July 2018

Struwig Ecological Monitoring Summary Report for 2017

By Dr. G. Teren (WEI)

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Key Information

This summary report was prepared for Struwig Eco-reserve in August/September 2018 and covers surveys conducted by WEI and Operation Wallacea during 2017. One of WEI's aim is to provide support for conservation managers through self-funded research throughout the year, involving international student volunteers supervised by trained and qualified field-guides. These projects are designed to harness the benefits of the volunteer model through increased scale and constant effort over long periods in order to collect large amounts of field data. Through the use of large sample sizes, we can reduce the error of using data collected by non-scientists. The data is further checked for rigor by the WEI ecologist.

Abstract

Our vegetation surveys and bird point counts take place at our long-term monitoring sites, of which there are 15 across the Struwig portion of OREC. In 2017 we conducted vegetation surveys at 14 of these sites and used improved methodology. There were 58 species of woody plant identified in the surveys and the woody component was dominated by broad-leaved species where nearly half of all plants were *Grewia bicolor*. We assessed elephant impact by evaluating the proportions of tree species with no impact, and variable levels of low impact (browsing) and high impact (which may lead to tree death). There were very low levels of impact, with the most impacted trees within the *Acacia* (*Vachelia*) genus. *Acacia burkei* displayed 5% of living trees with high impact, and *A. nigrescens* had 13% of dead trees with high impact. There is no evidence for concern over elephant impact.

Overall, there was high evenness and diversity of grass species, although many plants could not be identified down to species level due to the dry season. There was a spread in grazing intensity across sites, although the majority of plants had grazing indices above 1 (more than half of the tufts grazed), but no significant relationship was found with grass volume or grass height. All sites except for one were dominated by increaser II grasses, and this illustrates that the veld is generally in an overgrazed state, though this needs to be considered in the context of the low-rainfall typical of the region.

Bird Point Counts (BPC) were conducted at each of the sampling sites at dawn when bird activity is highest. Ninety different bird species were surveyed in 2017, which represents an average of species counts over the 6 year period (min 46 species in 2013, max 139 species in 2015). There were no differences in feeding-guild representation per year with the majority sightings of insectivorous and omnivorous species.

Three game transects were surveyed on Struwig in 2017, counting all herbivores larger than a hare, and estimating age, sex, and body condition. As expected, impala were the most commonly sighted species, and no obvious trends in sighting proportions were observed for mesoherbivores, excluding warthog which appeared to decline over the five-year period. All common species showed healthy population structures, but monitoring of the impala population should continue carefully due to the unusually low numbers of juveniles in 2017 considering these are annual breeders.

As requested by Struwig trustees, we compiled a trend of sightings of elephant, buffalo, and rhino (white and black) over time as has been done in previous reports, with a reminder of the caveats about assessing sightings of these widely roaming species over such a small area. Using the χ^2 test for trend in proportions we found that elephant sightings have declined significantly over the time period, but not buffalo and

rhino. This should be interpreted with caution, as these represent sightings, from diurnal drives, and not numbers (or populations). The proportions of ages in Buffalo showed a distinct lack of juveniles and subadults apart from 2014 which may be an artefact of the small sampling area considering the transient Buffalo populations, but should be monitored closely, to assess reproductive rates and success.

Considering the change in vegetation survey methodology and small sampling area for large mammals, no immediate management recommendations could be made, and we look forward to the 2018 report to provide further insight. Lists of species surveyed in 2017 are included in appendices.

Introduction

Wildlife and Ecological Investments (WEI) has conducted ecological surveys and biodiversity monitoring in the Struwig Eco-Reserve since 2012. Collection of data over extended time periods allows for an opportunity to detect trends and patterns. Ecosystems have a wide range of components each responding to their environment. Complete and holistic biodiversity monitoring is impossible due to the large taxa representation. It is for this reason that WEI surveys macro fauna and flora. By surveying key organisms within an ecosystem, we obtain clues into ecosystem functioning and processes. We conduct three main long-term biodiversity surveys: 1. Vegetation surveys of both the woody and herbaceous components, 2. Bird species and abundance counts, and 3. Large mammal distance sampling. To date the data that has been collected covers a wide ecological range and consists of herbaceous, woody vegetation, bird, insects and mammal surveys.

Struwig Eco- Reserve is approximately 3800 ha and falls within Balule Game Reserve, and our surveys cover approximately 1500 ha (calculated from GIS). The Olifants River forms the northern border. Ecological surveying began in 2012 in 17 sample sites evenly distributed across the reserve and cover different vegetation and landscape types. The main data collection period is during the dry season.

This report will cover baseline results of vegetation surveys conducted using improved methodology in 2017, and trends over time for the avian and large mammal component.

Sample Sites

Due to access constraints, from 2017 only 15 of the 17 survey sites were used (Fig 1). At each site both Bird Point Counts (BPC) and Vegetation Surveys (VS) were conducted (although one site was not surveyed for vegetation in 2017). These long-term sites have been used since 2012, but with various sampling intensity and methodology as outlined in Table 1. These surveys were conducted in the dry season (June to August) by Operation Wallacea volunteers under the guidance of WEI field assistants.

Table 1. Summary of sampling efforts over time.

Survey sites	2012	2013	2014	2015	2016	2017
Bird surveys	9	16	12	9	15	15
Woody vegetation	9	16	12	9	8	14
Grasses	9	16	12	-	-	14

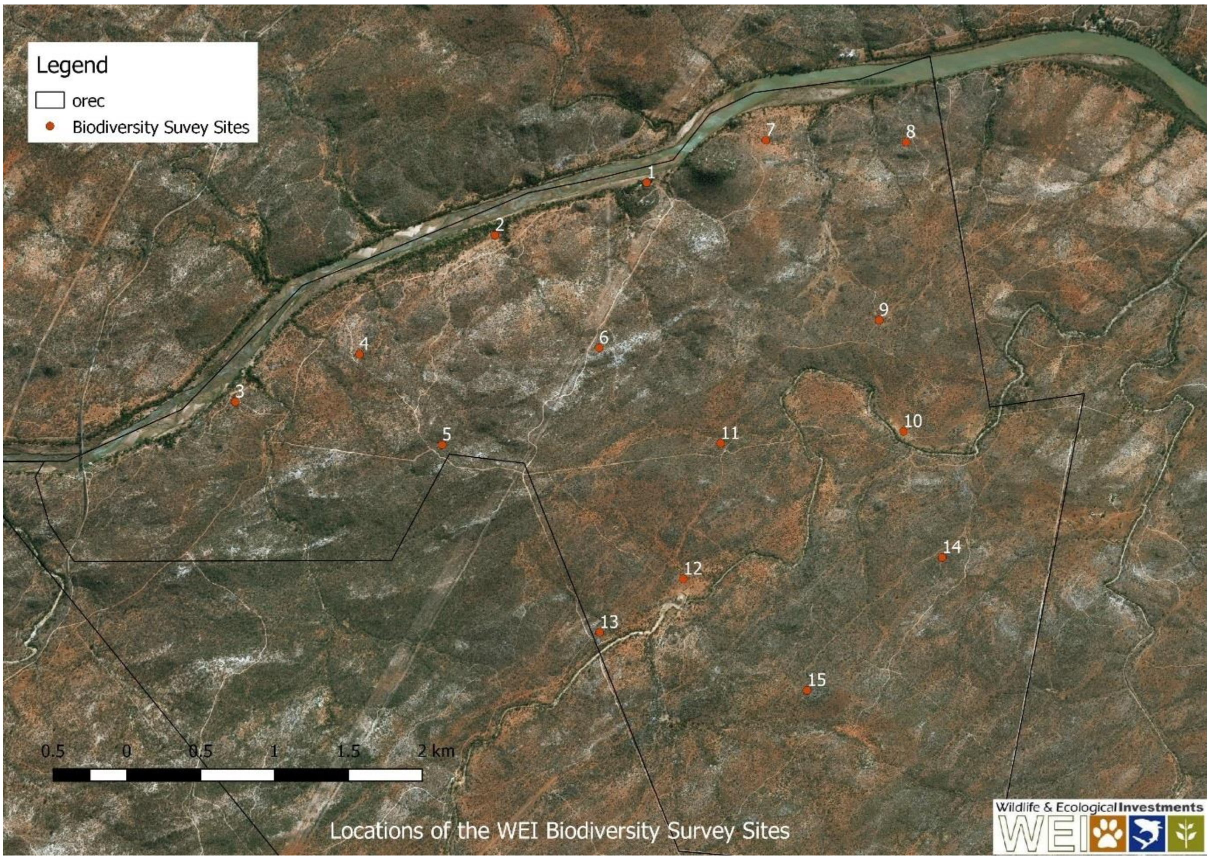


Figure 1. Locations of the 15 WEI Struwig Biodiversity Survey (SBS) sites

Vegetation Surveys

We sampled woody and herbaceous vegetation across 14 of the 15 sites in June-August 2017. Each site consists of four 25 m^2 quadrants to total 50 m^2 or 0.25 ha. The quadrants were situated around the central permanent marker creating NE, NW, SE, and SW quadrants. Each plot was started 1 m away from the marker to avoid overlapping sampling lines. The 25 m^2 plot was marked out using ropes and pegs and then subdivided into 5 long transects within the plot (Fig. 2). Each rope (4 boundary plus 4 internal) was marked every five metres with cable ties. These points (36 in total) served as grass sampling points. Not all 4 quadrants were sampled at each site during the season due to time restraints, but 33 quadrants or 825 m^2 were sampled (Table 2).

Table 2. List of sites and quadrants surveyed in the dry season 2017. Each quadrant represents a 25 x 25m plot.

Site	NE	NW	SE	SW
1				
2	1	1	1	1
3		1		1
4	1	1	1	1
5		1		1
6		1		1
7		1		1
8		1		
9		1		
10		1		1
11		1		1
12	1	1	1	1
13		1		
14	1	1	1	1
15		1		1

Each site was categorised according to landscape position (crest, upper-slope, mid-slope, lower-slope, sodic, riparian and floodplain) and soil was described according to colour and texture.

Plant survey methods

Grass survey

At each grass sampling point, the closest grass within a 30 cm radius was identified using van Oudtshoorn (2014). If there was no grass within 30 cm, a value of no-grass was recorded. For each grass, height, diameter and grazing intensity was measured. Grazing intensity was on a scale of 0-2 with 0 = not grazed, 1 = <50% of tuft grazed and 2 = >50% of tuft grazed. After measurement, volume of all grasses at that point was evaluated using a disc pasture meter (DPM). Grass was measured before woody plants to avoid trampling effects.

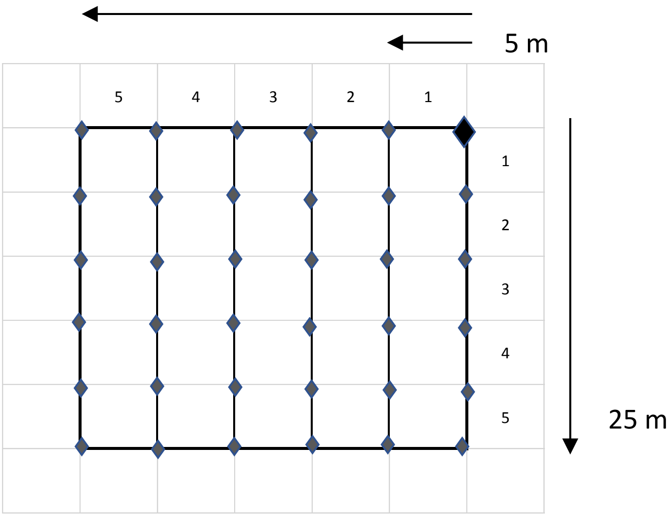


Figure 2. Vegetation survey plot design showing one quadrant (25 m x 25 m). There were four quadrants situated around a central point (top right corner shows origin making this the SE quadrant). The quadrants were further subdivided into 5 long transects with ropes marked every 5m serving as grass sampling points (blue diamonds).

Woody plant survey

All living and dead woody plants in each plot above 0.5 m were measured, using the transect lines to subdivide sampling to prevent missing plants or double-counting. Each plant was identified as far as possible in the field using van Wyk and van Wyk (2011). If species could not be determined in the field, a sample was brought back to camp to be identified using other resources. The following were also recorded: height (in categories 0.5-1; 1-2; 2-5; 5-10, >10 m), basal stem diameter in categories, or if it is a multi-stemmed shrub, the average of the majority (up to 6 stems should be sufficient) of basal stem diameters (categories: 0-2; 2-5; 5-10; 10-20; 20-50; >50 cm), and the width and height at the widest point of the canopy (in the same categories as height, with an additional category of 0-0.5m). Elephant, fire and other impacts were recorded according to the scale below. Interesting observations were also recorded.

Table 3. Impact categories on woody plants

	Elephant Impact (percentage impacted needed for D-J)
A	uprooted (is dead or soon to be dead)
A1	uprooted (alive)
B	Main stem broken, is or appears to be dead
C	Main stem broken but resprouting or likely to resprout
D	Secondary or smaller branches broken (% of stems needed)
E	Debarked (% of circumference needed)
F	(A+E) uprooted and debarked (% debarked)
G	(B+E) dead broken stem and debarked (% debarked)
H	(C+E) broken resprouting stem and debarked (% debarked)

J	(D+E) small branches broken and debarked (% debarked)
Z	None

	Fire impact (percentage burned needed for all categories)
A	Main stem(s) killed, entire plant dead, or apparently so
B	Main Stem(s) killed but coppicing from ground level
C	Main Stem(s) alive, re-sprouting
D	Only debarked area of main stem burnt
E	Primary stems killed, no sign of re-sprouting
F	Primary stems killed, re-sprouting off main stems
G	Secondary and/or smaller branches killed, re-sprouting
Z	None - no signs of fire impact

	Other impact (percentage impacted needed for all categories)
I	Insect
B	Buffalo
K	All antelope
G	Giraffe
P	Porcupine
R	Black Rhino
W	Wind
H	Hail
L	Lightning
O	Other (if known, the cause must be recorded)
A	Alien control (biocontrol agent or chemical) for Aliens only
X	Unknown

Vegetation Results and Discussion

Woody plant diversity and impact

The new vegetation survey methodology proved efficient and practical with a huge increase in the number of individual trees sampled (Table 2), although statistical comparisons with earlier years is limited. I recommend this method is continued.

Table 2. Summary of woody plant sample sizes from 2012 to 2017. 2017 Used a new method.

Year	# of sites surveyed	# of trees measured	# of species
2012	10	425	41
2013	16	747	38
2014	12	685	48
2015	9	160	20
2016	8	268	34
2017	14	1872	58

To estimate woody plant composition, we calculated proportional contribution of the most important species with more than 15 individuals counted. We compiled Size Class Distributions (SCD) of the most important species (n > 20) to look at population demographics using tree height.

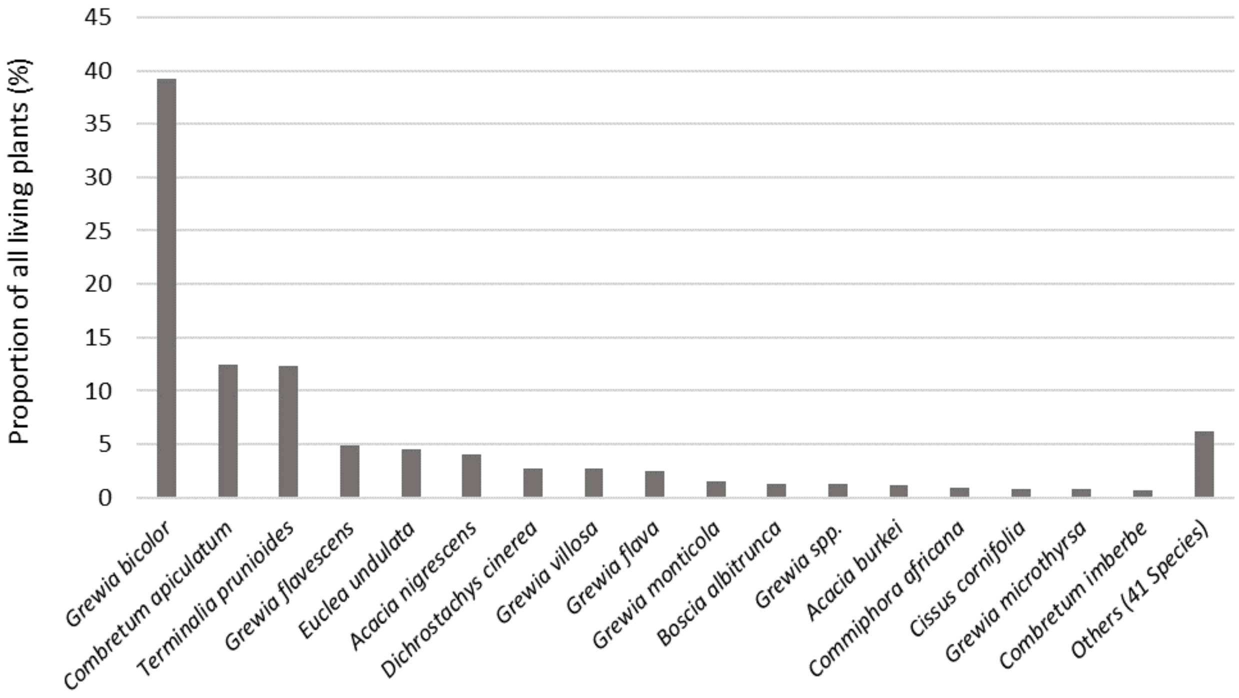


Figure 3. Woody plant proportional composition of plots sampled in the dry season 2017

As expected for the area, the woody component was dominated by broad-leaved species where nearly half of all plants were *Grewia bicolor* (Fig. 3). *Combretum apiculatum* and *Terminalia prunioides* also featured prominently, with the remaining species showing high evenness. The objective of the vegetation sampling is to identify trends over time, and as such, future surveys will enable us to distinguish changes in size class distribution, impact and population dynamics. From this single dataset, the most useful information is the baseline of impact (by elephants and other agents).

To assess elephant impact we differentiated between feeding damage and more severe impact. The highly impacted trees were all trees in categories A, B, C, F and G. For broken secondary branches (category D) we selected those trees that had over 50% secondary branches broken, and for debarked trees (categories E, H, J) we selected trees that had over 50% stem circumference debarked. We removed 105 trees from the analysis where an elephant impact category was not recorded, leaving 1765 trees in total.

Table 3. Summary of different types of elephant impact recorded

Class	Description	Low impact <50%	High impact >50%	Unknown	Total
A	uprooted (is dead or soon to be dead)	n/a	109		109
A1	uprooted (alive)	n/a	22		22
B	main stem broken (is or appears to be dead)	n/a	18		18
C	main stem broken but resprouting	n/a	105		105
D	secondary or smaller branches broken	685	165	15	865
E	debarked	6	3	1	10
F	(A+E) uprooted and debarked	n/a	5		5
G	(B+E) dead broken stem and debarked	n/a	1		1
H	(C+E) broken resprouting stem and debarked	3	4		7
J	(D+E) small branches broken and debarked	19	8		27
Z	No elephant impact				595
	Total	**713**	**440**	**16**	**1764**

To evaluate elephant impact preference on species, we summarised the species composition of trees in the low, high, and no impact categories (according to Table **3**), and discarded the unknown impact. Only those species where the sample size was higher than 10 trees were included (Table 4).

Amongst living trees, *Acacia burkei* exhibited the highest proportion of trees with high impact, followed by the commonly found *Combretum apiculatum* and *Dichrochstachys cinerea* (Fig. 4). Both of these species showed less than 5% of dead trees with high impact, indicating that elephant impact is not a significant contributor to mortality, but considering that *C. apiculatum* is the most common tree, elephant impact on specific size classes needs to be monitored over time. Amongst dead trees, A. *nigrescens* and *C. imberbe* had the highest proportion of trees with signs of high impact (Fig. 4) between 11 and 13% (Table 4.). This also does not call for much concern at this stage, and monitoring of these two highly palatable species over time will determine if impact is affecting regeneration, recruitment, or population size. Considering that *C. imberbe* is one of the least common large trees in the study site (Fig. 3), elephant impact on vulnerable sizes may be important for the population, although elephants have difficulty killing large trees of this species.

Table 4. Elephant impact on the most common species. Numbers are of percentage of total (n) impacted per different categories as defined in Table 3. Species are ordered by highest percentage of high impact.

Species	High Impact (%) Living	High Impact (%) dead	Low Impact (%) living	Low Impact (%) dead	No impact (%) living	No impact (%) dead	Total (n)
Acacia burkei	45.0	5.0	50.0				20
Combretum apiculatum	38.0	4.6	32.9		24.5		216
Dichrostachys cinerea	28.9		55.6		13.3	2.2	45
Combretum imberbe	23.5	11.8	5.9		41.2	17.6	17
Grewia flava	22.0		51.2		26.8		41
Acacia nigrescens	20.8	13.0	36.4	1.3	28.6		77
Grewia bicolor	17.9	0.8	53.7		27.7		643
Grewia flavescens	15.9	2.4	59.8		22.0		82
Commiphora africana	14.3		21.4		64.3		14
Grewia monticola	12.0		8.0		80.0		25
Boscia albitrunca	10.5		42.1		47.4		19
Grewia villosa	9.5		31.0		59.5		42
Terminalia prunioides	7.9	1.0	38.7		51.3	1.0	191
Euclea undulata			2.4		97.6		41

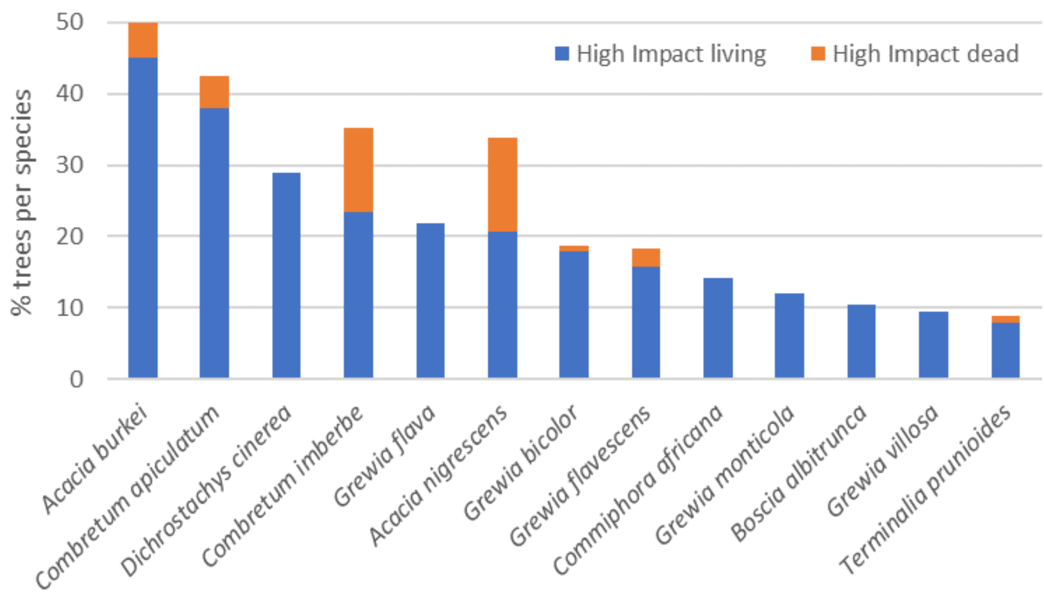


Figure 4. Tree species with the highest proportions of high impact on living and dead trees. Numbers displayed show percentage of trees of that species surveyed in 2017.

Grass floristic and structural diversity

There were 48 different grass species surveys in 2017 (Appendix 3), with the most common species *Panicum maximum* (9.5 % of all grasses), unidentified *Eragrostis* species (9.5 %), *Urochloa mosambicensis* (8.0 %) and *Enneapogon cenchroides* (6.4%) (Fig. 5). Overall, there was high evenness and diversity of grass species, although many plants could not be identified down to species level due to the dry season.

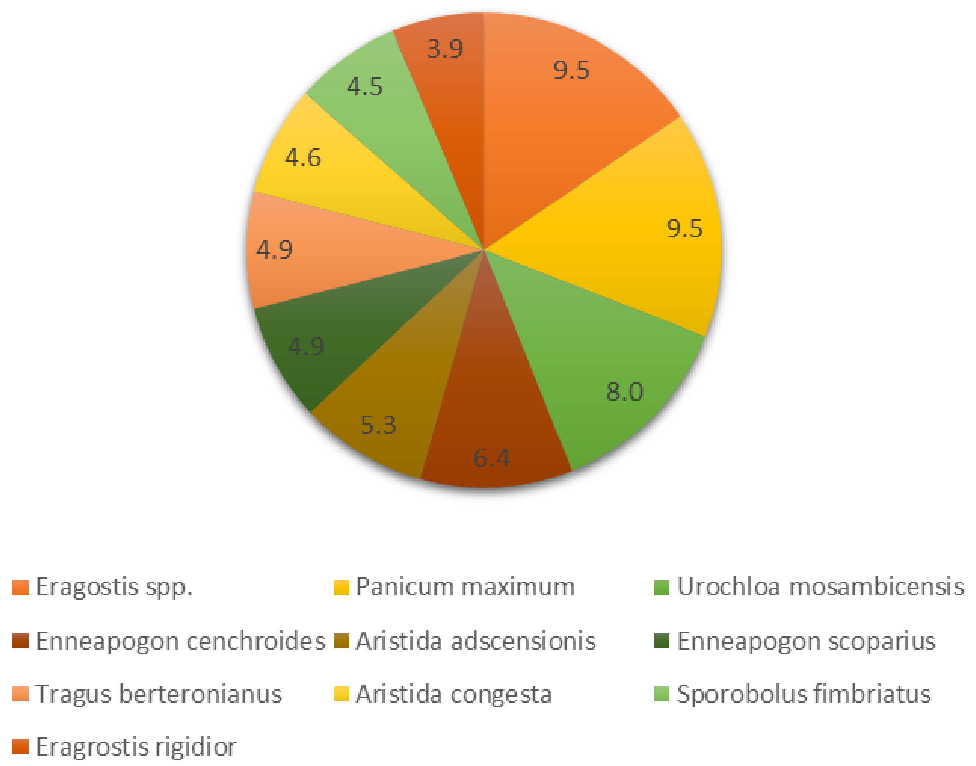


Figure 5. Composition of the herbaceous layer surveyed in 2017. The most common grass species and their percentage contribution. Less common species not displayed.

In addition to species composition, structure was surveyed in the form of height, volume (using the disc pasture meter), and grazing intensity. Grass volume was determined using the disc pasture meter (DPM) and calibrated using the equations developed for Kruger National park by Zambatis et al. (2006).

The equations are given respectively for a) grass ≤ 26cm DPM height and b) grass > 26cm DPM height:

a) $\text{Kg.ha}^{-1} = [31.7176\ (0.32181/x)\ x0.2834]^2$

b) $\text{Kg .ha}^{-1} = [17.3543\ (0.9893x)\ x0.5413]^2$

Because the average DPM height of all sites was below 26 cm, I used equation a. Grass volume was not calculated for other recent surveys (2015 onwards) and so a comparison over time could not be determined.

There was a spread in grazing intensity across sites, although the majority of plants had grazing indices above 1, but no significant relationship was found with grass volume (Fig. 6) or grass height (Fig. 7). Because the majority of plants measured showed some grazing, with a large proportion showing more than half of the tufts grazed, it is important to look at veld condition.

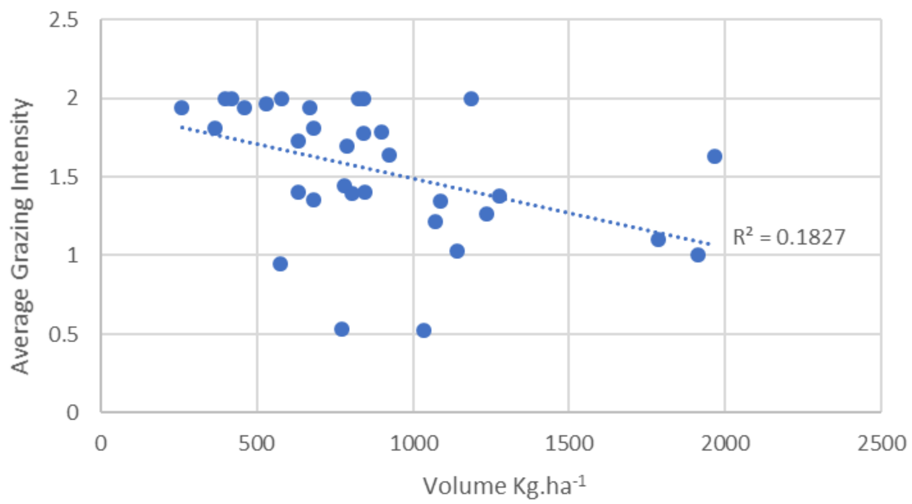


Figure 6. Average grazing intensity (scale 0-2) in relation to grass volume (Kg.ha^{-1}) per site (quadrant) across the 14 survey sites.

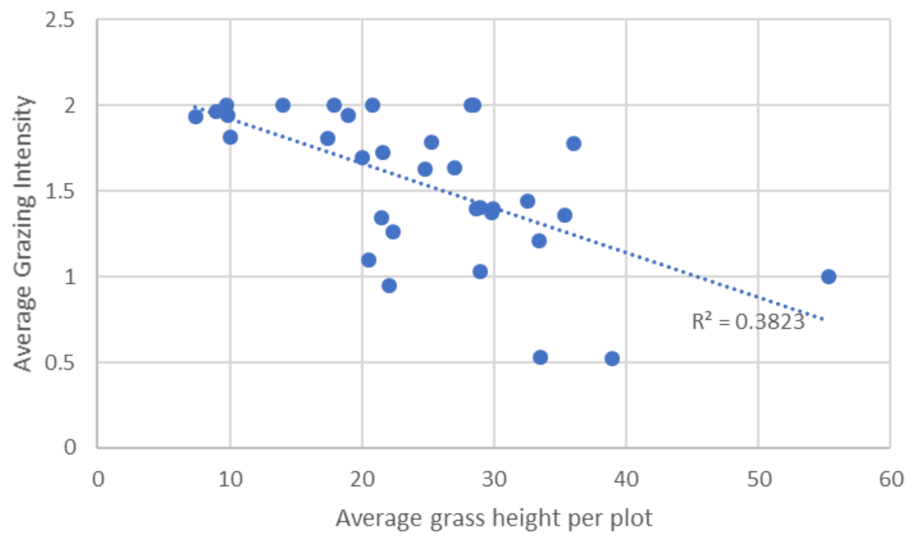


Figure 7. Average grazing intensity in relation to average grass height (cm) per site (quadrant) across the 14 survey sites.

I examined veld condition by classifying grass species according to their ecological status from van Oudsthoorn (2014). For each site the number of increasers and decreasers were summed for all of the quadrants sampled (unequal sample sizes) and divided by the total to get an average proportion for that area. This helped to minimise the contribution of outliers and micro-topography effects. All sites except for site 13 were dominated by increaser II grasses, with varying smaller proportions of decreasers, and increaser I and III (Fig. 8). This illustrates that the veld is generally in an overgrazed state, though this needs to be considered in the context of the low-rainfall typical of the region. I suggest that close attention needs to be paid on the veld condition to assess if this pattern is a result of the 2015/2016 drought or if there are longer-term patterns of overgrazing.

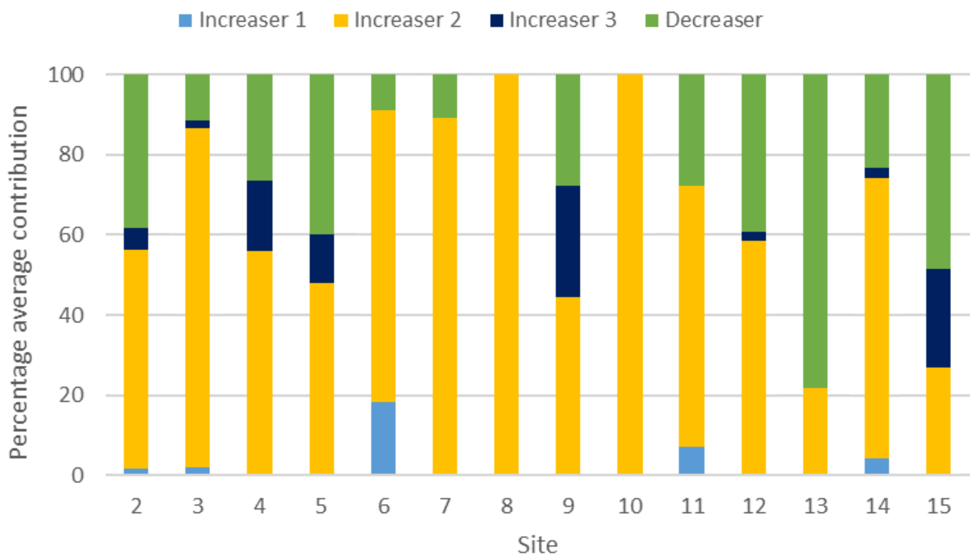


Figure 8. Ecological status patterns across the 14 survey sites, where percentage contribution of increasers and decreasers was summed across the quadrants for each site.

Bird Point Counts

Birds are highly responsive to changes in their environment and in particular, structural habitat change and disturbance. Being widespread, generally conspicuous and easy to monitor (even without sight), and highly mobile through flight, they are useful biodiversity indicators.

Bird Point Counts (BPC) were conducted at each of the sampling sites at dawn when bird activity is highest. All birds seen and heard were recorded, the birds behaviour (flying, perched in the canopy or mid-storey etc.), GPS geotagged the location and the environmental information recorded. Bird species richness and diversity were calculated between 2012 and 2015 in Struwig. For ease of analysis the bird species were divided into feeding guilds namely insectivore/invertebrates, omnivore, carnivore, frugivore, nectivore and granivore. The feeding guild of each species identified was verified in the Roberts Bird Guide (Chittenden 2016). We used the same feeding guilds as previous data analyses.

The Shannon Diversity Index (*H*) was used to determine the heterogeneity indices of the bird groups. This index measures species richness and evenness (Mirzaie *et al.,* 2013). I used the Shannon Index of Diversity to determine the species diversity between the guilds:

$$H = \sum_{i=1}^{S} (pi) lnpi$$

The Shannon Index (*H*) is scored between 0 and 1 where 0 means there is no diversity and 1 is highly diverse. Where *S* is the total number of species in the community (richness), *pi* the proportion of *S* made up of the i^{th} species.

Bird Diversity results across time

Ninety different bird species were surveyed in 2017, which represents an average of species counts over the 6 year period (min 46 species in 2013, max 139 species in 2015). Knob-billed ducks, black-chested snake-eagles, and African harrier hawks were recorded for the first time in 2017. There were no differences in feeding-guild representation per year (Fig. 9) with the majority sightings of insectivorous and omnivorous species. There are no obvious trends or causes for concern when regarding the pooled data, and attention should be paid to site-specific inferences post-2017 with repeated vegetation sampling. This will help inform the spatial structure of species distribution patterns in relation to habitat, important for understanding population declines and increases (Sirami et al 2009).

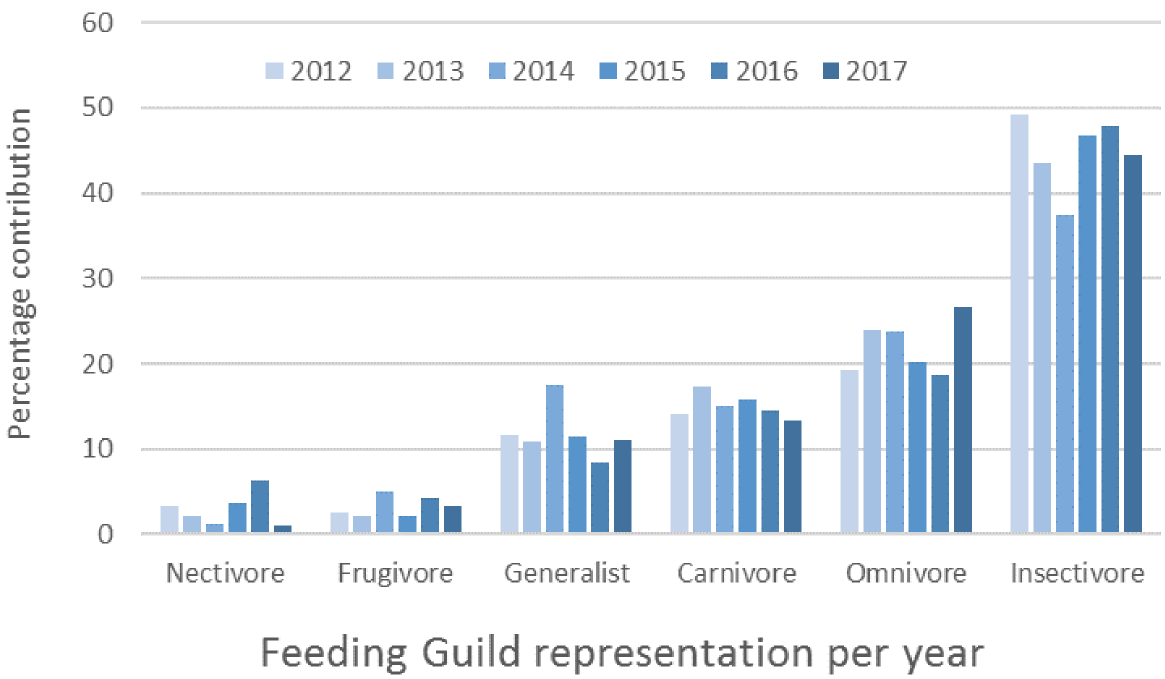


Figure 9. Feeding guild representation per year of bird sightings (not counts, as one sighting may represent one or more individual birds of that species).

There were also no obvious patterns in diversity index change over time, apart from a decrease in diversity of nectivores in 2017 (Fig. 10) which should be monitored, although the pattern in nectivores does vary widely between the years.

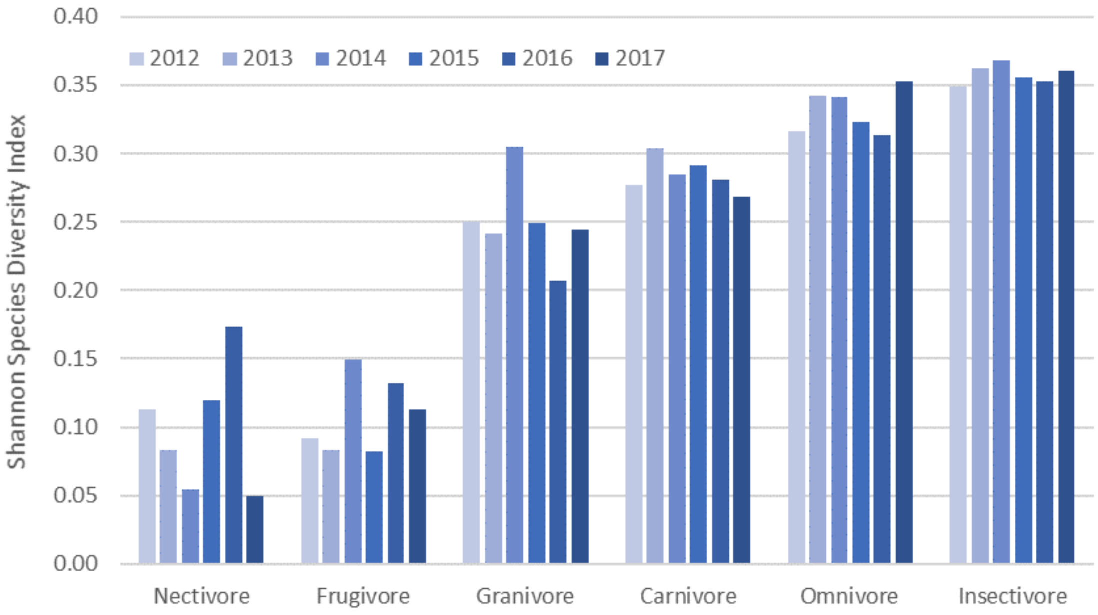


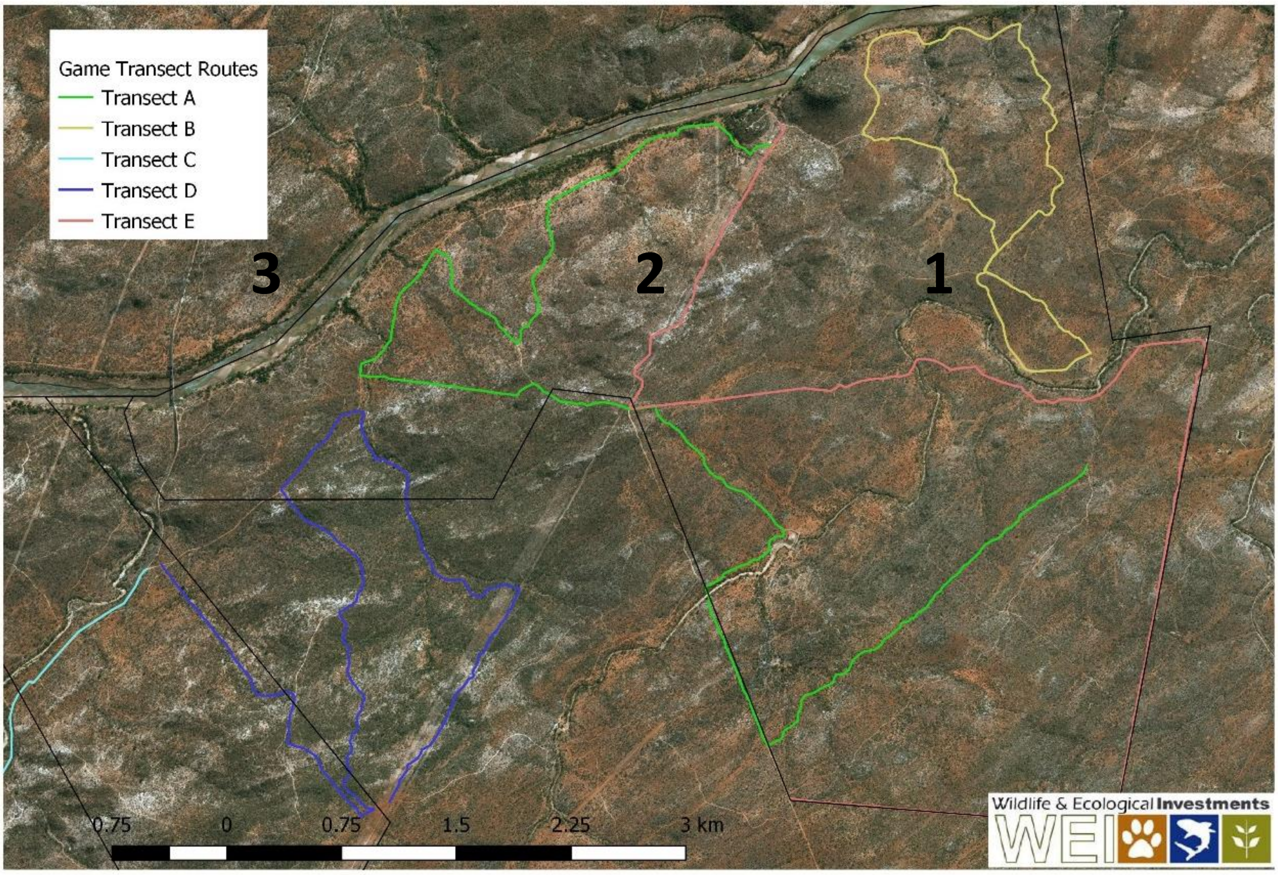
Figure 10. Shannon's species diversity index across different feeding guilds for all birds surveyed in the dry season from 2012 to 2017.

Game Transects

There are five transect routes in total, though only three are done on Struwig (Transect A, B, E, Fig. 11).

The game transects were driven in the early morning and late afternoon, with the vehicle driving at an average speed of 20km/hr. Spotters looked on either side of the road for any mammals larger than a hare. On spotting an animal, the vehicle was stopped, and the GPS coordinates of the vehicle were recorded. The distance to the animal was estimated in 20 m bands, up till 300 m. Any animals that were recorded as being over 300 m in the dataset were discarded in the analysis. The number of individuals and age and sex of each individual was recorded. On the vehicle the following responsibilities are allocated; spotters looking at both sides of the road to reduce the chances of double counting, a reader of the GPS and compass and a scribe. Ultimately the responsibility of the driver is to confirm the species observed, the herd size, ages and sex, the distance and the average condition of the herd or individual seen. This is then communicated to the scribe. Prior to game drives being driven, a visibility index. The visibility index is developed by following Steps 1 and 2. The visibility being a measure of the vegetation thickness and how deep into the bush it hinders your ability to see wildlife.

Average herd condition was assessed using Riney's (1960) 3 Category Scale (1- poor, 2- fair, 3 healthy) which uses fat reserves distributed on the spine, ribs and hind quarters as indicators of the animals' condition. The average condition of the herd is recorded unless an individual is seen then only that animals' condition is recorded. Within the herd, the adults and juveniles are conditioned together. This method allows for the detection of seasonal trends and patterns as well as any changes that may occur over time.



WEI Game Transect Routes on Struwig

Figure 11. Map showing the detail of the four main transect routes on OREC. The railway transit route (Transect C) is not shown in full.

Game sightings and population dynamics

Because of the spatial arrangement of some of the transects, the data is not suitable for statistical distribution analysis, however the temporal dynamics of sightings can provide some useful insight. We analysed the sightings (not the observed number) of all meso- and mega-herbivores for each year to assess the game-viewing experience and detect patterns in proportional observations of number of sightings per year.

As expected, impala were the most commonly sighted species, and no obvious trends in sighting proportions were observed for mesoherbivores, excluding warthog (Fig. 12). Warthog sightings have consistently declined over the 5 years and should be monitored.

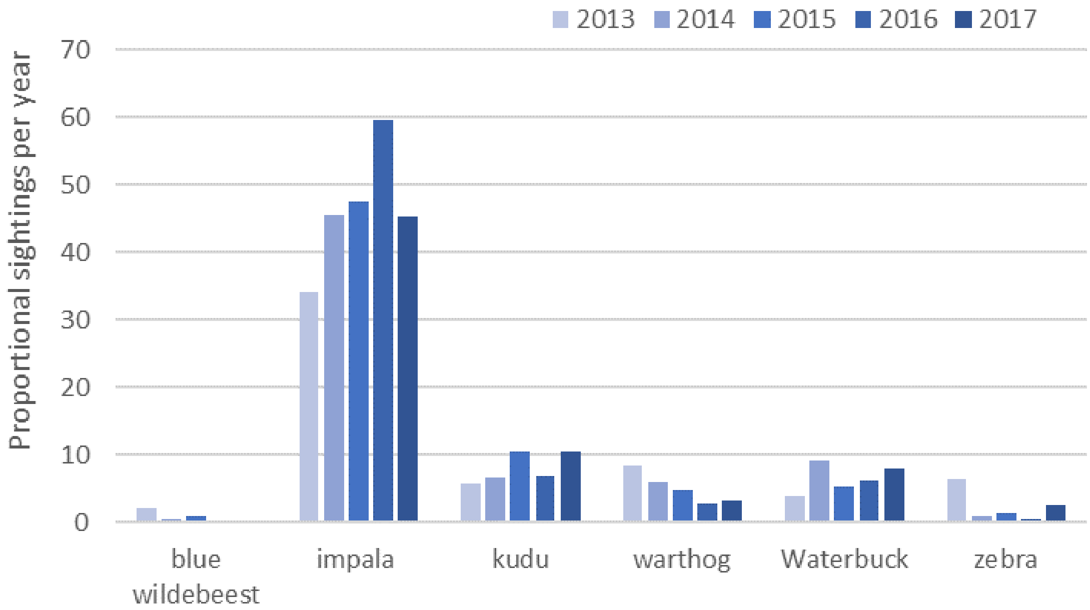
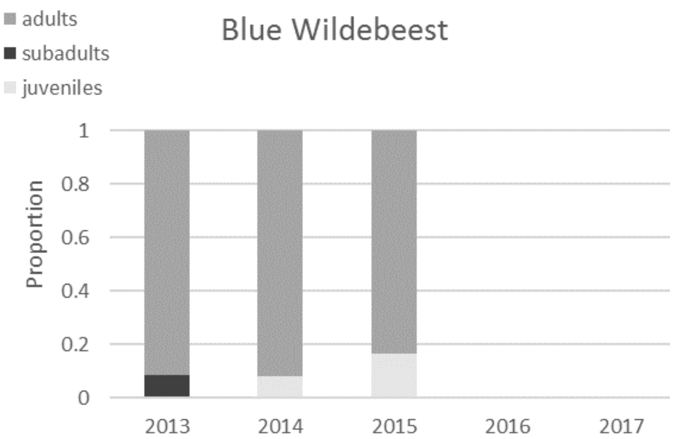
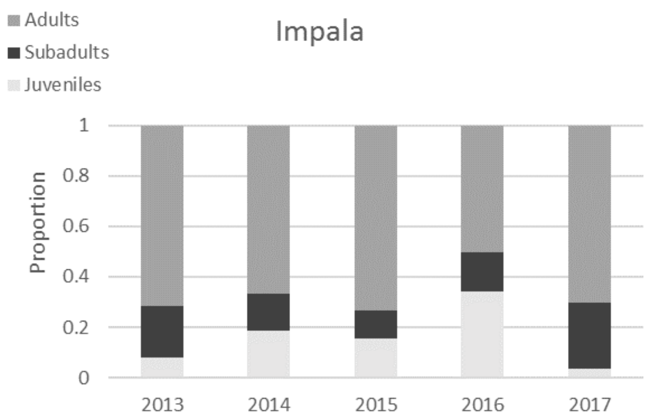


Figure 12. Proportional sightings of Mesoherbivores from 2013-2017

One of the key benefits of long-term annual monitoring is the ability to detect changes in population structures. Because we survey individual animals by categorising their age (stage) structure, distinguishing juveniles, sub-adults and adults, we can compare these proportions over time to get an idea of fecundity and recruitment. I analysed the stage structures of mesoherbivores with counts of over 10 individuals. All species were dominated by adults to varying degrees (Fig. 13)

All common species show healthy population structures, but monitoring of the impala population should carefully continue due to the unusually low numbers of juveniles in 2017 considering these are annual breeders (Fig. 13)





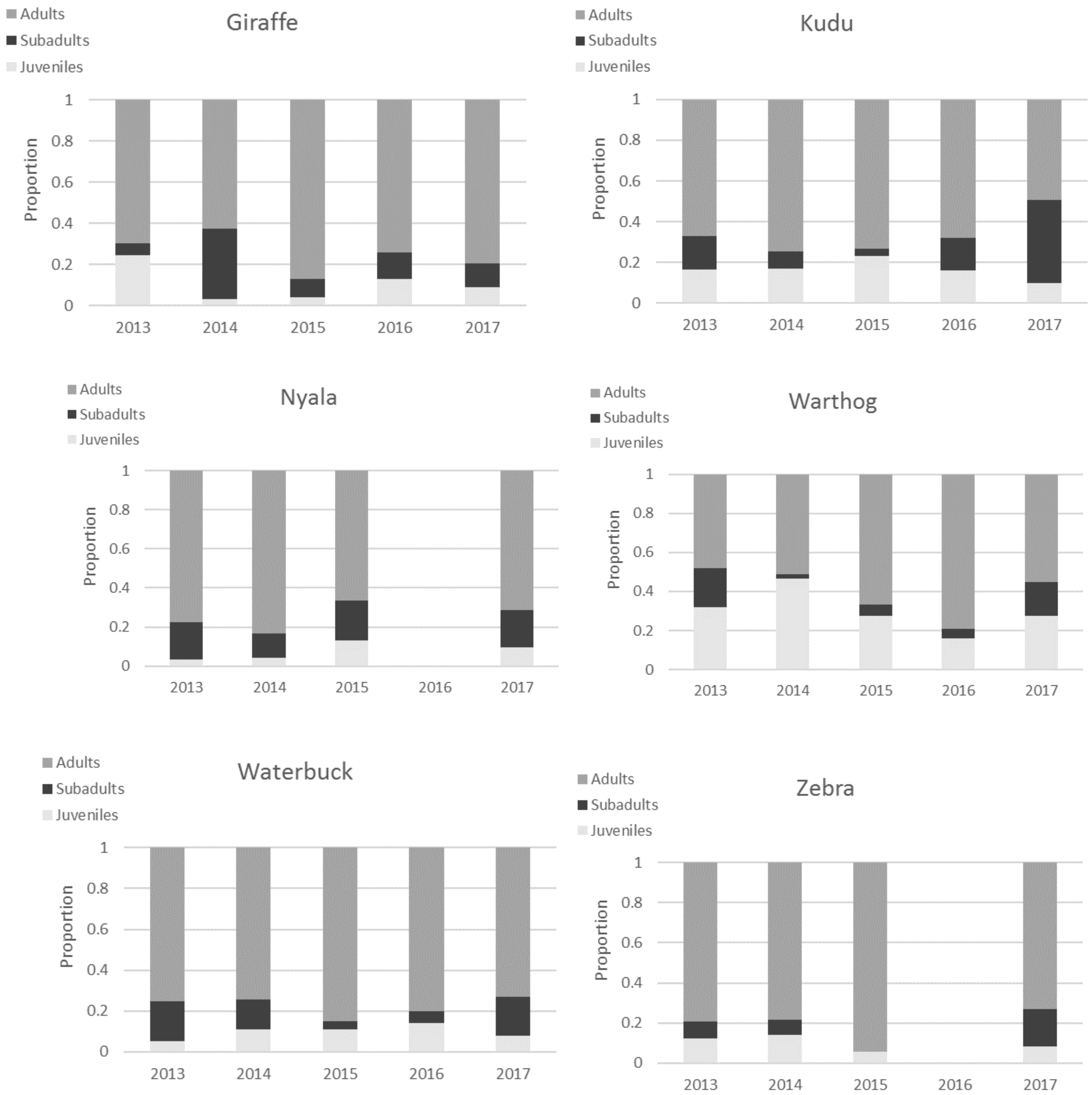


Figure 13. Proportional stage-structures of common common meso-herbivores surveyed in Struwig over 5 years.

Megaherbivore population structure and sightings

As requested by Struwig trustees, we compiled a trend of sightings of elephant, buffalo, and rhino (white and black) over time as has been done in previous reports with a reminder of the caveats from the 2015 report on elephant and buffalo numbers:

"To use game drives as transects, an area specific error would first need to be determined. This calculates the effective range that one would be able to observe an animal, which in turn gives an estimation of the number of animals not seen but that are present in the area. For example: at 10 meters all animals, 100%, are seen, at 50 meters 40% of animals are seen and at 100 meters 1% of animals are seen. This observation error must then be calculated for each habitat type, hill slope, valley, river side etc. Then, considering the movement speed of animals, transects on different areas would have to be done in rapid succession to avoid animals being observed in more than one transect. Therefore using transects as game counts only becomes viable on a larger scale operation, more vehicles simultaneously spread over the total area. Lastly at least roughly 10% of the area must be surveyed before one can begin to make inferences about the density of animals.

Further without identifying specific individuals one cannot comment on the number of herds in an area. For example: when only one individual is recorded, it may still be possible that it actually is a larger herd of animals seen elsewhere. Therefore the number of individuals in a herd is not an identification parameter of a herd.

Considering all of the above the inferences that can be made from the data is limited. However with certain assumptions, estimates can be made. We assume that the same herd is not counted twice in one drive. Volunteers would have noted the movement direction and speed of animals and considered this when encountering the same species more than once.

Lastly one has to consider the ecology of each of the species, Buffalo and Elephants. Both species are mega herbivores that can cover large distances in short periods. Neither species are territorial and have completely stochastic movements. Beyond giving the numbers of animals seen most calculations would be speculations."

With cognisance of these caveats, we have compiled a trend of sightings over time for the dry-season data by counting the proportion of days each species was seen on a game transect (Fig. 13).

Buffalo sightings were extremely erratic, and rhino sightings infrequent.

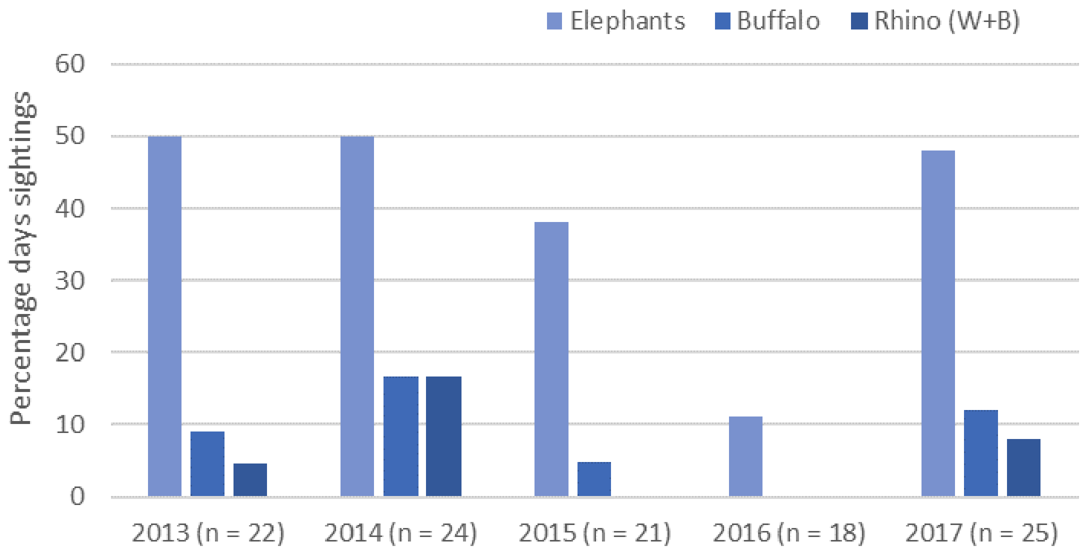


Figure 14. Proportion of days each charismatic herbivore was sighted over the dry season from 2013 to 2017.

To establish if proportional sightings were similar over the time period, we compared the megaherbivore proportions using the χ^2 test for equality of proportions in R 3.4.0 (without continuity correction). It should be noted that only dry-season transects were analysed and that this analysis should be continued over time. This showed that proportion of sightings was not the same over the time period (χ^2 = 38.007, d.f. =4, p<0.001) and using the χ^2 test for trend in proportions we found that elephant sightings have declined significantly over the time period (χ^2 = 6.995, d.f. =1, p < 0.01) when in 2016 there was the lowest frequency of elephant sightings (Fig. 14). 2016 sightings of all megaherbivores was low, but over the time period, buffalo and rhino sightings do not show any trends statistically. If elephant sightings have declined, even in particularly dry periods, this should be concerning, and monitored in the future to establish potential causes of decline.

There was no significant tend in the proportion of sightings of buffalo (χ^2 = 0.261 d.f. =1, p = 0.61), and rhino (χ^2 = 0.336 d.f. =1, p = 0.561).

The age-structures of megaherbivores were compared over time to assess changes in the proportions of juveniles, sub-adults and adult animals (Fig. 15). Rhino sightings were too infrequent to be included. The proportions of ages in Buffalo showed a distinct lack of juveniles and subadults apart from 2014 (Fig. 15) which may be an artefact of the small sampling area considering the transient Buffalo populations, but should be monitored closely, to assess reproductive rates and success.

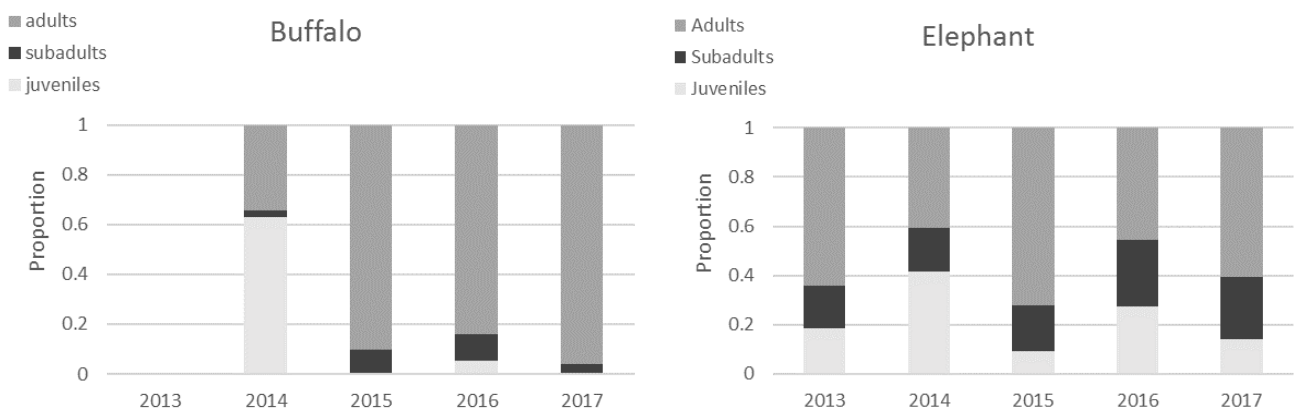


Figure 15. Proportional stage structure for megaherbivores Buffalo and Elephant. Rhino numbers were too low to include for comparison.

The collective information provided by the game transects is once again, most useful when viewed over long time periods considering the small size of the survey area and the large movement patterns of the animals in question. The 2018 report should be able to provide valuable insight into changes in vegetation impact and animal sightings.

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Appendices

Appendix I: List of birds identified during surveys on Struwig Eco-Reserve from 2012 to 2015 and birds on the IUCN Redlist birds that are Near Threatened*, Vulnerable**, Endangered*** or Critically Endangered****.

Acacia Pied Barbet	Black-winged Stilt	European Nightjar
African Barred Owlet	Blue Waxbill	Flappet Lark
African Darter	Bronze Mannikin	Fork-tailed Drongo
African Dusky Flycather	Brown Snake-Eagle	Gabar Goshawk
African Firefinch	Brown throated Martin	Giant Kingfisher
African Fish-Eagle	Brown-crowned Tchagra	Glossy Ibis
African Harrier Hawk	Brown-Hooded Kingfisher	Golden-breasted Bunting
African Goshawk	Brubru	Golden-tailed Woodpecker
African Green-Pigeon	Burchell's Coucal	Greater Blue-eared Starling
African Grey Hornbill	Burchell's Starling	Greater Honeyguide
African Hawk-Eagle	Cape Glossy Starling	Greater Striped Swallow
African Hoopoe	Cape Turtle-Dove	Green Wood-Hoopoe
African Jacana	Cape Vulture***	Green-backed Camaroptera
African Paradise-Flycatcher	Cape White-Eye	Green-capped Eremomela
African Pied Wagtail	Cardinal Woodpecker	Green-winged Pytilia
African Spoonbill	Cattle Egret	Grey Go-away-bird
African Wattled Lapwing	Chinspot Batis	Grey Heron
Alpine Swift	Chorister Robin-Chat	Grey Penduline-Tit
Amethyst Sunbird	Cinnamon-breasted Bunting	Grey Tit-Flycatcher
Arrow-marked babbler	Cloud Cisticola	Grey-backed Camaroptera
Ashy Flycatcher	Collared Sunbird	Grey-headed Bush-Shrike
Barn Swallow	Common Scimitarbill	Grey-headed Sparrow (Southern)
Barratt's Warbler	Common Swift	Groundscraper Thrush
Bar-throated Apalis	Common Waxbill	Hadeda Ibis
Bateleur*	Crested Barbet	Hamerkop
Bearded Scrub-Robin	Crested Francolin	Helmeted Guineafowl
Bearded Woodpecker	Croaking Cisticola	Hooded Vulture
Bennett's Woodpecker	Crowned Lapwing	House Sparrow
Black-chested Snake-Eagle	Dark Chanting Goshawk	Icterine Warbler
Black Cuckooshrike	Dark-capped Bulbul	Jacobin Cuckoo
Black Sparrow Hawk	Diderick Cuckoo	Jameson's Firefinch
Black-backed Puffback	Double-banded Sandgrouse	Klaas's Cuckoo
Black-collared Barbet	Dusky Flycatcher	Knob-billed Duck
Black-crowned Tchagra	Egyptian Goose	Kurrichane Thrush
Black-headed Oriole	Emerald-spotted Wood-Dove	Laughing Dove
Black-shouldered Kite	Eurasian Golden Oriole	Lesser Masked-Weaver
Blacksmith Lapwing	European Bee-eater	Lesser Striped Swallow

Levaillant's Cuckoo	Red-billed Buffalo-Weaver	Southern Yellow-billed Hornbill
Lilac-breasted Roller	Red-billed Firefinch	Speckled Mousebird
Little Bee-eater	Red-billed Hornbill	Spectacled Weaver
Little Egret	Red-billed Oxpecker	Stierling's Wren- Warbler
Little Rush-Warbler	Red-billed Quelea	Stripped Pipit
Little Swift	Red-crested Korhaan	Swainson's Spurfowl
Lizard Buzzard	Red-eyed Dove	Swee Waxbill
Long-billed Crombec	Red-faced Cisticola	Tawny Eagle
Long-tailed Paradise-Whydah	Red-faced Mousebird	Three-banded Plover
Magpie Shrike	Red-headed Weaver	Violet-backed Starling
Marico Sunbird	Reed Cormorant	White-bellied Sunbird
Martial Eagle**	Retz's Helmet-Shrike	Water Thick-knee
Mocking Cliff-Chat	Rufous-naped Lark	White-breasted Cormorant
Monotonous Lark	Sabota Lark	White-backed Vulture****
Namaqua Dove	Scarlet-chested Sunbird	White-browed Scrub-Robin
Natal Spurfowl	Shelly's Fracolin	White-fronted Bee-eater
Neddicky	Sombre Greenbul	Wood Sandpiper
Orange-breasted Bush-Shrike	Southern Black Flycatcher	Yellow-billed Stork
Pearl-spotted Owlet	Southern Black Tit	Yellow-breasted Apalis
Pel's Fishing-Owl	Southern Boubou	Yellow-fronted tinkerbird
Pied Crow	Southern Double-collared Sunbird	Yellow-throated Petronia
Pied Kingfisher	Southern Grey-headed Sparrow	Yellow-fronted Canary
Purple Roller	Southern Ground-Hornbill	Zitting Cisticola
Rattling Cisticola	Southern White-crowned Shrike	
Red-backed Shrike	Southern White-faced Scops-Owl	

Appendix 2. List of tree species and abundance of living plants surveyed in 2017

	Species	living
1	*Acacia burkei*	19
2	*Acacia caffra*	1
3	*Acacia exuvialis*	2
4	*Acacia gerardii*	1
5	*Acacia grandicornuta*	1
6	*Acacia karoo*	1
7	*Acacia nigrescens*	68
8	*Acacia nilotica*	5
9	*Acacia robusta*	2
10	*Acacia sieberiana*	1
11	*Acacia spp.*	5
12	*Acacua exuvialis*	2
13	*Boscia albitrunca*	22
14	*Boscia mossambiensis*	1
15	*Capparis tomentosa*	1
16	*Cassia abbreviata*	1
17	*Cissus cornifolia*	14
18	*Colophospermum mopane*	4
19	*Combretum apiculatum*	212
20	*Combretum collinum*	1
21	*Combretum hereroense*	6
22	*Combretum imberbe*	12
23	*Combretum mossambicense*	1
24	*Combretum spp.*	1
25	*Comiphora spp.*	9
26	*Commiphora africana*	15
27	*Commiphora mollis*	7
28	*Commiphora neglecta*	3
29	*Commiphora schimperi*	1
30	*Dalbergia melanoxylon*	2
31	*Dichrostachys cinerea*	46
32	*Ehertia amonea*	1
33	*Euclea crispa*	1
34	*Euclea undulata*	76
35	*Flueggea virosa*	2
36	*Gardenia volkensii*	1
37	*Grewia bicolor*	667
38	*Grewia flava*	43
39	*Grewia flavescens*	84
40	*Grewia hexamita*	5
41	*Grewia microthyrsa*	14
42	*Grewia monticola*	25
43	*Grewia spp.*	21
44	*Grewia villosa*	46
45	*Gymnosporia buxafora*	1
46	*Hippocratea longipetiolata*	5
47	*Kigelia africana*	1
48	*Opuntia ficus indica* *	1
49	*Pappea capensis*	1
50	*Peltophorum africanum*	3
51	*Philenoptera violacea*	5
52	*Rhigozum zambesiacum*	2
53	*Sclerocarya birrea*	2
54	*Terminalia prunioides*	210
55	*Terminalia spp.*	7
56	*Ximenia americana*	5
57	*Ziziphus mucronata*	3
58	*Ziziphus rivularis*	1

Appendix 3. List of grass species with their associated ecological grazing status and abundance surveyed in 2017

Species	Ecological status	n
Acrachne racemosa	unknown	1
Andropogon gayanus	increaser 1	2
Aristida adscensionis	increaser 2	36
Aristida congesta	increaser 2	31
Aristida diffusa	increaser 2	1
Aristida junciformes	increaser 2	16
Aristida scabrivalis	increaser 2	5
Aristida stipitata	unknown	1
Aristida spp.		21
Arundinella nepalensis	decreaser	3
Bewsia biflora	unknown	1
Bothriochloa insculpta	increaser 2	1
Bothriochloa radicans	increaser 2	18
Brachiaria brizantha	increaser 1	5
Brachiaria deflexa	increaser 2	1
Brachiaria eruciformis	increaser 2	1
Brachiaria nigropedata	decreaser	7
Bromus catharticus	alien	5
Cenchrus ciliaris	decreaser	4
Cymbopogon caesius	increaser 1	4
Digitaria eriantha	decreaser	18
Diheteropogon filiolius	increaser 3	2
Echhinochloa pyramidalis	decreaser	12
Enneapogon cenchroides	increaser 2	43
Enneapogon scoparius	increaser 3	33
Enteropogon macrostachyus	decreaser	1
Eragostis spp.		64
Eragrostis aspera	increaser 2	1
Eragrostis lehmanniana	increaser 2	19
Eragrostis rigidior	increaser 2	26
Eragrostis trichophora	increaser 2	10
Heteropogon contortus	increaser 2	4
Hyparrhenia hirta	increaser 1	3
Hyperthelia dissoluta	increaser 1	4
Monocymbium ceresiiforme	decreaser	18
Panicum coloratum	decreaser	2
Panicum deustum	decreaser	17
Panicum maximum	decreaser	64

Panicum spp.		2
Perotis patens	increaser 2	1
Pogonarthria squarrosa	increaser 2	16
Schmidtia pappophoroides	increaser 3	6
Setaria spp.		1
Setaria sagittifolia	increaser 2	1
Setaria sphacelata	decreaser	7
Sporobolus fimbriatus	decreaser	30
Sporobolus nitens	increaser 2	16
Sporobolus panicoides	increaser 2	2
Tragus berteronianus	increaser 2	33
Unknown		358
Urochloa mosambicensis	increaser 2	54