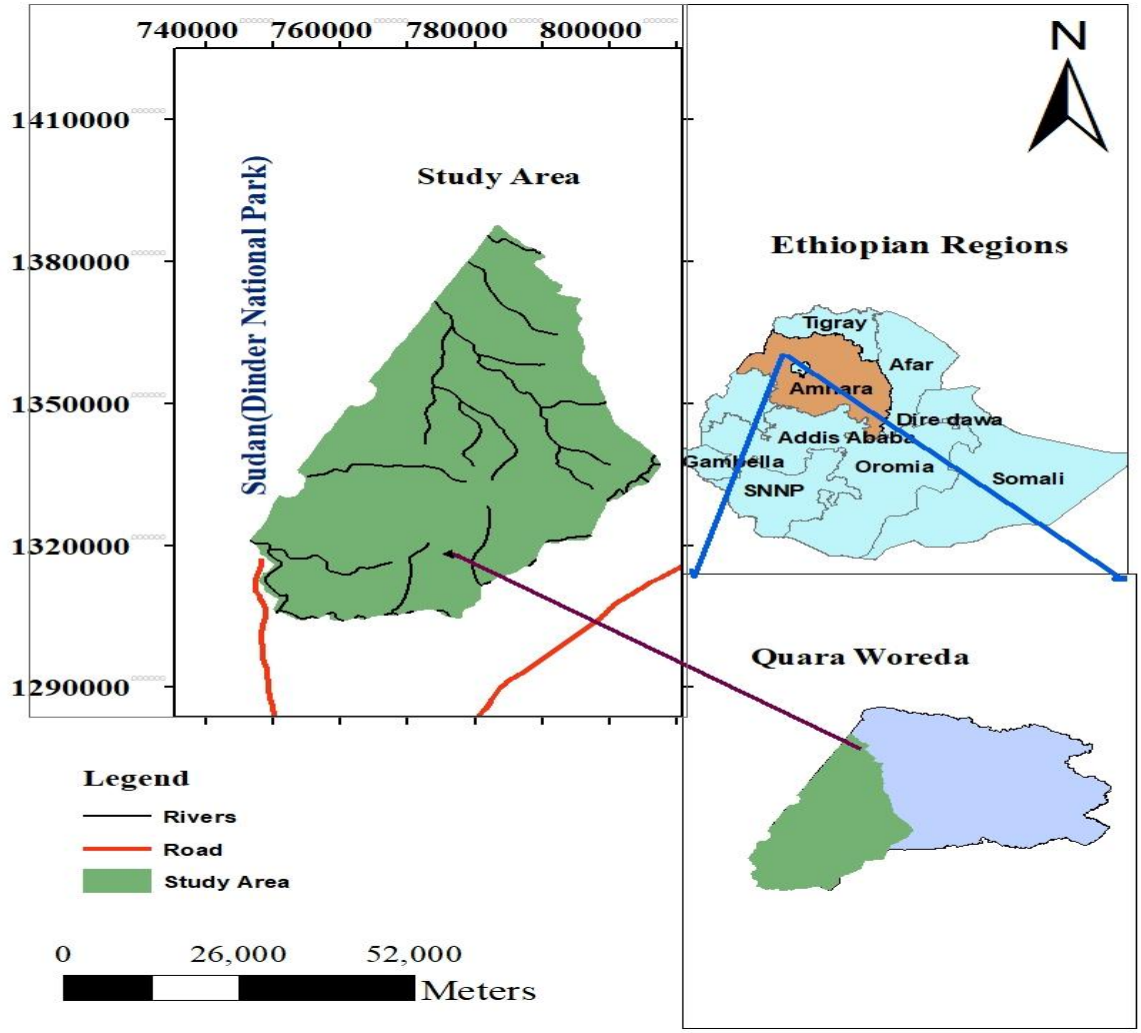

Figure 1: Location map of study area

2.2 Data collection and analysis

2.2.1 Data collection

Rapid assessments were conducted in November 2011, May 2012, December 2012 and March 2013 to identify causes of habitat loss. Slow moving vehicle survey was conducted along trials connecting five purposely selected sites of the park. Sites were purposely selected based on their accessibility to vehicle survey and being safe in security issue. Particularly, the survey was carried out from Bermil to Jabra, from Bermil to Amjale and from Amjale to Alga sites, from Bermil to Grara-Mehadid-Drasen sites. All data related to habitat degradation and threats were collected. Pictures and direct observation was used. Informal interview method was applied to the Park scouts and officers to collection data about inaccessible sites.

Ground truth of vegetation cover was sampled in the field to verify image classification. Ground truth information was collected during field survey using GPS on 88 Ground Control Points (GCP) on the study area. These Ground Control Points were collected using stratified sampling technique from each habitat types: Riverine woodland (10 GCP), *Combretum-Terminalia* Woodland (20 GCP), *Acacia* woodland (20 GCP), Wooded grassland (20 GCP), Bamboo woodland (8 GCP) and water body/flood plain (10 GCP). When taking sample GCP, the current land-cover classes and their corresponding GPS points were recorded in the field.

2.2.2 Data analysis

To quantify impacts of threats on habitat loss, land cover changes on the different habitat types was estimated using satellite imagery. Thirty meter resolution landsat images accessed from United States Geological Survey (USGS) was applied. Enhanced Thematic Mapper (ETM+) Landsat-7 and Landsat-8 satellite images of November 1999 and November 2013 on path 171 and row 51 and 52 were used. The Ethiopian Mapping Agency (EMA) topo-map with 1:250,000 scale locating on the study area was used for geo-referencing the satellite images. The satellite images were radiometrically and geometrically processed using ERDAS Imagine 10.0 (Ortho-rectification with WGS 1984 UTM Zone 36 N).

Land-cover classification was made by supervised classification method. The GPS points were overlaid on the imagery and used for refinement of the land cover map interpretation. For Land Cover mapping, visual interpretation technique was employed. Based on the ground truth samples, training samples and signature generation (interpretation keys) were developed. In the process of classification, training area was taken on each of the land-cover class, based on the reflectance signature of different features on the false color composite 4-3-2 (FCC) band combinations. Image classification was done using Maximum likelihood classifier technique, and a 3 x 3 pixel moving windows majority filter was employed to smoothen the classification. Accuracy test for the prepared land-cover classification was computed by taking the field collected ground control points from the six land-cover classes through ENVI 4.7. Change detection statistics matrix of land-cover and rate of change were also computed by ENVI 4.7. The rate of land-cover pattern change during the period 1999–2013 was estimated as the difference in the respective land-cover type in hectare divided by duration of years. The prepared supervised land-cover images were exported to ArcGIS 10.0, and LC maps were prepared for the years 1999 and 2013.

3. Results and Discussion

3.1 Threat of habitat loss

It was observed that fire was the conservation threats of the Park. Fire burning severely degraded habitat quality by removing tree coverage of the park to the extent that burnt trees cannot be regenerated. Fire also affected the pattern of seasonal ground cover change. The non-woody vegetation cover of woodland and wooded grassland ecosystem was removed by fire and the clay and sandy soil remain bare in the long dry season (Plate 1). This implies that the conservation threat of the park reported at the early stage of the park establishment (Heckle *et al*., 2007; Habtamu and Bekele, 2008) is still the threat of habitat loss.

Plate 1: Intense fire burn that removed trees and herbaceous land covers (Photo taken by author)

All (thirty) of the interviewees confirmed that fire burn was induced by cattle-raising nomads. During early dry season survey, November to December, fire was most frequently observed along the Ethio-Sudan border and some parts of the Park. However, in the peak dry season March to May fire burn was not observed. In their patrol, the Scouts who were assisting the field surveys around Alga and Jabra sites attested the observed fire burning were due to Fellata pastoralist nomads who are coming across the neighboring country of Sudan. According to informants the cattle-raising nomads encroach seasonal wetlands and river banks during dry season.

The survey conducted in this study after eight years of the park establishment found that the park has still been severely affected by fire. At the early stage of the park establishment fire was reported as the major conservation threat in the park (Heckle *et al*., 2007; Habtamu and Bekele, 2008). The park office manages conservation threats imposed by humans through legal enforcement and community participation. However, the conservation threat linked with fire and cross country intruder nomads was reported after some years' conservation efforts of the park (Minale, 2011). The impact of Fellata pastoralist nomads' in the Park is still a problem.

Commonly in livestock herding, fire has been used as a tool to control ectoparasite load, reptiles and predators attack; and to clear dried tall grass for subsequent improving forage quality (Myers *et al*., 2004). The fresh offshoots that regenerate around seasonal wetlands and riverine habitats after burning during the dry season and in the beginning of the rainy season would provide palatable fodder for herbivores. These strategies seem to be used by the neighboring Sudan nomads who intrude into the park. Since most of the fire incidents were observed in the Sudan border of Alatish Park and the Park Scouts usually caught the Sudanese nomads inside Alatish. Although controlled fire has positive effects in managed areas (Taledo *et al*., 2014), uncontrolled fire that spread fast due to the presence of large dry fuel load resulted in deforestation of the Park.

Fire has been also recorded as threats in most western lowland vegetations of Ethiopia (Jensen and Friis 2001; Gashaw *et al*., 2002a, b; IBC, 2005; Demissew *et al*., 2005). Even in the conservation area, Alatish National Park, controlling the activities of Sudanese nomads in the Park and fires induced by them has not been effective for setting long lasting solution of the conservation area. Since the nomads are armed, the scouts face challenges when they were trying to educate them and protecting the Park. According to the park staffs, the fail immplementation of legeal enforcement and application of transboundary park/boarder agreement contributes for the impact of fellata/ nomads on the Park.

In the field survey it was observed that conservation threats imposed by local people were managed by the park office through legal enforcement and community participation. According to the community mobilization expert, elders of local people are park committee members. They contribute for conservation of the Park through conservation education and mediating conflict of local people interest with park conservation. None of the interviewees

reported impacts of local people in causing fire burn. Nevertheless, signs of wild honey collection and fire induced in to the Park were observed during the field surveys (Plate 2).

Plate 2: Destructive activities of honey collectors. Honey collection practice inside the tree holes by cutting down trees (left); fire induced in the park to collect honey in tree holes (right). (Photo by Author)

3.2 Land cover change

The comparative land cover maps (Figure 2) show change on land cover between 1999 and 2013. As observed on the map, coverage of deciduous woodland was reduced from 1999 to 2013. Complementary to this land cover shrinkage, the coverage of wooded grassland and Acacia woodland was increased from 1999 to 2013.

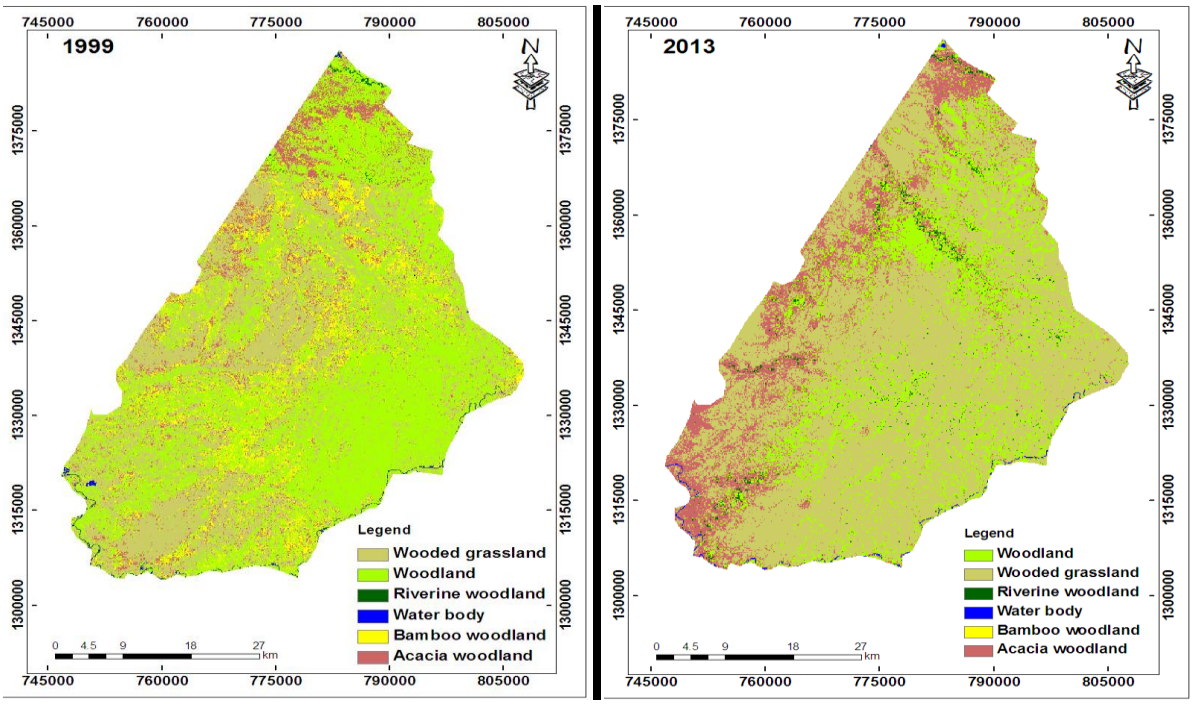

Figure 2: Land cover maps of 1999 (left) and 2013 (right). Source: own survey 2013

The land cover changes matrix between 1999 and 2013 indicated declining trend in coverage of woodland vegetation (Table 1). Mainly the deciduous woodland was changed into wooded grassland and Acacia woodland. Bamboo woodland cover was also largely converted into wooded grassland.

Table 1: Land cover and change matrix between time periods of 1999 to 2013 of Alatish National Park.

		1999 Land Cover (ha)						
		AW	WB/FP	RW	WGL	BW	DW	Class total
2013 Land Cover (ha)	AW	4291.8	111.1	132	12832.9	3497.8	**18551.8**	**39417.5**
	WB/FP	10.6	210.7	357.4	6.52	0.9	94.9	681.0
	RW	24.8	5.7	124.5	1211.3	46.64	1436	2848.9
	WGL	16011	141.8	9.5	71769.6	**18215.0**	**70423.1**	**176570.4**
	BW	2.48	0.3	0.1	12.87	3.8	13.7	33.1
	DW	1967.1	164.2	191.8	11077.5	3879.3	36920.5	54200.4
	Class total	22308	633.8	815.2	96910.7	25643.5	127440.0	
	Class change	18016.3	423.1	690.7	25141.1	25639.7	90519.5	
	Image difference	**17109.4**	47.2	2033.8	**79659.7**	**-25610.4**	**-73239.6**	

Note: AW- Acacia Woodland, WB/FP- Water Body/Flood Plain, RW- Riverine Woodland, WGL- Wooded Grassland, BW- Bamboo Woodland, DW-Deciduous Woodland

Deciduous woodland was the highest land cover (46.55%) in 1999, but this land cover was only 19.8% cover in 2013 (Table 2). The change analysis depicted that the woodland cover was reduced by 26.7% with rate of 5231.4 ha per year. Bamboo woodland is another land cover that reduced through time. Bamboo woodland which was 9.34% in coverage in 1999 was extremely shrunk below 1% in 2013. However, wooded grassland which was the second highest land cover (35.4%) in 1999 was highly increased with a rate of 5689.98 ha annually. In 2013 wooded grassland covered 64.5% of the total land cover. *Acacia* woodland also

showed increasing change of trend with rate of 1222.1 ha per year; from 1999 to 2013 *Acacia* woodland increased by 6.25%. Riverine woodland and seasonal flood plain/wetlands are generally small in their coverage and did not show noticeable changes. Even though, riverine woodland cover is small in total proportion, it seems to be increasing in coverage from 1999 to 2013.

Table 2: Proportion of land covers of Alatish National Park during 1999 to 2013 and annual rate of change

Land cover class	1999		2013		Rate of change (ha/year)
	Area (ha)	%	Area (ha)	%	
Acacia woodland	22308.08	8.15	39417.45	14.40	1222.10
Water body/ Flood plain	633.83	0.23	681.01	0.25	3.37
Riverine woodland	815.19	0.30	2848.97	1.04	145.27
Wooded grassland	96910.70	35.40	176570.40	64.50	5689.98
Bamboo woodland	25643.49	9.37	33.07	0.01	-1829.32
Deciduous woodland	127440	46.55	54200.40	19.80	-5231.40
Total	273751.30	100.00	273751.30	100	

The overall patterns of land cover changes in Alatish might be related to variation in fire intensity among land covers, fire resistance nature of plant types and effect of fire on plant regeneration capacity. Gashaw *et al*. (2002a, b) reported that removal of vegetation and seeds are manifested due to the adverse effects of fire in western Ethiopia. Similarly, changes in land cover of this study are observed due to fire effect.

In deciduous woodlands, woody plants are not much dense, rather understory herbaceous plants and grasses as well as grass ground coverage range 30%-60% (White, 1983). According to Gashaw *et al*. (2002a) fire is relatively more intense in sites where grass biomass is huge. Thus, large herbaceous and grass fuel load density in deciduous woodland and wooded grassland might allow intense fire burning to occur annually and remove or minimize tree coverage. Such condition can cause reduction of woodland and increment in wooded grassland coverage in the park. On the other hand, reduction in woodland and

increment of wooded grassland coverage might be explained by fire resistance capacity of trees. As Gashaw *et al*. (2002a) suggested trees with thick barks and wide breast height tree diameter might resist fire better than small trees and trees with thin bark. According to these authors moisture content and flammability of tree barks also determine fire resistance ability of tree species. Trees with dry, string, fibrous and rough bark are prone to fire. Most trees in the woodland coverage of Alatish are small to moderate in size with rough and string barks such as *Terminalia sp*., *Combretum sp*., Pterocarpus and Lannea (ANPMP, 2009). When fire burn appears, these woodland plant species burn immediately (Gashaw *et al*., 2002a). However, *Acacia seyal* with smooth barks, and *Balanitus aegypthicus* with thick bark and large stem diameter may protect their cambium from fire. Expansion of *Acacia* woodland might be also related to this fire resistance and regeneration capacity of *Acacia* trees. In addition to fire resistance of trees, Gashaw *et al*. (2002b) noted that significant proportion of large seeds of woody species such as *Combretum* sp. and *Entada africana* probably do not enter the soil but stay in the litter and are exposed to fire. Alternatively, reduction in woody plant coverage may result from the effect of fire that precedes seed dispersal and cause low surface soil seed pool of some broadleaved herbs and woody species (Gashaw *et al*., 2002b).

Unlike other ecosystems, the fire regime did not affect riverine woodland. This finding agrees with broadly defined Sudanian vegetation zone where fire seems to affect nearly all vegetation types, except closed forest (Jensen and Friis, 2001). Such fire effect was observed in western Ethiopia, from the border region with western Eritrea in the North to the Boma Plateau south west of the town of Maji in the South (Jensen and Friis 2001). Unaffected vegetation cover of the riverine woodland in Alatish might be related to fire resistance potentials of trees due to their thick stem or large diameter and moist bark. Most riverine woodland is dominated by large sized trees like *Ficus sycomorus, Hyphaene thebaica, Acacia sieberiana, Stereospermum kunthianum, Tamarindus indica* and others. In addition, within this woodland, understory grass and herb ground cover is moist, weak and discontinuous. This poor grass and herb layer do not allow frequent and intense fire burn. The main ground layer grasses cover of includes *Bekeropsis uniseta*, *Eragrostis tremula* and *Sorghum sudanenis.* These grasses have capacity to regenerate immediately after fire burn due to residual moisture content of the soil. Thus, riverine woodland and wetland ecosystems used as feed source for wild animals and cattle in the long dry season when green vegetation of other land covers were rarely found.

4. Conclusion

The habitats of Alatish like other western lowlands of Ethiopia are highly seasonal. The fire induced by illegal nomads and honey collectors mainly caused habitat loss and degradation beyond the seasonal ecological stress. This human disturbance intensifies the aridity of the habitat during dry season. Thus, extreme seasonality of the environment and human induced fire are the major conservation challenges for wildlife conservation in Alatish National Park.

The overall vegetation covers show changes in the reduction of woody vegetation and expansion of open habitat or wooded grassland. Most of the conservation threats in the Park that altered natural habitats were caused by nomad intruders along Ethio-Sudan border. As a result the habitats of wild animals and the animals themselves dwelling in the Park are being threatened. There is a great chance for the local extinction of elephant due to habitat degradation. As a result endangered wildlife species like elephants are being forced to migrate other areas like Dinder National Park in Sudan. Therefore, urgent interventions are needed to manage fire incidences in the park as well to safeguard the wildlife and their habitats. The Federal Government should give due attention for the implementation of the National Park Management in collaboration with local peoples, national stake holders and NGO's as well. Further and detail studies on the fauna and flora of the National Park should be given priority to evaluate the impacts of fire and habitat loss on the population status and diversity of wild animals.

Conflict of interest

The authors declare that there is no conflict of interest in publication of the manuscript on this journal.

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