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EFFECTOF ELEPHANTS AND OTHER UNGULATES ON THE VEGETATION IN SERENGETI NATIONAL PARK IN TANZANIA

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ABSTRACT

This study assessed the effects of elephants and other ungulates on the vegetation in Northern Part of Serengeti National Park (SENAPA) in Tanzania. This study is peculiar since it assessed the effects of elephants and other ungulates on the vegetation in Northern Part of SENAPA which is missing in the literature. The objectives were to determine plant species composition in the Northern Part of SENAPA, examine the effects of elephants and other ungulates on vegetation in the Northern Part of SENAPA and determine plant species damaged by elephants and other ungulates in the Northern part of SENAPA. The study adopted descriptive explanatory research design. Data was collected by transect walks, interviews, questionnaires, observations and documentary literature review. The data were organized and analysed using Statistical Package for Social Sciences Computer Program Version 22, Micro-Soft Excel and content analysis. Findings indicated that, the most plant species composition in the northern part of Serengeti National Park were Vachellia xathophloea, Senegalia polycantha, Shrub vegetation, open savanna grassland and woodland species, Vachellia tortilis, Vachellia drepanolobium, Sclerocarya birrea, Lannea schweinfurthii, Vachellia Africana, Commiphora species, Brachystegia species, Salvadora persica and Vachellia nilotica. Effects of elephants and other ungulates were manifested in the death of grasses and vegetation structure, uprooting of plants, breaking tree branches, toppling of trees, stripping barks of trees and seeds dispersal. Furthermore, findings revealed that, different plant species were damaged by ungulates between paths or trails and habitats. The conclusion from the study is that, elephants and other ungulates (giraffe, rhinoceros, wildebeest, hippopotamus and buffalo) negatively affect the vegetations in SENAPA. Therefore, the study recommended the need for plant species inventory and close monitoring of changes in vegetation composition and structure and the construction of an artificial water point in the northern part of SENAPA which will reduce the impacts of elephants and other ungulates on vegetation.

Keywords: Elephants, ungulates, SENAPA, vegetations, dry seasons, Tanzania

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INTRODUCTION

According to Mendoza *et al*. (2002), ungulates are hoofed mammals. *Ungula* is a Latin word meaning hoof. Amongst others, large ungulates are black rhinoceros (*Diceros bicornis*), giraffe (*Giraffa camelopardalis*), eland (*Taurotragus oryx*) and the smallest ungulate, the damara dik-dik (*Madoqua kirkii*). Vegetation is a plant, while vegetation community is a group of plant species within a geographical unit that is distinguishable from other types of vegetation patches(Petersen *et al*., 2004).The provision of water in wildlife management areas is one of the essential management practices. Ungulate communities, vegetation covers and waterholes form the major part of the environment with a significant role in

controlling the ecosystem. According to James *et al*. (1999), the vegetation is not directly affected by the presence of water but is often affected by a large number of grazing and browsing animals and their activities around water holes.

The concentration of ungulate species around waterholes is more prominent during thedry seasons,resulting in the extinction or dying ofvegetation used by the elephant and other ungulate communities(Lange, 1969). Ungulates tend to play, fight and feed on vegetation around water holes before and/or after drinking (Brits *et al.,* 2002). According to Makhabu *et al*. (2002), the concentration of ungulates around waterholes leads to soil trampling and vegetation degradation. Water provision in savannahs and semi-arid environments determines the distribution and abundance of wildlife on a specific landscape. This is because water is essential for all living organisms (Hagwet *et al*., 2014). It has been observed that,the distribution and quality of water is a prerequisite factor that influences the carrying capacities of wildlife in savannahs and semi-arid ecosystems *(*Kamanda*et al*., 2008). Globally, large herbivores have a major impact on vegetation dynamics in ecosystems, ultimately influencing ecosystem processes, species composition and distribution (Chamaillé-Jammes *et al.*, 2007).

The African elephant (*Loxodonta Africana)* has been reported to cause damage to different species of trees in various protected areas in Africa (Nahonyo, 1996) and other ungulates. Elephants (*Loxodonta africana*) are known as ecosystem engineers which play an important role in changing vegetation structures and compositions of African savannahs (Valeix *et al*., 2007). Hagwet *et al.* (2014)carried out a study on the impacts of grazing ungulates on vegetation and soils in areas closer to waterholes in Serengeti plains and discovered that during dry seasons, animals spend more time around and utilising vegetation in areas close to waterholes. Despite the mentioned studies, nothing is known about the effects of elephants and other ungulates on vegetation in the Northern Part of Serengeti National Park. This paper assessed the effects of African elephants and other ungulates on vegetation in the Northern Part of Serengeti National Park in Tanzania. The following objectives underpin the study; to determine plant species composition in the Northern Part of SENAPA, examine the effects of elephants and other ungulates on vegetation in the Northern part of SENAPA and determine plant species damaged by elephants and other ungulates in the Northern part of SENAPA.

MATERIALS AND METHODS

This study was carried out in Serengeti National Park in Tanzania located in the north-western part of the country (Figure 1). SENAPA has a mild and dry climate, with average temperatures ranging from 15 to 25 degrees Celsius. Descriptive-explanatory research design was adopted whereas the target population of this study was SENAPA staff and Serengeti residents/ villagers. A plot-based spatial sampling design was adopted to gather data on species composition for objective i. For examination of the effects of the elephants and other ungulates on vegetation, this was done by observation coupled with site visitation(for objective ii).In determining plant species damaged by elephants and other ungulates in the Northern part of SENAPA (objective iii),the study collected data using questionnaires, in-depth interviews, focus group discussions, site visits, observation and transect walk. The transect walk coupled with observation and in-depth interviews was done in collaboration with wardens, tour guides, ecologists and park managers. Direct observation was useful because the researcher had an opportunity to visit and observe the general situation of the effects of elephants and other ungulates on vegetation around the study area physically. Moreover, a desktop review of the literature was undertaken to interrogate the conservation implications identified in the study areas, such as a change in species composition, species diversity and evenness with distance from the waterholes at the study waterholes/ water points. Data collected were analysed using SPSS, Micro-Soft Excel and Content analysis presented in tables, figures, and plates and verbatim. SENAPA was selected for this paper because of the following three key reasons: (i) it has vast vegetation and high ungulate distribution (ii) debarking of trees and tree felling was observed in a different part of SENAPA (iii)has the

wildebeest (nyumbu), which are ungulate that moves in communities from SENAPA to Maasai Mara Kenya for breeding. Wildebeest move in packs/ groups when migrating. These are three reasons which influence the selection of SENAPA for this study.

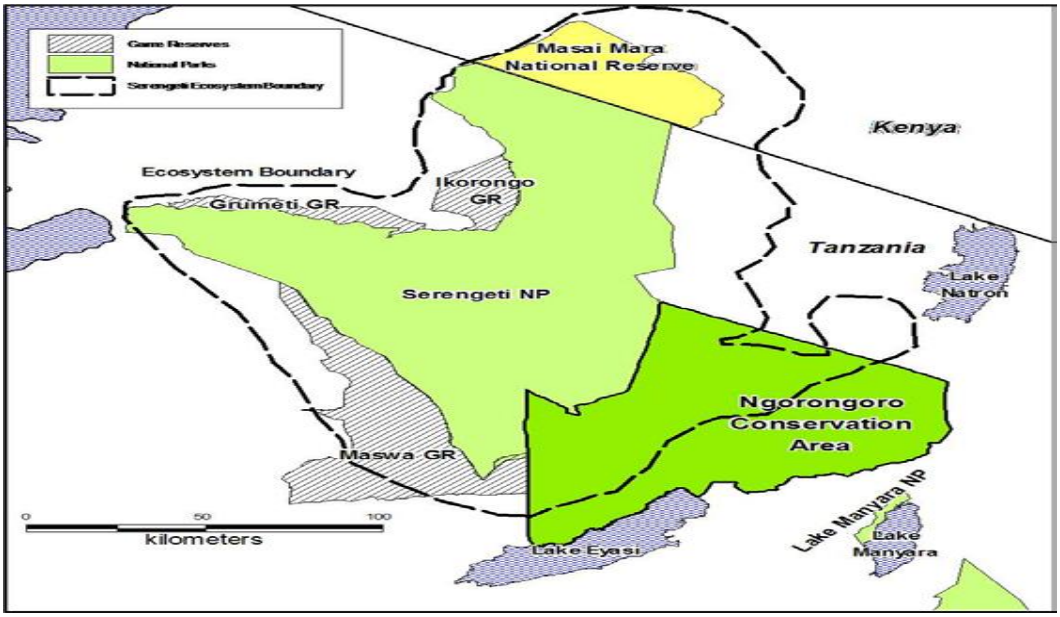

Figure 1: The Serengeti National Park
Source: Africa Safaris, 2019

RESULTS

Plant species composition and diversity in the Northern Part of SENAPA

The first specific objective of this paper was to determine plant species composition and diversity in the Northern part of SENAPA. Respondents were provided with a list of plant species composition in the Northern Part of SENAPA and asked to tick the most species they found in the park (Table 1). Table 1 present species composition identified in the study area. It was disclosed that, the most dominant species found in the Northern Part of SENAPA were *Acacia drepanolobium* mentioned by 32% of the respondents. The second specie mentioned after *Acacia drepanolobium* was *Acacia tortilis* mentioned by 13% of the respondents. Other species mentioned or identified in the study area are presented in Table 1.

Table 1: Plant species composition found in the Northern Part of SENAPA

Species composition	Frequencies	Percentages
Acacia drepanolobium	38	32
Acacia tortillis	16	13
Shrub vegetation	14	12
Open savannah grassland	11	9
Acacia Africana	10	8
Acacia polycantha	8	7
Acacia xanthoplea	7	6
Acacia nilotica	5	4
Brachystegia spiciformis	5	3.8
Commiphora Africana	3	2.2
Sclerocarya birrea (Marula tree)	2	2
Salvadora persica	1	0. 5
Kigelia africana	1	0. 5
Total	**120**	**100**

The ordination pattern indicated a low gradient score at Ololosokwani (unprotected site), which was indicative of a less disturbed condition than it was for sites in the protected areas, which were Lobo, Togoro, Tabora B and Lamai sites at the central part of SENAPA. Both protected and unprotected areas were characterised by various vegetation types that form a typical savanna woodland, wooded grassland or savanna grassland with an obvious difference in plant species composition between them. Inside the protected areas around Tabora B was a conspicuous woodland community represented by *Kigelia Africana*, and *Commiphora Africana* whereas a large part of Lobo site in SENAPA was dominated by *Acacia drepanolobium, Acacia Africana, Acacia xanthophlea, Acacia polycantha, Acacia nilotica and Acacia tortilis*. The Lamai and Togorositesare the protected areas dominated by *Brachystegia* and open savanna grassland with a few scattered trees. Ololosokwani and Kibeyo sitesare unprotected areas dominated by *Acacia drepanolobium*. The Ololosokwani woodland is a valuable habitat for large mammals like elephant species, wildebeest and giraffes in the northern part of the Serengeti ecosystem. The protected areas were commonly represented by native plant species with a few colonising species due to fire and wildlife disturbances. However, in the unprotected areas, weeds mostly colonise big plant species. In the Northern Part of SENAPA few stands of indigenous species and crops constituted the common plant species were found in some places.

Field results showed that distance has no significant effect on species composition around the waterholes in the Northern part of SENAPA.Results further revealed that the number of plant species increases with distance from the waterholes. However, there was a strong correlation between species observed and distance ($r= 0.6827$, $p= 0.0045$), i.e. there was an increase in the number of plants species with reference to increased distance from the waterhole. The study showed that there was a high number of species recorded at distances between 0 m to 1000 m from the waterholes. The number of species was almost the same at all distances except from 1300 m to 1800 m from the waterhole, where the number of species fluctuated. Overall, there was no significant variation between waterholes in species composition in the study area to the distance ($p =0.103$, $K =4.54$, $df =2$).

Effects of elephants and other ungulates on plant species

The second objective of this paper was to examine the effects of elephants and other ungulates on habitats and species in the Northern Part of SENAPA (Table 2). The effect of elephants and other ungulates on habitats and plant species was more serious during the dry seasons than rainy seasons. Table 2 presents the mean scores of the effects of elephants and other ungulates in their habitats during the dry season in the Northern Part of SENAPA. Averages were added and divided to the total number of effects associated with their habitats and came up with 4.01, a total mean, which stands high as per the Likert Scale i.e. 3.4 – 4.1 (Table 2). From this background, the researcher established the effects of elephants and other ungulates in their habitats during the dry season in the Northern part of SENAPA. As per interviews with ecologists and wardens, plant species which are mostly affected by elephants were *Acacia trees, Acacia tortilis, Acacia drepanolobium, Kigelia trees*, shrub vegetation, open savanna grassland, and woodland vegetation, *Acacia polycantha, Marula trees, Acacia Africana, Commiphora species, acacia xathophlea, brachystegia species, salvadora pelca* and *Acacia nilotica.*

Table 2: Effects of elephants and other ungulates on vegetations and habitats

Effects	Mean	Rank
Extinction of elephants preferred plants	4.42	1
Elephants and other ungulates continuous movement have led to the death of grasses	4.38	2
Elephants and other ungulates feeding behaviour changed woodland vegetation to open grassland vegetation	3.94	3
Elephants and other ungulates contributed to the change of vegetation structure composition within the park	3.70	4
Elephants and other ungulates uproot roots, break tree branches, topple trees, strip barks of trees, disperse seedsand change their habitats	3.62	5
Total mean	4.01	High

Key: Rating scale

Mean Range		Response made	Interpretation
1.	1.0-1.8	Strongly Disagree	Very Low
2.	1.9-2.5	Disagree	Low
3.	2.6-3.3	Neutral	Moderate
4.	3.4-4.1	Agree	High
5.	4.2-5.0	Strongly Agree	Very high

Findings indicate that theeffects of elephants have led to the total extinction of elephant's preferred plant species in their habitats. The mean per this finding was 4.42 rated by respondents, which is very high per the Likert Scale (Table 2). This view was supported by the majority (85%) of the respondents who strongly agreed with the statement while 15% disagreed. Similarly, elephants and other ungulates continuous movement contributed to the death of grasses within their habitat. This reason was ranked 2 with a mean of 4.38 (Table 2), as per the Likert Scale. This result is strongly agreed by 78.2% of the SENAPA staff and residents, while 22.8% of them disagreed with the statement. This finding implied that, to a large extent, drying of grasses within the park, apart from climatic factors, elephantsand other ungulates play a significant role in their death. In addition, elephants and other ungulates feeding behaviour have changed woodland vegetation to open grasslands; this was highly agreed upon, as shown by the mean of 3.94 in Table 2. Because of this, 68.3%and 31.3% of the SENAPA staff and residents found within a park agreed and disagreed with the statement, respectively. This implies that in most cases, open grassland within the Northern part of SENAPA has been affected by elephants, wildebeests, giraffes and other ungulates.

Elephants and other ungulates contributed to the change of vegetation structure composition within the park. The mean of 3.70means that, most respondents agreed that elephants and other ungulates contributed to the change of vegetation structure composition as presented in Table 2. Furthermore, other effects associated with elephants and other ungulates in their habitats included uprooting roots, breaking off trees, tree branches, toppling of trees, stripping barks of tree, seeds dispersal and habitat change as shown by a mean of 3.62, which stand for high consideration according to Likert Scale. The findings in Table 2 correlate with the findings from a study done by Eckhardt *et al*. (2000) who found that the ecological effects of toppling by elephants and other ungulates differ from pollarding (total breaking of the stem) in that the roots may be removed from the soil in which mortality is caused.

However, if the roots remain in the soil, many species can resprout for instance, *Combretum apiculatum.* Factors that influence species being toppled include the strength of the wood, the depth and extensiveness of the root system and substrate stability as noted by O'Connor *et al*. (2007), who postulates that *Commiphora* species

that are uprooted completely by elephants may also be greatly reduced in their prevalence by elephants, as has happened in Ruaha National Park, Tanzania (Barnes and Jensen, 1985). Similarly, Williams *et al*. (2004) contend that the impact of stripping on a plant species is dependent on the degree to which the bark is stripped. For example, ring barking in most cases results in mortality; if some phloem remains intact, the bark may re-grow. This may vary between species. For instance, Mopane, may lose up to 95% of the bark without visible signs of stress. Features of the tree influence their vulnerability to bestripped. For example, elephants can cause more damage to trees with stringy bark like *Acacia* species than those with bark that breaks off in chunks such as *Sclerocarya birrea*. The study done by Barnes (2002) acknowledged the effects of elephants on seeds dispersal though few studies explore elephant impact on seedlings. There is evidence for species-specific impacts. For instance, 35% mortality in *Acacia erioloba* in Chobe National Park, Botswana is the result of elephants and other ungulates. Elephants may cause mortality by ripping seedlings from the soil. Moreover, a study done by Chafota (2007) stressed that elephants might fall or uproot trees up to 60 cm in basal diameter. Sometimes they may feed on the branch tips or roots of these trees, but on other occasions they walk away from the fallen tree without feeding. It has been suggested that some of the trees falling may be a social display unrelated to feeding but this has proved hard to confirm.

Damages by elephants and other ungulates on the vegetationin the Northern part of SENAPA

The third objective of this paper was to determine the different damages by elephants and other ungulates on plant species between the water sources and their habitats in the Northern part of SENAPA. Table 3 presents damages by elephants and other ungulates to water sources and their habitats.

Table 3: Damage by elephants and other ungulates to the environment and plants

Statements	Mean	Std. Deviation
Elephants and other ungulates consume considerable amount of barks and roots of trees	4.28	0.643
Elephants and other ungulates consume high amount of water leading to drought	4.23	0.641
Elephants and other ungulates damage contribute trees debarked to vulnerable to fire	4.21	0.619
Total	**4.24**	**0.634**

The findings in Table 3 indicates that most of the respondents strongly agreed that there was very high plant damage by elephants and other ungulates between water sources, paths/trail and habitats in the Northern part of SENAPA, with a mean score of 4.24. The damage caused by elephants and other ungulates between water sources, elephant and other ungulates trail and habitat contributed very high to consumption of a considerable amount of barks and roots of trees, high utilisation of water sources as well as debarking of trees which make the area vulnerable to fire within the Northern part of SENAPA by the mean of 4.28, 4.23 and 4.21,respectively (Table 3). These results imply that the density of browsed and debarked plants around water points was high within the distances close to the water points and decreased with increasing distance from the water points in the study area. These findings corroborate with a study done by Fullman & Child (2013), which found that elephants preferred to browse near water points. Areas that are within a 1 km radius from water points are normally areas of high elephant utilisation (Simbarashe and Farai, 2015). An example of damage caused by elephants in SENAPA is presented in Plate 1 and Plate 2.

Plate 1: Tree debarking, damage caused by elephants

Plate 2: Barks tearing by elephants in Serengeti National Park

DISCUSSION

Several studies have pointed out the composition and diversity of plant species in the national parks (Mligo *et al.*, 2009). Tropical forests are species-rich ecosystems that are being depleted at very high rates (Myers, 2000). Water provision in savannahs and semi-arid environments determines the distribution and abundance of wildlife on a specific landscape as it is essential for all living organisms (Hagwet *et al*., 2014). Globally, large herbivores are known to have a major impact on vegetation dynamics in ecosystems, ultimately influencing ecosystem processes, species composition and distribution (Chamaillé-Jammes *et al*., 2007).

Feeding of the ungulate community (both grazers and browsers) in areas nearby water holes after drinking is their common behaviour, mostly in dry seasons when forage contains low moisture content than in wet (rainy) seasons. Subsequently, ungulates concentrate more on areas close to water holes than far away areas(Owen-Smith, 2008). This habit of ungulates eating near the water sources changes the plant species composition. As observed in

SENAPA like other national parks in the world, the Parkis composed of a diversity of plant species.

Various factors have attributed to the species composition as observed in the Northern Part of SENAPA. One of the factors affecting species composition in the study area was the disturbance of herbivores. A herbivore is an organism that mostly feeds on plants.The effect of herbivory on plant diversity leads to colonisation and extinction of plant species due to disturbances (Csergo *et al.*, 2013). Browsing and grazing animals cause a series of additional disturbances which are often overlooked in models of the impact of grazing on species diversity (Csergo *et al.*, 2013). For instance, trampling of animals can destroy soil porosity and increase soil density through compaction which may affect root development in plants. Trampling of animals may also cause a reduction in infiltration capacity which can cause a concentration of nutrients such as phosphorus from animal excreta in the topsoil which might affect seed germination.

The depletive effects of elephants and other ungulates have been described in several studies. According to Faison *et al*. (2016), large herbivores are leading drivers of terrestrial plant composition and dynamics and therefore important determinants of biodiversity and a host of ecosystem services. According to Magandana *et al*. (2020), indigenous grass species are often the most dominant plants because of their superior adaptation to stress and extreme conditions such as water stress and extensive grazing thus, preserving the rangeland's stability and productivity in semi-arid environments.

Several studies such as those done by Augustine & McNaughton (1998), Skarpe & Hester (2008) and Tashiya (2022),showed that abundant ungulates populations affect productivity and nutrient flow in different ecosystems. Ungulates can alter the flow of energy and nutrients by changing the community's plant species composition, altering the chemical composition of plant tissues during digestion; altering inputs from eaten plants to the soil due to changes in the root system or leaf litter quality, and altering plant and soil micro-environments. This means that the diversity of the plant communities in a grass-dominated waterhole area remained unchanged throughout the study done between January 2021 to November 2021 despite consistently being grazed and trampled upon by ungulates (Wilson, 2022).

CONCLUSION AND RECOMMENDATIONS

Findings of this study indicated that the plant species composition in the Northern part of Serengeti National Park were *Acacia xathophloea, Acacia polycantha,* Shrub vegetation, open savanna grassland and wooded vegetation, *Acacia tortilis,* Acacia *drepanolobium, Marula trees, Acacia Africana, Commiphora species, Brachystegia species, Salvadora pelca and Acacia nilotica*. The effects of elephants, wildebeest, giraffe and other ungulates during the dry season was high, ranging from the death of grasses, habitats change, vegetation structure change, uprooting of roots, breaking tree branches, toppling of trees, stripping barks of tree and seeds dispersal. These species are the most eaten by ungulates, and most of them are in danger of extinction in the near future.

To inform and guide conservation efforts in the Northern Part of SENAPA, further studies particularly concerning ecosystem-based measures to improve plant species diversity are highly recommended. Such measures could be incorporated in the SENAPA Management Plan or other relevant framework documents for the park to provide ecosystem-based adaptation and restoration measures. Ungulates such as elephants are characterised by unique foraging behaviours including non-herbivory related destruction of plants. Based on the findings and discussions, the following recommendations are proposed:

- A possible intervention to control the effects on the vegetation such as to destock elephants and other ungulates in the area of the game through translocation to allow for the vegetation in the area to recover or regenerate.
- To inform and guide the conservation efforts in the study areas as a whole, further studies concerning ecosystem-based

measures to improve species diversity is highly recommended.

- Except for the existing water provisional points, waterholes should be evenly distributed. New waterholes should be createdin open areas with low vegetation cover to avoid vegetation losses. The creation of more waterholes will eliminate the prolonged collection of ungulates around waterholes during drinking periods.
- Furthermore, artificial waterholes should be closed during rainy seasons when ample water is present in water puddles in the field to allow vegetation recovery around waterholes and maintain resilience.
- Lastly, the study recommends that plant species inventory and close monitoring of changes in vegetation composition and structure should be done and documented for the future references.

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