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Research Article

Estimation of the population size of the flagship species of Burchell's zebra (*Equus quagga*) in southern Great Rift Valley, Africa

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Abstract

Burchell's zebra (*Equus quagga*) is one of the most abundant ungulates and a useful model for the conservation and management of the other equids in Africa. This study aims to determine the population status of flagship Burchell's zebra of the Nech Sar National Park in the Great Rift Valley of Ethiopia. Population estimates of such wild animals were conducted with the line-transect method, and a GPS was used to walk along transects. The results have shown that a total of 155 individual Burchell's zebras had been counted, and the population density was 8.34/km^2. The age ratio of adults to young was 1:0.65. The plains zebra's most significant observed challenges are the invasion of the alien, exotic woody species on the plain grasslands, agricultural expansion, degradation of grazing lands, clearing forests, charcoal production, and the park management-settler conflict. Unless and otherwise, such threats immediately reversed and resolved, will put in danger the conservation status of the flagship species of Burchell's zebra and other wildlife species dwelling in the southern Great Rift Valley.

Keywords: African biodiversity, conservation challenges, Nech Sar National Park, plains zebra, wildlife management

Introduction

Equids or the horse family comprises six extant wild species and 22 subspecies (Baillie *et al*. 2004, Orlando 2015). The fossil record of the genus *Equus* is rich; however, the knowledge about the taxonomic relationships within this genus is inadequate (Vilstrup *et al*. 2013). Numerous equine subspecies have gone extinct over the last few centuries, and nowadays, a substantial number of subspecies are under the threat of extinction (Orlando 2015). In Ethiopia, three of the equids species; such as Burchell's or Plains zebra (*Equus quagga*), African wild ass (*Equus africanus*), Grevy's zebra (*Equus grevyi*), and in the world, Ethiopia is the only country to harbor the three of the wild equids species. The aforementioned species are among the best-known flagship species but are at high risk of extinction (EWCA and IUCN/SSC 2017).

Like many large African mammals, all three equid species have declined in their range and population size (Moehlman *et al.* 2016). Estes (2012) described that the Plains zebra formerly existed throughout eastern and southern Africa, except Western and central Uganda. They are currently distributed along with the

range of the Somali-Masai dry regions throughout the south of savannah and slightly in the southwest dry zones, from southeastern Sudan to South Africa and Angola (Duncan 1992).

The Plains zebra's major populations in Ethiopia are occurring in Yabelo Wildlife Sanctuary and Nech Sar, Omo and Mago National Parks (EWCO 1995). Such species' estimated population size was around 2000 individuals in the four protected areas (Duncan 1992). Graham *et al*. (1996) stated that there was no adequate protection in the aforementioned protected areas since 1975 and leading to severe poaching. Even though the Nech Sar National Park was established to protect key wildlife species and their habitats, habitats have been critically vulnerable to human-induced impacts (Kelboro *et al*. 2013). At present, Nech Sar National Park holds the largest populations of plains zebra (NSNP 2019) where their distribution is limited mainly in the Nech Sar plains (Fig. 1). Burchell's zebra is listed as Near Threatened as it is close to qualifying for Vulnerable (EWCA and IUCN/SSC 2017).

Figure 1. Burchell's zebra in Nechisar Plain's

Currently, the flagship species Plain's zebra of Nech Sar National Park is under threat due to several factors. These conservation challenges include high grazing pressure by pastoralist 'Guji' community on critical zebra habitat of open grassland. Besides, the encroachment of invasive weed species and encroacher bush species is threatening this critical habitat by causing habitat change, which is not preferred by zebra (NSNP 2019). Thus, understanding the population status, density, size, habitat preference, and relative abundance is crucial to implement integrated population and habitat management measures of the park. The study tried to answer the following important questions: (i) What are the current population structure, density, and size of Burchell's zebra? (ii) What is the relative abundance of Burchell's zebra? (iii) What can be the possible recommendations for appropriate population and habitat management measures for better and effective management measures in Nech Sar National Park of the Great Rift Valley? Hence, the study aimed to estimate the population size of Burchell's zebra's flagship species in southern Great Rift Valley, East Africa.

Material and methods

Study area

Nech Sar National Park (NSNP) is situated in the Great Rift Valley of southern Ethiopia with an elevation varying between 1108 m-1650 m asl (Fig. 2). The area is characterized by relatively hot climatic conditions with 12.2°c and 34.3°c temperature ranges. At the same time, annual rainfall follows a bi-modal system with an average of 880mm, mostly falling in March, April, and May and rarely between September and November (NSNP 2019). The park comprises 514 km^2 in which 85% of land covers and 15% is a water body. Grassy plains, wooded grassland, bushland, and riverine forest are known vegetation in the study site.

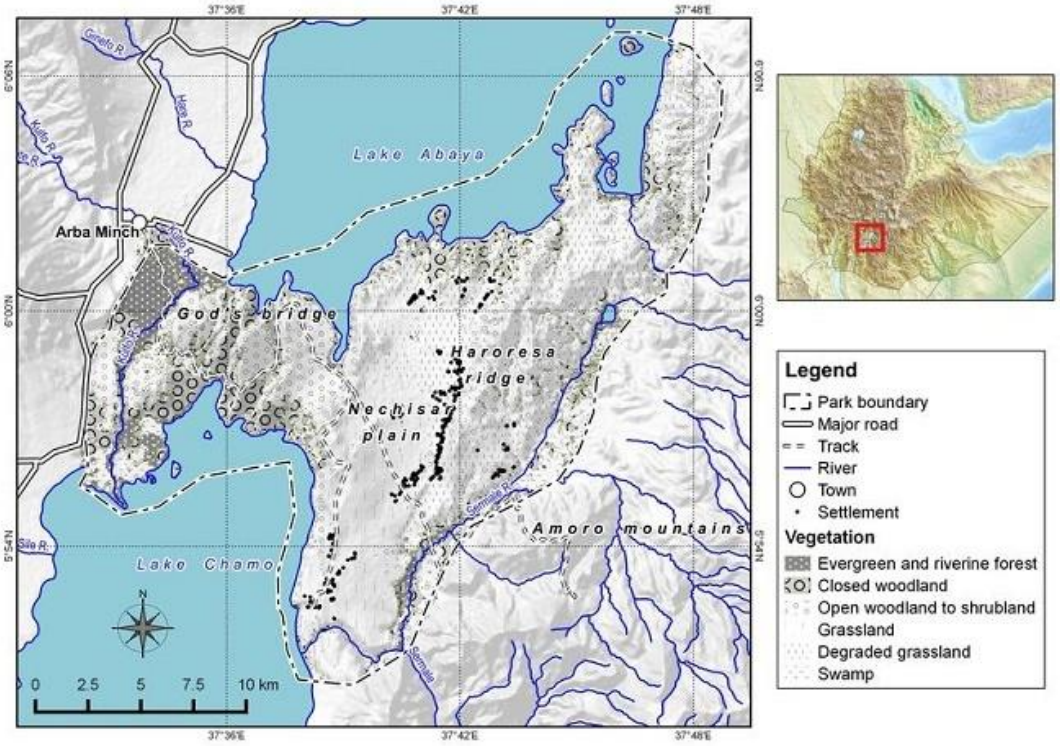

Figure 2. Map of Nechisar National Park (Marsboom 2014)

The study area highly contributes to the country's development in wildlife tourism. In addition to Plains zebra, Greater kudu (*Tragelaphus strepsiceros*), Waterbuck (*Kobus ellipsipprymus*), Hippopotamus (*Hippopotamus amphibious*), Nile crocodiles (*Crocodylus niloticus*), Black-backed jackal (*Canis mesomelas*), Side-striped jackal (*C. adustus*), Hunting dog (*Lycaon pictus*), Cheetah (*Acinonyx jubatus*), Leopards (*Panthera pardus*), Lion (*Panthera leo*), Serval cat (*Felis serval*), Caracal (*F. caracal*), and Spotted hyena (*Crocuta crocuta*), are some of the most important large mammalian wildlife species in the area.

Methods

To define the counting zone, the suitable habitat of the animals was identified through stratifying the area based on the main vegetation types, which are the plain grass as well as open bushland parts of the park. The park already has eleven transects lines developed following natural marks and features for this habitat to conduct total wildlife count twice a year. For our study, we divided the counting zone of the suitable habitat by stratifying the area into two based on major vegetation types, such as open grassland and open bushland. Therefore, due to time and resource limitation, we used sample transect counting by randomly taking two transects for open grassland and one transect for open bushland. The transect width

and length varied between 100 m up to 500 m and from 3.5 to 5 km, respectively. The survey was conducted on foot walking along transects bi-monthly. Two observers were involved from the left and right side of each line transects. Each transect was walked twice in a single visit, early in the morning and late in the afternoon. The double recording was avoided using easily recognizable features.

Thus, three survey teams with three individuals (observer, pacer, and recorder) have been prepared. The group comprises mainly seven experienced park scouts, and two experts get orientation on how to conduct counting on sampled transects. Then every three counting teams have been deployed to sampled transects early in the morning at the same time and stopped counting almost at the same time. The counting team is provided with a standard wildlife count sheet and GPS to locate the sighting of the zebra on transects. A GPS was used to walk along transects, and the starting and ending coordinates were recorded in the GPS. During counting, each of the individual animals in a group was identified and categorized into their respective age and sex categories using binocular (Klingel and Klingel 1966). The classes used were adult male, adult female, sub-adult male, sub-adult female, juvenile, and calf. In comparison, the HCIYET HT-1500A range finder has been used to measure the animal or group's distance from a transect in which observation is conducted.

Advanced ecological census method following the work of Buckland *et al.* (2007) and Sutherland (1996) has been used for the analysis as followed: D=ns/2LW; where, D=estimated density of Burchell's zebra, n=number of Burchell's zebra/group of Burchell's zebra seen, s=mean group size of Burchell's zebra, L=length of transect line(s), and W=mean perpendicular distance of Burchell's zebra (or groups of Burchell's zebra) seen.

The population size of Burchell's zebra was estimated by multiplying the population density (D) with the total suitable habitat for Burchell's zebra (Open grassland and open bushland only), which is (A=269.85 km^2). N=D x A; where N = total population size of Burchell's zebra, D=Population density of Burchell's zebra (individual per km^2), A=Total suitable habitat of Nechisar National Park for Burchell's zebra (in km^2).

Results

More Burchell's zebras were sighted on the transect during the counting, which extended from Bedagedela to Kalokoreke to Abaya shore to the northern part of the plain grassland and extended 12.44km. In contrast, a small number was observed on the sample transect of open bushland, which is 7.8km and extended from Degabule to Belte through Gods Bridge between Lake Abaya and Lake Chamo (Table 1). For both of the habitat types, a total of 22 herds/groups of Burchell's zebras were observed in the Nechisar National Park, with 21.57 of individual Burchell's zebra on average per herds/groups. A total of 155 individual Burchell's zebras had been counted during the study period. The population density of Burchell's zebra in Nechisar National Park was 8.34/km^2. Therefore, the estimated total population size was 2,267 individuals during counting.

Out of a total number of 158 individuals observed during the counting period, 36 (22.78%) was an adult male; 58 (36.71%) adult females, 21 (13.29%) sub-adult males, 14 (8.86%) sub-adult females, and the rest 29 (18.35) were unknown sub-adult, juvenile, and calf age groups. The age ratio of adults to young was 1:0.65. Averagely, 59.49% of the total population was adults and only 38.61% was young. The more detail age category during counting showed that 36 (22.78%) was the adult males, 58 (36.71%) adult females, 21 (13.29%) sub-adult males, 14(8.86%) sub-adult female, 13 (8.23%) juvenile, and 13 (8.23%) were calves (Table 2, Fig. 3 and 4). The population density of Burchell's zebra in open woodland was 10.7 zebra/km^2, whereas

on open grassland 6.94 zebras/km^2 (Table 3). This also showed that Burchell's zebra was more abundant on open woodland than that of the open plain grassland.

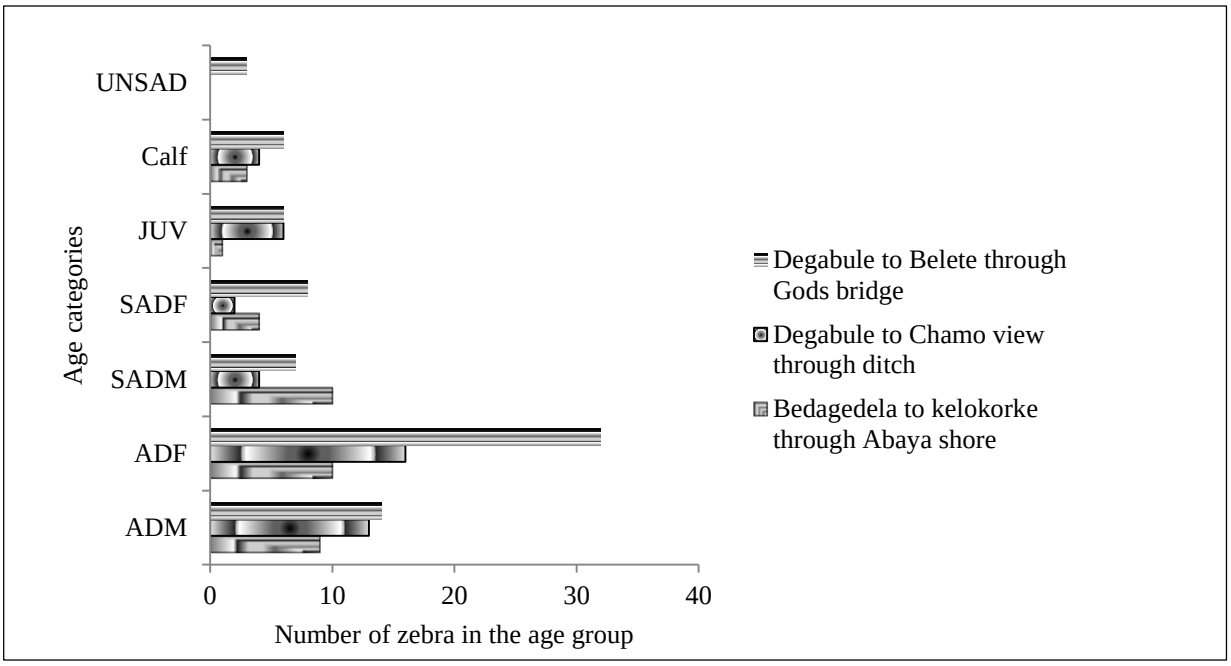

Figure 3. Age categories of sampled Burchell's zebra in Nechisar National Park

Table 1. Number of herds/individual Burchell's zebra counted on sample transects

Name of Transect	Number of herds/zebra cluster observed	Herds size/ Number of individuals per cluster	Total individuals counted
Bedagedela to Kelokorke through Abaya shore	11	6.9	76
Degabule to Chamo view through ditch	5	9	45
Degabule to Belete through Gods bridge	6	5.67	34
Total	22		155

Table 2. Age and sex categories of sample Burchell's zebra

Transect	Distance of transect (km)	Total observation	Observation by age category						
			ADM	ADF	SADM	SADF	JUV	Calf	UNSAD
Bedagedela to Kelokorke through Abaya shore	12.44km	34	9	10	10	4	1	3	0
Degabule to Chamo view through ditch	11.3km	45	13	16	4	2	6	4	0
Degabule to Belete through Gods bridge	14.8km	79	14	32	7	8	6	6	3
Total	38.54	155	36	58	21	14	13	13	3

Key: ADM: Adult Male ADF: Adult Female SADM: Sub-Adult Male SADF: Sub-Adult Female UNSAD: Unknown Sub-Adult JUV: Juvenile

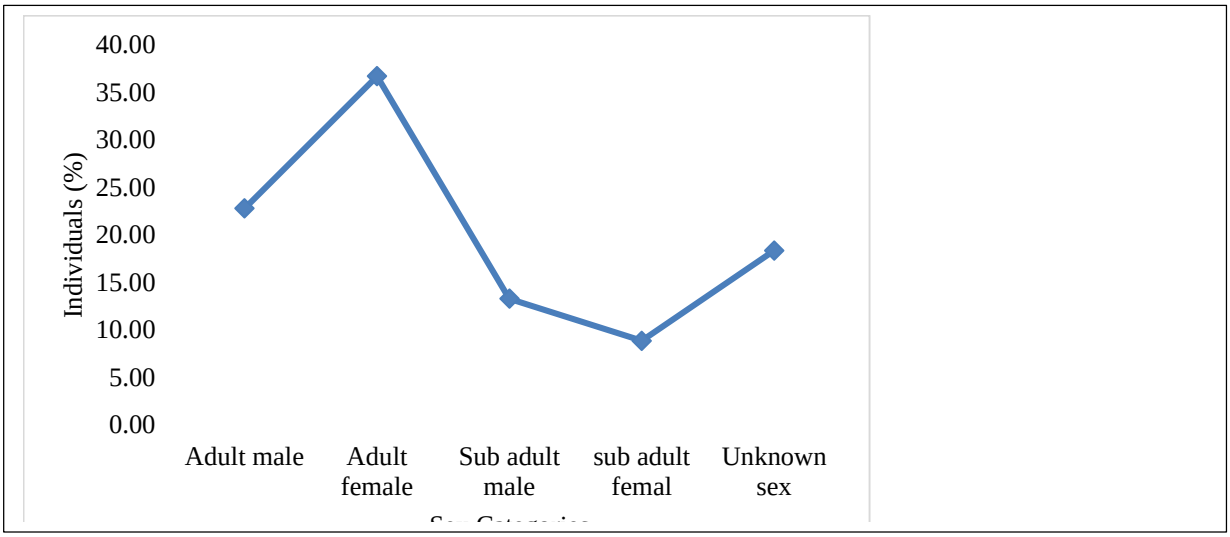

Figure 4. Sex categories of sampled Burchell's zebra in the study area

Table 3. Habitat preference and relative abundance of zebra

Habitat type	Transects	Number zebra sighted	Transect distance (km)	Density (km^2)
Open grassland	Transect 1 and 2	79	23.74	6.94
Open bushland	Transect 3	76	14.8	10.7

Discussion

Estimating the population status, distribution, and abundance of Burchell's zebra, which is the flagship species of the Nechisar National Park, at southern Great Rift Valley is very important to take a conservation measure for the proper management action of that population and other exiting large mammalian species of the area. During the counting period, a total of 158 individuals were observed in the study area. The sex ratio of an adult male to adult female of Burchell's zebra was 0.6:1.0, and the age ratio of adult to young was 1:0.65. This is similar to that of the study done in Yabello Wildlife Sanctuary on the same animal by Regassa and Yirga (2013). Doku *et al*. (2007) explained that the female-biased sex ratio and the somewhat high ratio of young in the animal population indicate a healthy and growing Burchell's zebra population in Nechisar National Park.

The population size we found using the sample transect line is not significantly different from population size counted using total count in the study area during the wet season just before one month of this count. The population size found using the total count is 1,976, whereas our finding using the sample transect method is 2,267. Differences in the counts of zebras in the three transects have most likely resulted from Burchell's zebras' tendency to seek the habitat with an adequate supply of nourishment. This implies that more zebras were found where a good quality of the grass is accessible. The relative abundance of animals is naturally associated with a preference towards a given habitat. This depends on what the habitat provides in terms of food, breeding site, protection from predators, overheating, and cold and free space. This is mainly due to competition of feed by a large number of cattle on open grassland by the Gujii community. In contrast, relatively the open woodland is free from cattle grazing due to its inaccessibility by Guji pastoralists (NSNP 2019). Following our findings, Doku *et al*. (2007) discussed that the habitat requirements of the zebra in the Nechisar National Park are directly related to the availability of water and grasses suitable for eating. In the present study, zebra were never

observed browsing herbs and shrubs. While the investigation of Lamprey (1963) in the Tarangire Game Reserve, Tanganyika indicated that the majority (92.5%) of the zebra forage depends on the grass, while the rest on herbs and shrub plant species.

Due to the rapid agricultural land expansion, substantial degradation of grazing lands, clearing activities of the forests, production of charcoal, conversion of the habitat due to invasive plant species, and the conflict between the park management and the settler for the natural resources of the area and water the flora and wild mammalian species including the keystone Burchell's zebra of the park are gradually declining from time to time (Temesgen and Warkineh 2018). Chanie and Tesfaye's (2015) studies also indicated that fuel-wood collection, illegal fishing, and charcoal production are some of the main challenges of biodiversity in Nechisar National Park. The studies of Fetene *et al*. (2014) indicated that the forest and grassland mean size area of Nech Sar National Park has declined due to habitat loss and fragmentation. The increase in habitat destruction has a negative effect on the home ranges of the large mammals in the area, which leads to species loss and local extinction as evident to the endemic endangered Swayne's hartebeest of the park, which is currently not seen at all in the whole area of the park and locally extinct as witnessed during the study stay and the park management staff (NSNP 2019).

The main reasons for the decline of key wildlife species such as the loss of Swayne's hartebeest over the past three decades in the Nechisar National Park area are human activities which are mainly related to the habitat loss and fragmentation, livestock overgrazing and human intrusions to the wildlife area by declining the quality of the grass, and the competing tribal groupings of the Guji-Oromo and the Kore farmers claiming parts of the Parkland for livestock grazing, farming activity, and residence (Sebata 2017, Regassa and Yirga 2013, Bedane *et al*. 2020). According to NSNP (2019), human settlement into the surrounding natural habitat had a deep impact on the existing wildlife species.

The Nechisar grassland plains in which the grazing wildlife, including the keystone Burchell's zebra depends upon, are invaded by alien invasive woody species (Fig. 5). According to Yusuf *et al*. (2011), the density of woody species and their cover, bare land cover, and unpalatable forbs were considerably going higher in the greatly grazing grassland plain of zebra and other terrestrial mammalian herbivores. They observed that among the encroaching woody species inside the plain of Nechisar National Park, *Acacia nilotica*, *A. mellifera*, *A. senegal*, and *A. oerfota* covered the fertile hillside areas of the grassland plain, whereas the bunch of *Dichrostachys cinerea* and Arn. (Fabaceae) occupied the alluvial and clay soils of the flat plain of the Park area. According to their explanation, Hayne was amongst the main woody species in the grassland plain. The grazing wild mammals, including the Zebra species, are affected due to the shortage of palatable grasses.

Conclusion

The study showed that the population structure of Burchell's zebra is in a good status both in terms of age and sex categories mix. The same is true for the density and population number for the sustainability of the population. Whereas, the habitat preference and relative distribution of the Zebra showed that open woodland area is more preferred than that of the open grassland habitat, which is more suitable for the Zebras' grazing access. This shift of the habitat is currently more essential foraging resources found on the open woodland habitat than that of the open grassland, which mainly resulted in the competition of the grazing and other foraging resources by the livestock of the local community. The other major factor that is affecting the availability of pasture land on the open grassland is the encroachment of invasive weeds and encroacher woody plant species. Therefore,

park management should implement various management measures to improve open grassland habitat for improving the conservation status of Burchell's zebra and other species existing in the southern Great Rift Valley of Africa.

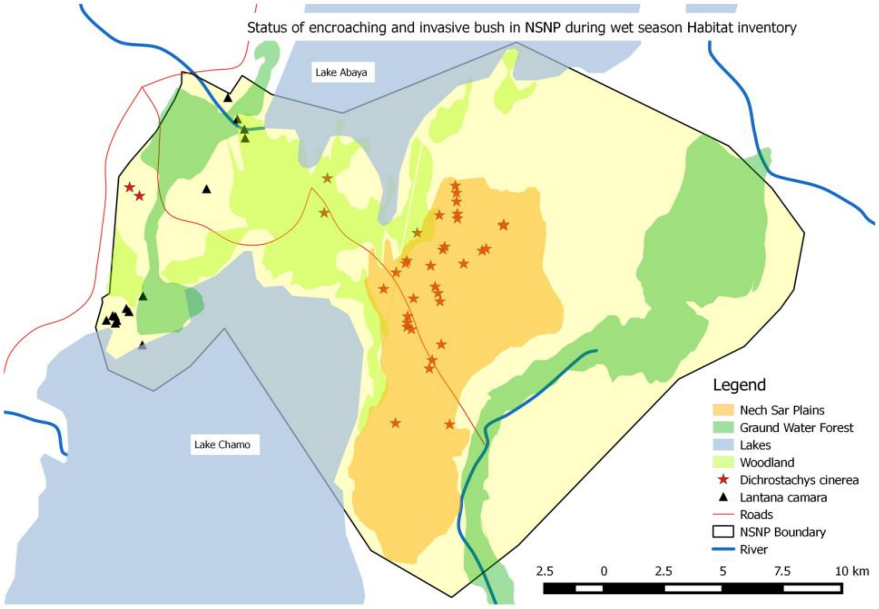

Figure 5. Encroachment of alien invasive woody species in the study area

Based on the above findings, the following suggestions recommended as a conservation measure of the studied animals and their habitat: (i) re demarcation of the park to reduce external pressure, mainly grazing pressure on wildlife and their habitats, Ethiopian Wildlife Conservation Authority (EWCA) could take the leading role; (ii) application of integrated invasive plants management and control measures in the park; (iii) establishment of law enforcement support groups/park advisory committee from the community around the park to fight illegal activities with the community; and (iv) implement enhanced ecological monitoring system to monitor conservation threats and biodiversity status and also to evaluate the effectiveness of management actions and to realize adaptive management.

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