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THUTO KE THEBE
UNIVERSITY of BOTSWANA
Okavango Research Institute

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Southern African Science Service Centre for Climate Change and Adaptive Land Management

The Savuti-Mababe-Linyanti ecosystem of northern Botswana: policy implications for management and conservation of an unmodified ecosystem of global scientific significance

Richard W.S. Fynn

Okavango Research Institute, University of Botswana, Maun, Botswana.

Introduction

The Savuti-Mababe-Linyanti ecosystem (SMLE) consists of extensive woodland landscapes between the Okavango Delta and the Linyanti Swamps (Figure 1) and has a great diversity of seasonal habitats from the extensive pristine wetlands of the Okavango Delta and the Linyanti Swamps to extensive pristine mopane, sandveld and riparian woodlands, as well as the extensive open grasslands and savanna of the Mababe Depression (see the Vegetation and Wildlife Habitats of the Savuti-Mababe-Linyanti ecosystem - Sianga and Fynn in review; Figure 1). This great heterogeneity in functional seasonal habitats, combined with few barriers to wildlife movement and little modification by artificial water, results in exceptional niche diversity for wildlife, which supports great diversity of wildlife and key populations of rare species such as wild dog, roan and sable antelope and eland. A key factor underlying the functional nature of the landscapes of the SMLE is that a large proportion of the woodland landscapes occur greater than 15km from water during the dry season, well beyond the maximum foraging distance from water of the more mobile bull elephant herds (and other large herbivores). This large distance from available water during the dry season creates a spatial refuge in these landscapes where vegetation is spared from excessive impact and degradation by large herbivore populations and also provides niches for rare herbivores that are dependent on these back-country woodlands far from water, such as roan and sable antelope and eland. Of interest is that the greatest proportion of the SMLE is outside of Chobe National Park and Moremi Game Reserve, being mainly in the wildlife management areas of NG 14, 15, 16, 18, 20, 21, 22, 23 and CH1,2. This emphasizes that wildlife management areas play a critical role in maintaining the functional nature and wildlife diversity of the northern conservation area of Botswana.

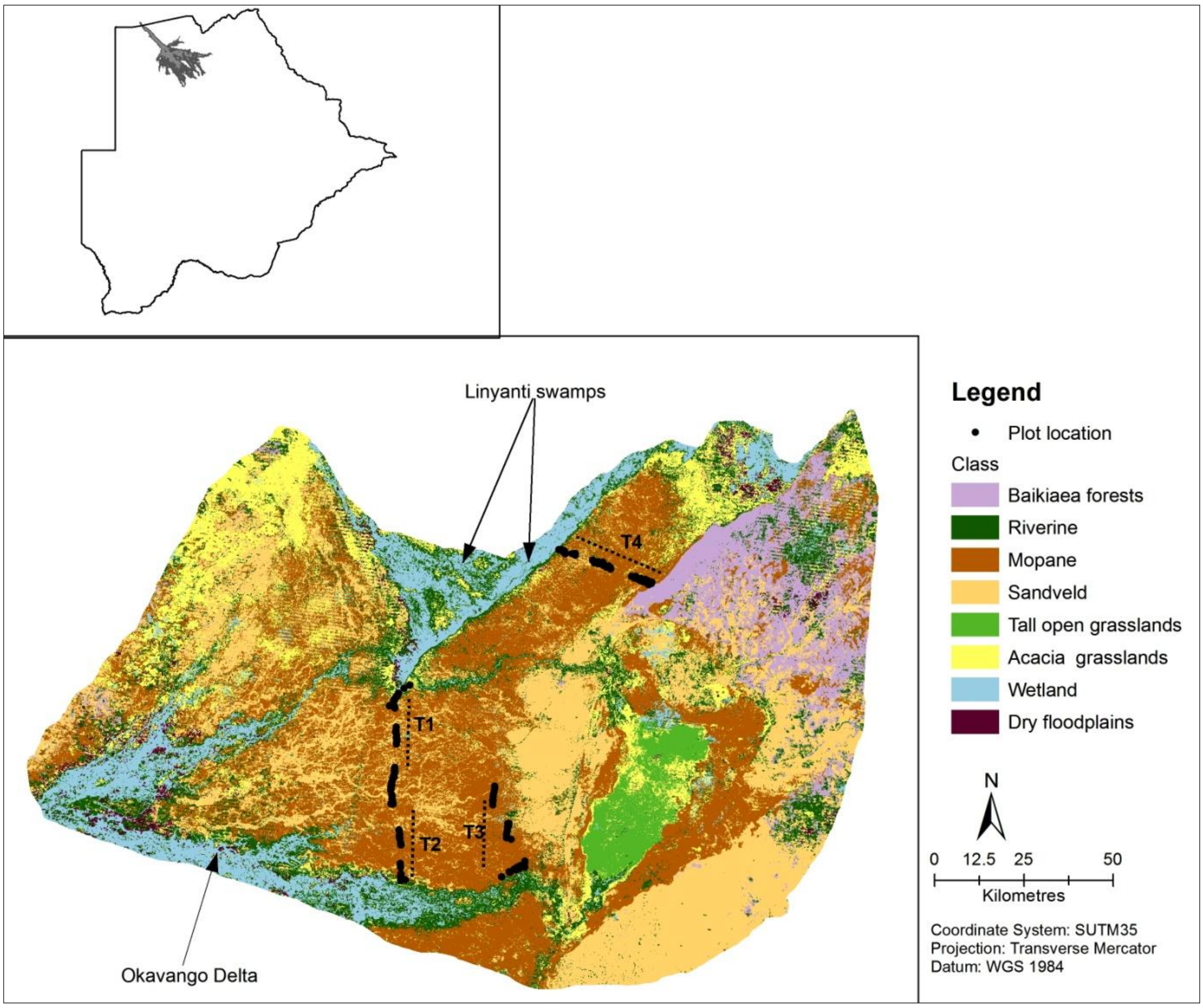

Figure 1. Vegetation map of the study area showing the transect locations (T1-4). From Sianga and Fynn in review.

The African elephant (*Loxodonta Africana*) is particularly notorious for its effects on woody vegetation and there is much concern that growing elephant populations may negatively influence ecosystem function and diversity in protected areas (Cumming et al. 1997) and have even been proposed by some (Thomson 2011) to be responsible for the observed declines of several herbivore populations in northern Botswana. Elephants are strongly constrained in their ability to access food by water availability, with bulls generally limited to foraging within 15 km and cow-calf herds to within 5 km of water (Young & Van Aarde 2010). As a result plants further from water are likely to experience less frequent damage by elephants than those closer to water. Thus areas further than the viable foraging range of elephant from water (> 15 km) are likely to represent a spatial refuge from elephant impact (and from impact by other large herbivores such as hippo, buffalo, zebra, wildebeest, impala and warthog). Also of importance, the SMLE is an open system being part of the vast northern conservation area of Botswana, which is one of the few remaining open wildlife systems in Africa where there are few fences and settlements restricting movement (> 80 000 km^2 on the Botswana side and extending into protected areas in Namibia and Zimbabwe). The northern conservation area supports the largest elephant population globally at around 130 000 (Chase 2011). In extensive unfenced savannas, where large scale heterogeneity in water availability and vegetation types exists, elephants are constrained on where they may forage during the dry season but have greater ability to shift their foraging away from over-utilized areas, thereby allowing heavily utilized vegetation to recover. Thus the vast open nature of the SMLE combined with its pristine unmodified landscapes, is expected to promote greater resilience under large elephant and other herbivore populations than many other protected areas in Africa where a large amount of artificial water provision has reduced the effectiveness of spatial buffers across landscapes and where fences and other barriers impede herbivore movement.

In this document I summarize studies on elephant (and other large herbivore) impacts on vegetation and how large herbivores respond to these effects. Through strategic funding from the German government via the TFO and SASSCAL projects, ORI has made the SMLE a focal area of research with a wide range of herbivore and vegetation studies having been conducted over the last five years. A key project has been the development of a detailed vegetation map and vegetation classification of the SMLE (Sianga and Fynn in review; Figure 1), which has included a study of herbivore impacts on the vegetation of the landscapes of the region (Sianga et al. in review; Figure 1). This has enabled a better understanding of the ecology of the region and allows formal analyses of wildlife habitat use studies to be conducted – thus this study now provides a foundation upon which further research in the SMLE can be built. This detailed vegetation and habitat spatial data will be made available in the public domain for use by researchers, conservation practitioners and other stake holders.

For the large herbivore impact study, researchers and students from the Okavango Research Institute (Maun, Botswana) and Wageningen University (Netherlands) conducted a study to examine how elephants and other large herbivores may impact vegetation at different distances from permanent water in the landscapes of the SMLE (Sianga et al. in review). Four large transects perpendicular to the permanent water sources of the Linyanti Swamps and Okavango Delta (Figure 1) were sampled during the wet season (from January to end of March 2014). Each transect was divided into three distance zones: near zone (0-5 km), intermediate zone (10-15 km) and a far zone (> 20 km; up to 27 km) from permanent water (Figure 1). Thus, our four large transects represent landscapes with > 40 % of their total area being beyond the maximum foraging distance of elephant from available water during the dry season. We controlled for environmental effects by selecting only mopane woodland and sandveld woodland as these are dryland plant communities that occur in all three distance zones. Thus we avoided the confounding effects of soil type and soil moisture by keeping vegetation and soil types constant along the large transects. In each distance zone from permanent water we sampled herbaceous and woody vegetation using the point centre quarter method (woody species), 40 x 20 m releve plots (herbaceous and woody diversity) and 1 x 1 m quadrats (grass cover).

Findings

Richness

We found that in sandveld woodland grass and forb richness was higher in the near zone from permanent water (0-5 km) than far from permanent water (>20km), whereas mopane woodland showed the opposite trends. Grass and forb richness increased with increasing elephant dung count (a reliable index of elephant density) in sandveld woodland but showed the opposite trend in mopane woodland. Greater richness in the near zone (or with greater elephant density) of sandveld woodland is because greater grazing and trampling effects in the near zone in more productive sandveld woodland prevents large grass species from excluding small grass and forb species but in less productive mopane woodland grazing and trampling effects increase environmental stress and thus reduce richness (a globally observed response of richness to herbivory on productivity gradients – e.g. Bakker et al. 2006). Tree richness had no significant relationship with distance zone from permanent water or with elephant dung count.

Grasses

High-quality perennial grasses such as *Digitaria eriantha* were more abundant in the far zone (around 25 % cover) than near zone (around 12 % cover) from permanent water, whereas high-quality annual grasses such as *Urochloa trichopus* were more abundant in the near zone (around 18 % cover) than the far zone (around 3 % cover) (Figure 2).

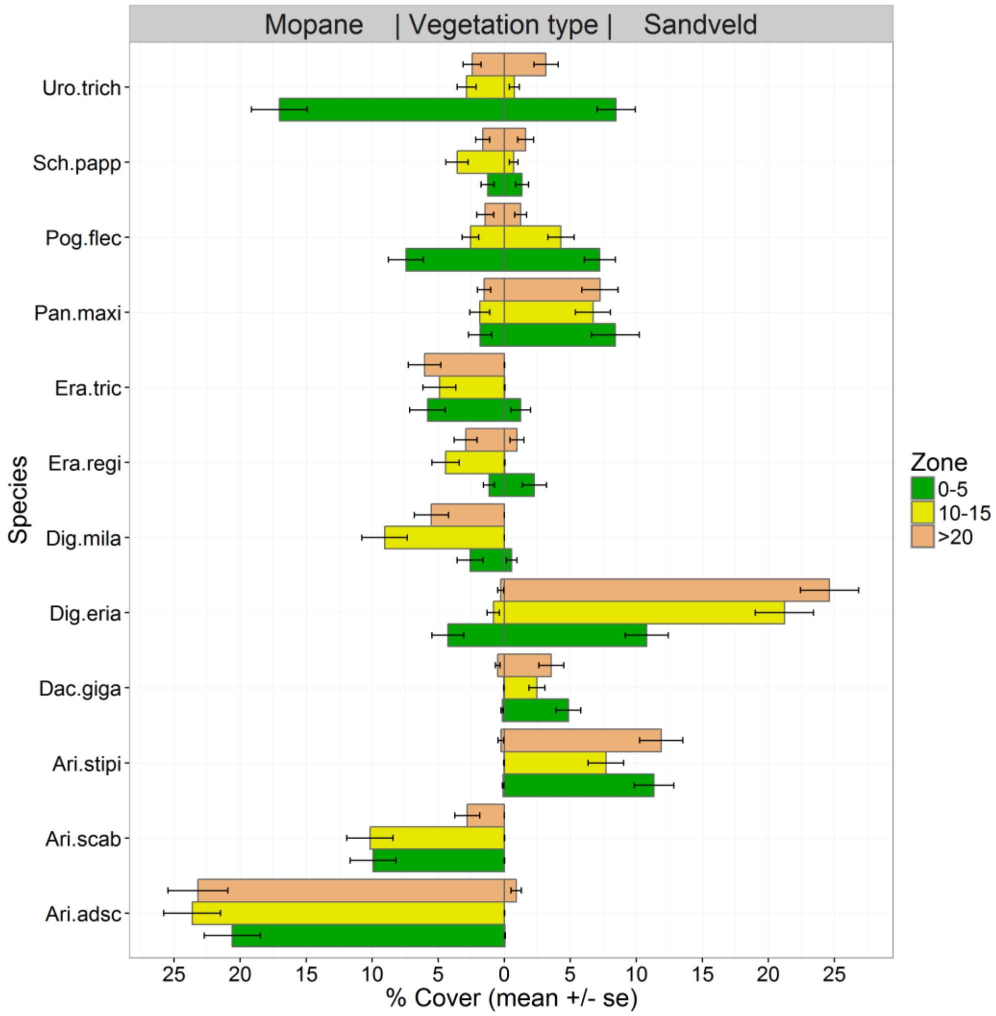

Figure 2. The relationship between the cover of the major grasses of the study area and distance zone (0-5km, 10-15km and >20km) from permanent water. Ari.adsc = *Aristida adscensionis*; Ari.scab = *Aristida scabrivalvis*; Ari.stipi = *Aristida stipitata*; Dac.giga = *Dactyloctenium giganteum*; Dig.eria = *Digitaria eriantha*; Dig.mila = *Digitaria milanjiana*; Era.regi = *Eragrostis rigidior*; Era.tric = *Eragrostis trichophora*; Pan.maxi = *Panicum*

maximum; Pog.flec = *Pogonarthria fleckii*; Sch.papp = *Schmidtia pappophoroides*; Uro.trich = *Urochloa trichopus*. From Sianga et al. in review.

Trees

Tall individuals (> 4 m) of favoured woody species during the dry season, such as *Terminalia sericea*, were more abundant in the far zone (around 60 % probability of occurrence at a sampling point) than the near zone (around 2 % probability of occurrence) from permanent water (Figure 3).

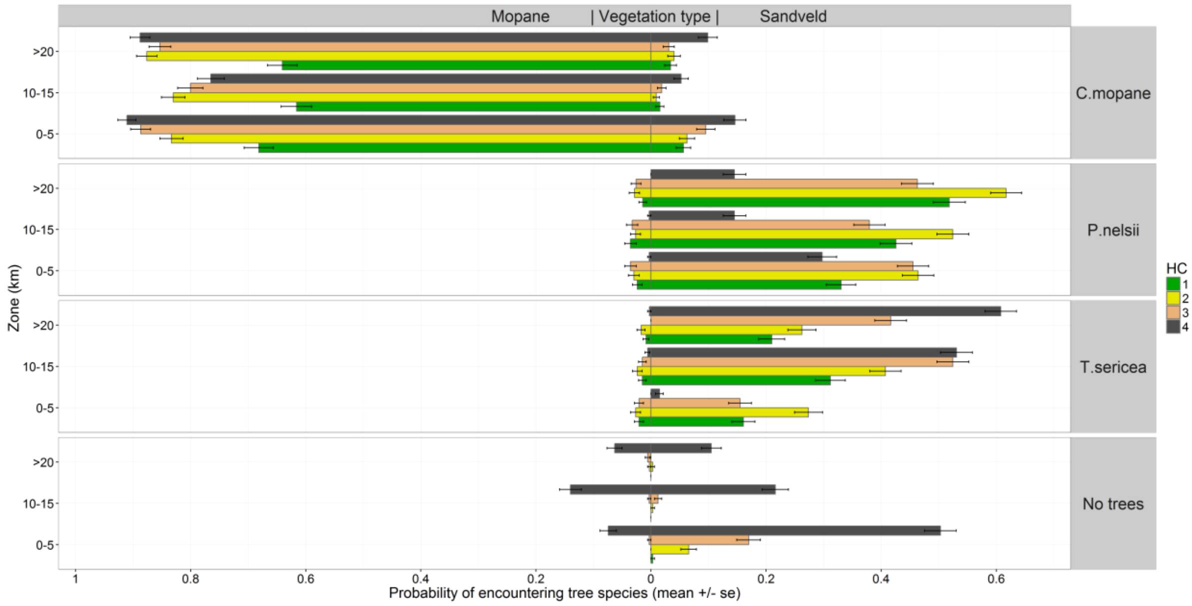

Figure 3. The probability of encountering at a sample point a tree of a specific height structure (1 = 0-1m; 2 = 1-2m; 3 = 2-4m; 4 = >4m) in a specific distance zone (0-5km, 10-15km and >20km) from permanent water. T.sericea = *Terminalia sericea*; P.nelsii = *Philenoptera nelsii*; C.mopane = *Colophospermum mopane*. From Sianga et al. in review.

Thus we found that those areas of the landscape beyond 15-20 km from permanent water provide spatial refuges from excessive impact for plants favoured by large herbivores and this suggests that spatial refuges buffer savanna landscapes against homogenization and degradation by large populations of herbivores, but rather facilitate creation of spatial heterogeneity in plant richness, composition and structure. We found no evidence that the large elephant population of the region has degraded forage resources for herbivores but rather has created spatial heterogeneity across landscapes in the distribution of plant richness, short and tall high-quality grasses and woodland structure. This is likely to improve adaptive foraging options for herbivores (Owen-Smith 2002) and promote greater niche diversity and herbivore coexistence and diversity. Thus claims by some people that elephant have degraded habitats for herbivores and are responsible for the observed declines of some herbivore species in northern Botswana (see Thomson 2011) are not supported by the scientific evidence provided by our study and can be confidently discounted.

In addition, studies on roan antelope (Haveman 2014), sable antelope (Hensman et al. 2013) and buffalo (Sianga 2013) conducted in the same region as this vegetation study show that these herbivore species use areas far from water (> 10 km) during the wet season (buffalo) or over large parts of the year (sable and roan antelope). This is because (1) their favoured high-quality grass, *D. eriantha*, is most abundant far from water (Figure 2) and (2) because lion densities are much lower far from water. Thus rare antelope such as roan and sable are able to find a refuge from predation far from water, which is critical for the well being of their populations (Harrington et al. 1999). Placement of artificial water out in the back-country woodlands of the SMLE will enable elephant and other herbivores to spend all year out far from water, thereby resulting in overgrazing of high-quality grasses and thus degradation of habitats, as well as loss of predation refuges for rare herbivores as lions set up territories in areas where they were previously unable to do so. This will likely result in a decline in buffalo populations as they lose their most important grazing resource of high-quality perennial grasses and also result in a decline in important rare herbivore populations as happened in Kruger National Park after artificial water points were placed in the landscapes far from water (Harrington et al. 1999). Elephant will also be able to homogenize woodland structure and plant diversity across large landscapes leading to loss of habitat heterogeneity for herbivores and ultimately a decline of wildlife populations. The other major concern with too many artificial waterholes is that they will remove dry season forage limitation on elephant populations, which keeps the population in check by limiting calf survival as a result of long walks between water and forage (Young & Van Aarde 2010). Placement of many artificial water points in the back-country woodlands will result in renewed growth of an already large elephant population to even greater levels, leading to habitat degradation across large landscapes and higher levels of human-wildlife conflict.

Policy implications

The SMLE (Figure 1) is one of the few remaining pristine ecosystems in Africa, unmodified by fences, developments and artificial water holes. We have shown how the extensive unmodified landscapes in the ecosystem, which have large parts of the woodland landscape occurring beyond 15km from water during the dry season, have spatial refuges for vegetation and for rare herbivores. Instead herbivore impacts (elephant and other large herbivores) create heterogeneity in vegetation structure, composition and richness along environmental gradients (plant community productivity gradients and distance from water in the dry season). Thus these landscapes are functionally diverse and resilient to degradation by large herbivore populations, which enables maintenance and creation of functional niche diversity with associated benefits for wildlife diversity and population viability. Thus we suggest that the SMLE should be a priority conservation and research area in Botswana with no artificial waterholes allowed (except for the few that are already present at the only safari camp in the back-country woodlands at Hyaena Pan) and minimal further development allowed that may restrict herbivore movement and access to key habitats. The SMLE makes up the core ecosystem for Botswana’s wildlife and tourism industry and should be given priority protection. We also suggest that these landscapes are ideal for establishment of a long-term ecological research site (LTER) because of the rare pristine nature of the landscapes of the region, which will enable researchers to investigate savanna ecology in a state unmodified by humans. In addition, great heterogeneity of different seasonal habitat types and wildlife biodiversity make the region a key research area. There are few natural areas remaining globally where ecological processes can be studied under pristine unmodified conditions across large landscapes, providing insights into ecological dynamics prior to human expansion and modification of ecosystems. Thus the SMLE is a region of global ecological significance for research (a research supersite) and concerted efforts should be made to promote this region as an international LTER site and also to ensure that it remains in a pristine unmodified state.

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