Preliminary Herbivore Monitoring Research in Northern Botswana

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Abstract

Recent studies indicate that wildlife populations have been experiencing an overall decline throughout Africa. With a third of its land under protection, Botswana is considered to be an exemplary model of wildlife conservation in southern Africa, however, wildlife populations in the country have been following the same declining trends that are evident across the continent. Our objectives were to gain insight on how northern Botswana herbivore populations are fluctuating, determine recent populations trends, find any evident patterns among specific species and the habitats they were present in, and to continue the preliminary research that Round River Conservation Studies has been conducting through wildlife monitoring using distance sampling line transects. Round River has collected data on various herbivore populations for the past four seasons: 2013 dry season, 2014 wet season, 2015 wet season, 2015 dry season. For the 2015 dry season, our results have shown that sightings of elephant (*Loxodonta africana*), giraffe (*Giraffa camelopardalis*), kudu (*Tragelaphus strepsiceros*), impala (*Aepyceros melampus*) and Burchell's/plains zebra (*Equus burchelli*) show no significant increase or decrease in the number of individuals sighted over the past four seasons. The presence of these five species throughout varying habitat types was also analyzed, but no conclusive trends were deduced.

Introduction

Located in northern Botswana, the Okavango Delta has been described as the most essential wetland in the water-scarce region of southern Africa (Evans et al. 2001). The Okavango Delta has been designated as a UNESCO World Heritage in 2014 and is the largest wetland in southern Africa, comprising of approximately 28,000 km^2 of relatively intact ecosystems and abundant wildlife (Evans et al. 2001). The Delta's headwaters begin in the Angola Highlands, then flow south through the Caprivi strip in Namibia, and eventually empty into the Kalahari, creating an alluvial fan panhandle (Ramberg et al. 2006). The panhandle has a low elevation gradient that allows floodwaters to spread rapidly and extensively through dense patches of vegetation, which creates a diverse mosaic of habitats across the Delta. With its frequently altering habitats, the Delta has the defining characteristic of being a highly heterogeneous landscape.

The Delta is further characterized by a distinct wet season during November through March and a dry season from July to September. Mean annual rainfall ranges from 460 mm in the south and 490 mm in the northern region of the Delta, with evapotranspiration rate at about 1,500 mm (Ramberg et al. 2006). Rainfall from the Angola Highlands reaches the Delta during the dry season and also causes flooding, giving a total yearly average inflow from about 7,000 to 15,000 million m^3 (Motsumi 2007). With a low gradient, even slight fluctuations in yearly rainfall and inflow can dramatically affect the extent of the floodwater patterns. This creates unique and constantly changing flood patterns throughout the Delta, resulting in a variety of habitats on a relatively small spatial scale (Evans et al., 2001). Of the 28,000 km^2, 6,000 km^2 is swamp habitat, 12,000 km^2 is floodplain, and between 4,000 km^2 and 10,000 km^2 are dry land depending on the time of year (Motsumi 2007).

With such diverse and constantly changing habitats, the Okavango Delta holds an extraordinary amount of biodiversity with a number of species, including 1,300 plant, 71 fish, 33 amphibian, 64 reptile, 444 bird, and 122 mammal species (Ramberg et al. 2006; Heinl 2007). Together, the Chobe-Linyanti-Zimbezi Wetland and the Okavango Delta support Africa's largest concentration of carnivores and are home to over 80,000 elephants (Round River 2015).

Despite this abundance of wildlife, "a major population crash of several ungulate species following the fragmentation of key seasonal resources were observed in the Kgalagadi ecosystem in Botswana," and "…ungulate populations in general… have declined to a mere fraction of their former numbers" (Fynn et al., 2011). Zebra (*Equus burchelli*), wildebeest (*Connchaetes taurinus*) and impala (*Aepyceros melampus*) populations have all shown this significant decline in the Okavango Delta (Mbaiwa 2006). This population decrease is the consequence of mainly anthropogenic factors, including human population growth, habitat fragmentation and degradation, impediment of migration due to fence obstruction, cattle grazing, human-wildlife conflict, illegal hunting, overharvesting, rural sprawl, lack of conserved land, drought caused by climate change, and much more. Extensive wildlife monitoring and inventory must be done in order to obtain an accurate representation of the wildlife populations in wildlife management and concession areas.

Round River Conservation Studies is non-profit conservation research and education organization focused on obtaining an accurate representation of northern Botswana's wildlife populations. In Botswana, Round River students are involved in fieldwork that focuses on determining wildlife populations and assisting local communities in monitoring these populations. Students conduct a variety of research activities such as assisting wildlife counts and demography studies, rare/threatened bird monitoring, vegetation surveys, and monitoring ecosystem services in the Okavango Delta (Round River 2015). In the 2013 wet season, students assisted the Okavango Research Institute (ORI) with developing and implementing the first round of Standardized Natural Resource Monitoring. This involved working closely with community guides in Sankuyo, Mababe, and Khwai to develop methodologies to monitor wildlife in the eastern Okavango Delta (Round River, 2015). This dry season of 2015, students are continuing this research by conducting wildlife counts using the methodology of Demographics and Abundance through Distance Sampling (DADs), which was created through a collaboration between Round River and SAEREP, and implemented with ORI, to acquire more accurate results from wildlife monitoring. In the past, wildlife has been surveyed using MOMS (Methods of Monitoring Survey), which generates more generalized information by only recording the presence or absence of species. DADS is more conducive to revealing population trends and other relevant data by collecting details such as age, sex, habitat, number of individuals, and precise location.

Using this methodology, data was collected from four different community concession areas: NG 18/19 (Khwai), NG 33/34 (Sankuyo), NG 41 (Mababe) and in the CH 1 (Chobe Enclave). For the past four seasons, Round River has been conducting transects in each of these concession areas, with the exception of the Chobe Enclave where data was only collected in wet season of 2015 (CH 1 and CH 2), and dry season of 2015 (in only CH 1). The objective of this study was to analyze the data that was collected from these concession areas in order to find significant trends among the wildlife population numbers. The subject of the study was focused on five selected herbivore species: elephant (Loxodonta africana), giraffe (Giraffa camelopardalis), kudu (*Tragelaphus strepsiceros*), impala, (*Aepyceros melampus*) and zebra. (*Equss burchelli).* These species were chosen because they had the most available recorded data, which helped make trend inferences with larger sample sizes. In addition, the habitat in which these species were found was recorded and analyzed to determine if there were any evident patterns with the type of habitats where species were present.

This study is not only important to see how wildlife population numbers are fluctuating, but it also provides essential baseline data for the community trusts and their conservation management plans. Several community concessions, such as Khwai, Sankuyo, and Mababe, rely on ecotourism and photographic safaris as their main source of revenue. These industries, which make up the second largest revenue source for Botswana, place an emphasis on the need to ensure stable wildlife populations because high densities of wildlife attract tourists and safari companies (Mladenov 2007). Monitoring and correct management of the various populations is therefore essential not only for the survival of

species, but also to ensure that viable populations are available for Botswana's major revenue generating industries.

Trophy hunting is also a topic of interest to this study, since the hunting ban was implemented in 2013 as a conservation tool to stop population declines. If populations show a significant increase, this could indicate that populations are recovering and that the hunting ban was a successful conservation strategy.

Methods

Study Area

Our study was conducted in the Ngamiland (NG) and Chobe Districts of northern Botswana, east of the Okavango Delta, lying on the wildlife side of the expansive Buffalo veterinary fence, which was erected in 1982 and 1996 (Mbaiwa 2006). From September to December 2015, transects were driven in the four community concessions of NG 18/19 (Khwai), NG 33/34 (Sankuyo), CH 1(Chobe Enclave) and NG 41 (Mababe), respectively. The community areas of Khwai, Sankuyo, and Mababe make up a buffer zone between the Moremi Game Reserve and surrounding villages. The Chobe Enclave includes the villages of Kachikau, Kavimba, Mabele, Satau and Parakarungu (Figure 1).

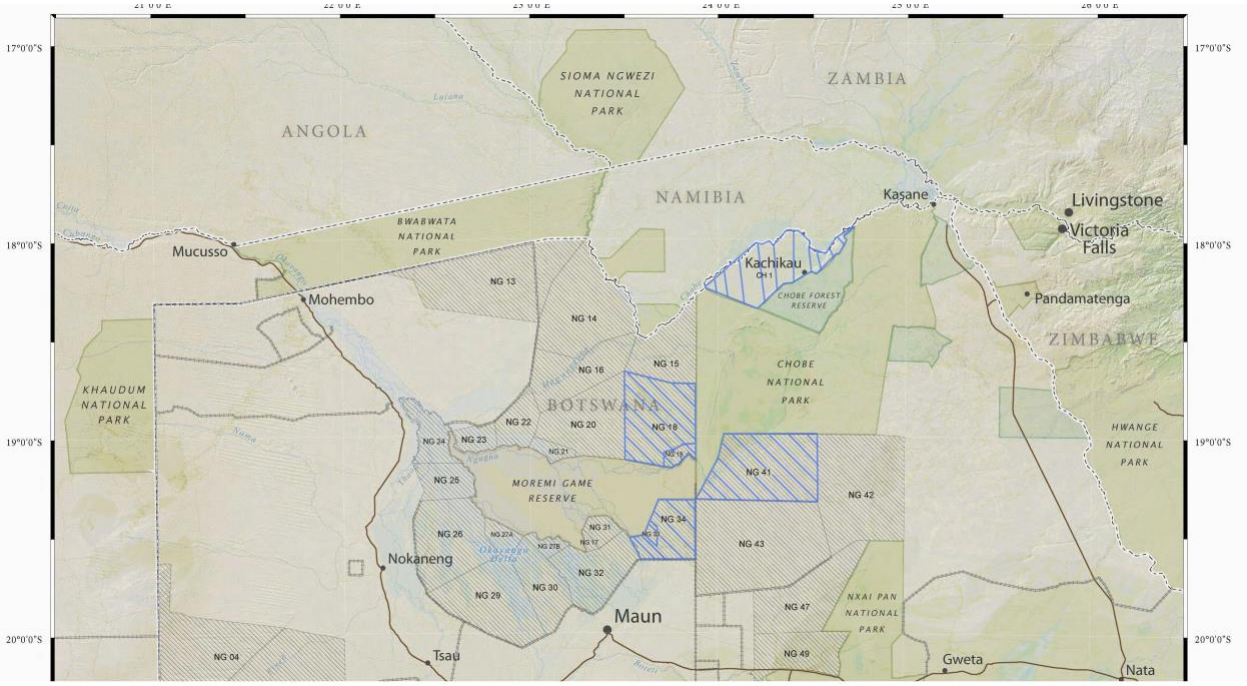

Figure 1. The four community concessions (delineated with blue lines) and study area.

Each concession had various habitat types. The most common observed habitats included grassland, mopane (*Colophospermum mopane*) woodland, open pans, riverine, floodplain, apple-leaf (*Philinoptera nelsii)* scrub, and acacia woodland (*Acacia* spp.) (Table 1) (Cotnoir and Everett, 2015). The smallest concession area was NG 33/34 at 916 km^2 and the largest concession area was CH 1 at 15,678 km^2. The total area of all of the concessions was 20,762 km^2 (Table 1).

Table 1. Total area of the four concessions in the study area (adopted from Cotnoir and Everett, 2015).

Concession	Total area (km^2)
NG 18/19	1,960
NG 33/34	916
NG 41	2,208
CH 1	15,678

Data Collection

Data was collected on line transect drives using the DADS method (Demographics and Abundance through Distance Sampling) in each concession area**.** During each season, transects were driven a total of three times within each concession, with two days in between each repetition. This procedure was repeated from September to December in the dry season and from February to April in the wet season (with the exception of the 2014 dry season). At the beginning of each transect the following data was recorded: air temperature in Celsius, percent cloud cover, GPS coordinates at the starting point, date and start time, name of transect (ex. T1.1), name of that concession area (ex. NG18/19), start odometer reading (in km), and the names of the observers and the driver.

Transects were only driven in the mornings and started between 6 a.m. and 6:30 a.m. Each day, two vehicles drove two separate transects in that particular concession at 10 km/hr. Vehicles were accompanied by a community escort guide from each of the concessions (with the exception of CH 1 for both 2014 and 2015). Transects were approximately 20 km in length and lasted for about two to three hours, with the shortest transect being NG 33/34, T3.2 at 10 km and the longest transect being NG 33/34, T1.2 at 38.1 km. For each animal seen on transect the following data was recorded: species name, GPS coordinates, odometer reading, time of sighting, number of individuals, demographics of the group (such as number of individuals in each age class: adult, sub-adult, juvenile, or unknown), genders of individuals, distance from vehicle to animal (in meters), habitat type/code.

All herbivore species, large carnivore species, select small mammal species, and ostrich (for the 2015 dry season) were recorded. The habitat types of mopane (*Colophospermum mopane*) scrub (MOSC), acacia (*Acacia* spp.) woodland (AW), mixed species mixed age (MMA), open pan (OP), grassland (GS), riverine (R), riverine scrub (RS), floodplain (F), apple-leaf (*Philenoptera nelsii*) (AL), mixed species (MS/LBW), mopane mixed age (MOMX), silver leaf terminalia (*Terminalia cericea*), and water (W) were recorded.

Data necessary for DADS methodology of wildlife monitoring and surveying was collected using a rangefinder to obtain the distance, a mirrored compass to determine the angle from North, a GPS unit to retrieve odometer readings, mark waypoints, GPS coordinates, save and log tracks, and to ensure that tracks were driven correctly.

At the end of each transect, end time, odometer reading, and GPS coordinates were taken down. Data from each drive was handwritten on individual data sheets during the transects. This data was then entered into Excel spreadsheets throughout the season.

To accommodate for the varying amounts of effort for collecting data over the four seasons, the numbers of individuals seen were weighted. For each concession, the total number of individuals sighted for the five selected species was weighted according to how many transects were driven in that concession area in that particular season. This method of weighing was also used with the total average sightings of other various species seen (Table 2).

Results

Data was organized by each concession: NG 18/19 (Khwai), NG 33/34 (Sankuyo), CH 1 (Chobe Enclave), and NG 41 (Mababe). Impala were analyzed separately from the other four species since the amount of impala sightings were drastically higher than the other four species. And in the case of CH 1, zebra were also analyzed separately since their number of total sightings were higher than the four other selected species.

NG 18/19 (Khwai)
Throughout all four seasons in NG 18/19, the largest average sightings per transect drive for the selected species were 17.17 elephant in the 2014 wet season, 5.13 giraffe in the 2013 dry season, and 3.88 kudu in the 2015 wet season (Figure 2, Appendix 1). There were no obvious increases or decreases in sightings, except for the increase in sightings with elephant in the wet season of 2014.

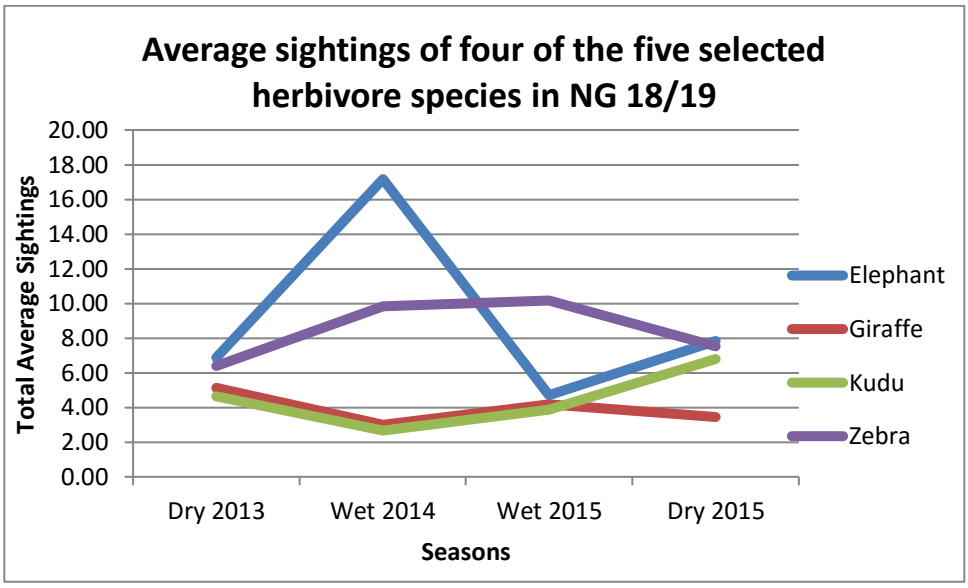

Figure 2. Total average sightings per transect drive of four of the five selected species in NG18/19 (Khwai) throughout all four seasons.

NG 33/34 (Sankuyo)
The highest recorded average sightings per transect drive in NG 33/34 for the selected species were 10.83 zebra in the 2015 wet season, and 8.83 elephants, 9.67 giraffes, and 2.5 kudu were all in the 2015 dry season (Figure 3, Appendix 2). Again, there was variance between the number of sightings for all species throughout the seasons there was no significance.

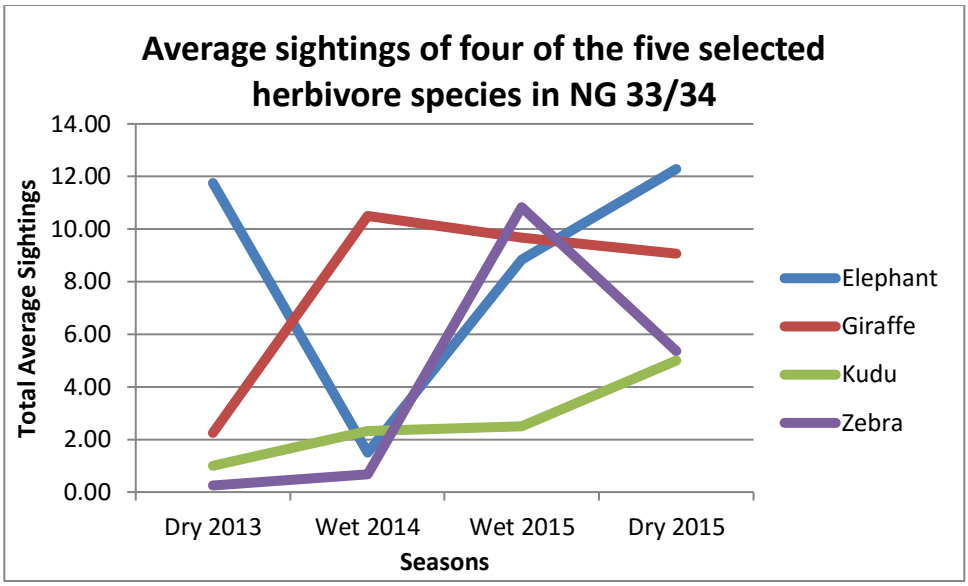

Figure 3. Total average sightings per transect drive of four of the five selected species in NG33/34 (Sankuyo) throughout all four seasons.

CH 1 (Chobe Enclave)

From all four seasons in the community concession of CH 1, the largest average sightings per transect drive for the selected species were 3.88 elephants and 1.32 kudu in the dry season of 2015. The highest total average sightings for zebra and impala were in the 2014 wet season at 12.17 zebra and 4.17 impala all in the 2015 dry season (Figure 4, Appendix 3). The sightings fluctuated throughout the two seasons, especially the number of zebra sightings that decreased from the 2015 wet season and the 2015 dry season.

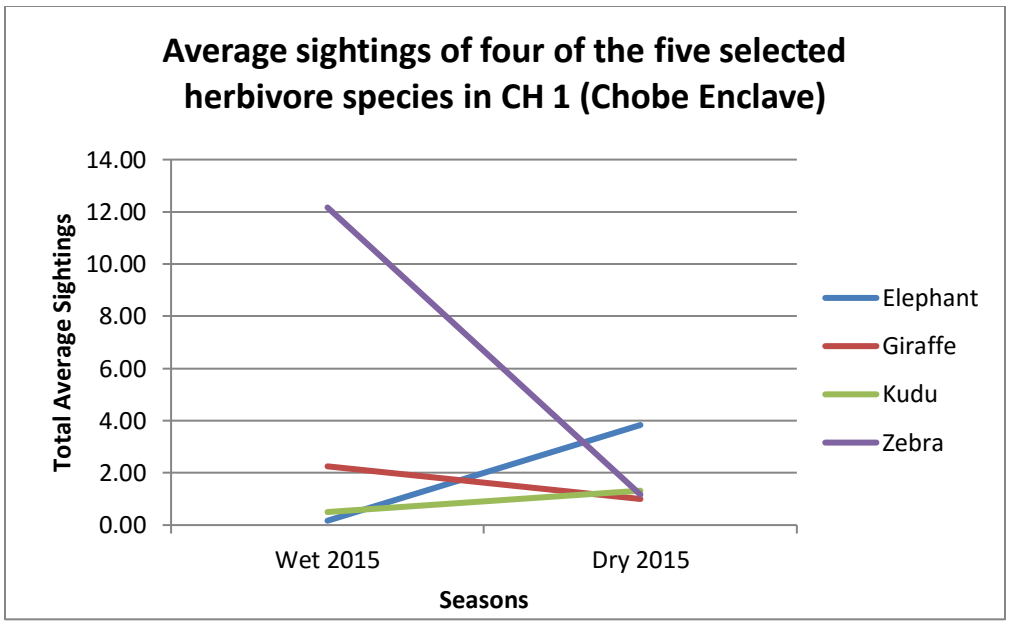

Figure 4. Total average sightings per transect drive of four of the five selected species in CH1 (Chobe Enclave) throughout two seasons.

NG 41 (Mababe)
The highest average sightings per transect drive in NG 41 were 22.83 elephants in the 2014 wet season, 4.58 kudu in the 2015 dry season, and 53.58 zebra and 6.25 giraffe both in the 2015 wet season (Figure 5, Appendix 4). Fluctuations occurred among all species occurred with a noticeable increase in the number of sightings for zebra in the wet season of 2015.

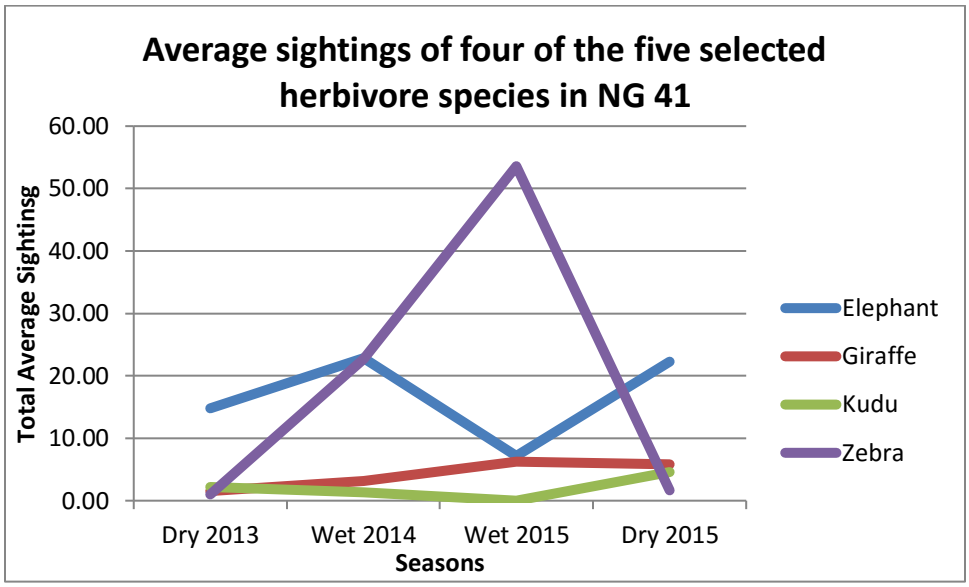

Figure 6. Total average sightings per transect drive of four of the five selected species in NG 41 (Mababe) throughout all four seasons.

Impala sightings throughout all concessions
In NG 18/19, an average of 76.17 impala sightings per transect drive was the highest average of impala seen in the 2015 wet season (Figure 7). In NG 33/34, the highest average of impala seen per transect drive was 74.83 individuals in the 2015 dry season (Figure 8). In NG 41, an average of 83.67 impala sightings per transect drive was the highest average of impala seen in the 2015 dry season (Figure 9). In CH 1, the highest average of impala seen per drive was in the 2015 dry season with 19.67 individuals (Figure 10). Overall the total average sightings of impala per drive fluctuated throughout the seasons for each concession with a general increase in sightings per drive.

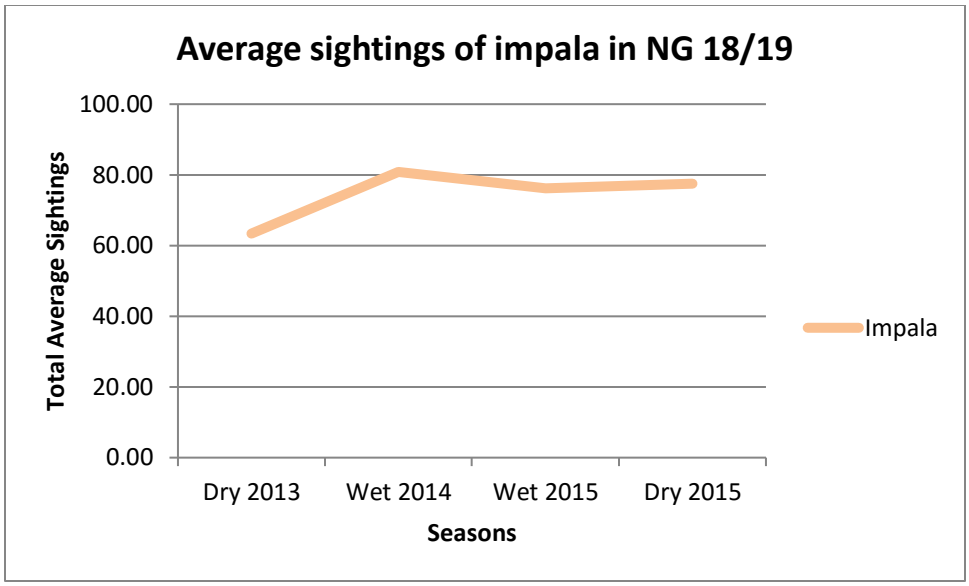

Figure 7. Total average sightings per transect drive of impala in NG 18/19 (Khwai) throughout all four seasons.

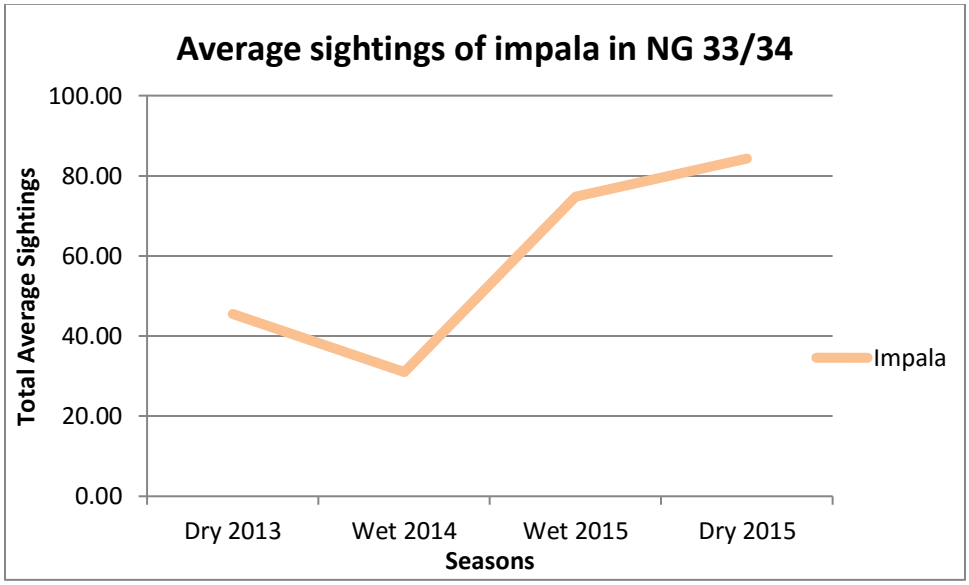

Figure 8. Total average sightings per transect drive of impala in NG 33/34 (Sankuyo) throughout all four seasons.

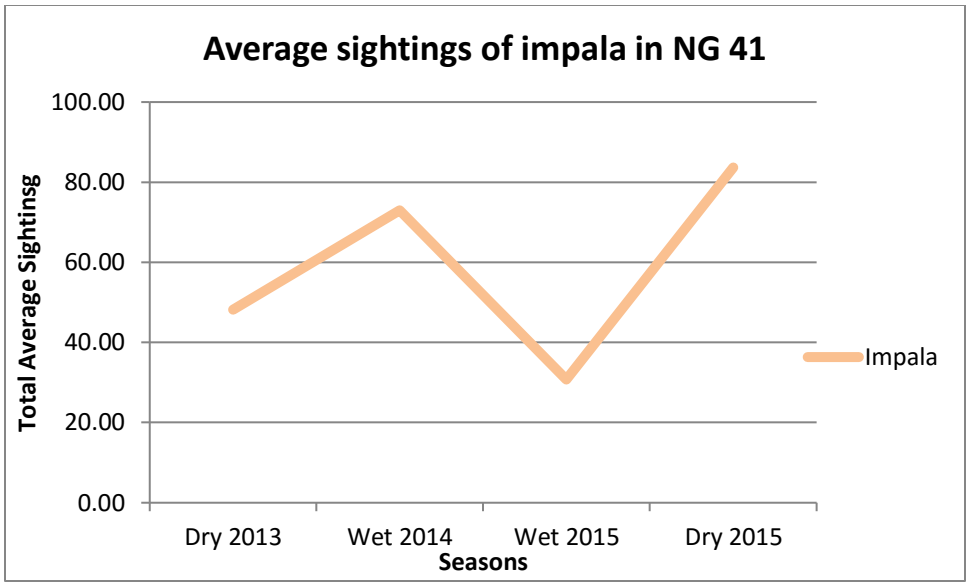

Figure 9. Total average sightings per transect drive of impala in NG 41 (Mababe) throughout all four seasons.

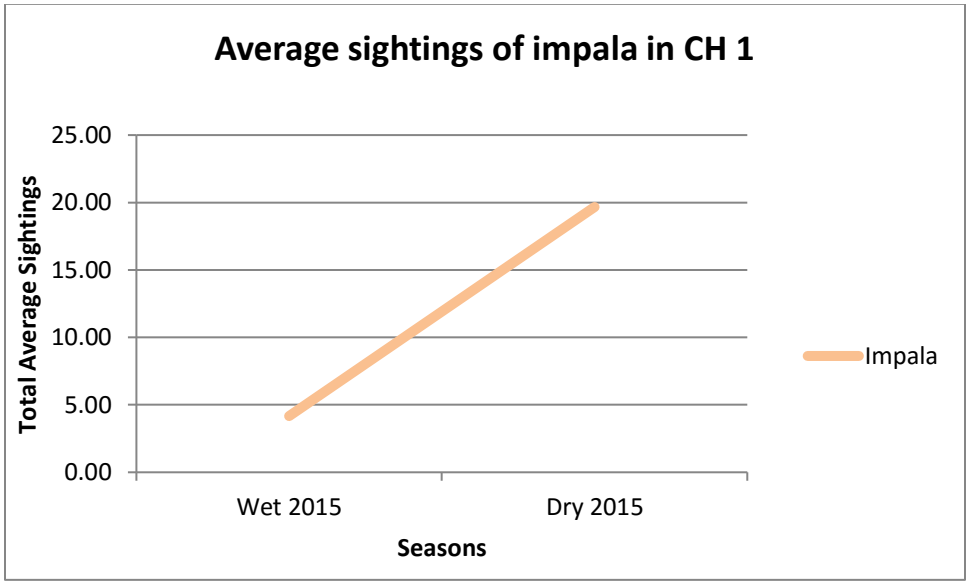

Figure 10. Total average sightings per transect drive of impala in CH 1 (Chobe Enclave) throughout two seasons.

Other various species

Average total sightings per transect drive for other various species did not exhibit a general decreasing or increasing trend, but within each species there were fluctuations with the numbers of sightings (Table 2).

Table 2. Total average sightings for all drives throughout all concessions for various species throughout the four seasons.

	2013 Dry	2014 Wet	2015 Dry	2015 Wet
Baboon *(Papio cynocephalus ursinus)*	0.69	3.58	2.72	3.62
Black-backed jackal *(Canis mesolemas*)	0.15	0.33	0.08	0.09
Blue Wildebeest *(Connochaetes taurinus)*	2.54	7.08	2.77	3.53
Cape Buffalo (*Syncerus caffer*)	8.35	50.33	3.07	24.48
Cheetah (*Acinonyx jubatus*)	0.08	0.00	0.00	0.00
Common Duiker (*Sylvicapra grimmia*)	0.13	0.00	0.00	0.10
Eland (*Tragelaphus oryx*)	0.00	0.92	0.05	0.64
Elephant (*Loxodonta africana*)	11.88	6.08	5.22	13.14
Giraffe *(Giraffa camelopardalis)*	4.19	2.63	5.30	5.72
Hippo (*Hippopotamus amphibious*)	3.75	1.88	6.57	4.48
Spotted Hyena (*Crocuta crocuta)*	0.13	0.08	0.27	0.47
Impala (*Aepycerus melampus*)	71.98	36.75	52.70	71.79
Kudu (*Tragelaphus strepsiceros*)	4.50	2.50	2.18	5.45
Leopard (*Panthera pardus*)	0.02	0.08	0.02	0.14
Lion (*Panthera leo*)	0.33	0.67	0.10	0.16
Red Lechwe (*Kobus leche*)	2.52	1.75	2.12	9.16
Reedbuck (*Redunca arundinum*)	0.73	1.46	0.00	0.43
Roan (*Hippotragus equinas*)	0.31	0.00	0.00	0.83
Sable *(Hippotragus niger)*	0.06	0.08	0.00	0.00
Steenbok (*Raphicerus campestris*)	1.38	0.67	0.57	1.47

Tsessebe (*Damaliscus lunatus*)	0.50	1.92	0.37	1.88
Warthog (*Phacochoerus atheopicus*)	2.90	3.58	1.63	3.60
Waterbuck (*Kobus ellipsiprymnus*)	2.27	1.00	2.27	3.48
Wild Dog (*Lycoan pictus*)	0.29	0.00	0.60	0.17
Zebra (*Equus burchelli*)	3.60	6.29	19.45	20.93

Habitat
The data collected on which habitats the five species were found in shows no consistent trends seen throughout the seasons and the concessions. In NG 33/34 it did appear that elephants were found in mixed species mixed age during the dry season much more than during the wet season, but this was the only possible trend observed at this early stage of the monitoring program.

Discussion

There were no evident decreasing or increasing trends among the sightings of the five selected herbivore species throughout all four seasons and in all concessions. This result could be due to several reasons. First, these herbivore populations may be remaining stable and not experiencing drastic fluctuations in their population size within the study areas. Second, the sample size of this study may need to be larger, indicating that this is a preliminary study that needs to be continued over several more seasons in order to see significant trends.

However, there were other evident results in the data other than population trends. For example, the most sighted selected herbivore species was impala in every concession.Impala might have been the most seen species throughout the other three concession areas because they are a highly adaptable species that are efficient browsers and gazers (Gutteridge and Reumerman 2011; Makhabu 2005). CH 1 had zebra for its species with the highest sightings per drive. One explanation for this could have been that CH 1 may have had more preferable habitat, such as grasslands, for zebra compared to the other concession areas. From our habitat analysis, 59% of the zebra sighted were in grassland in 2014 wet season, and in dry season of 2015, 73% of the sighted zebra were also found in grassland.

The total average sighting per transect drive of both impala and kudu were highest in the same season (of either 2015 wet or dry season) for all concessions. This relationship between impala and kudu could be attributed to similar resource usage and browsing habitats (Makhabu 2005). For example, when a specific food resource or preferred habitat is abundant during a season, both species may benefit.

There were no evident patterns in the habitat selection of the five selected species. For apparent patterns in habitat usage among herbivore species to be seen, this study needs to be continued for a longer time scale. This data shows preliminary trends at most, such as elephants being found in mixed species mixed age during the dry season, and with further research and more data, more conclusive trends are likely to emerge across the concessions and seasons.

Using DADS through line transects can be precise and systematic when done correctly, however it comes with implications such as a bias towards the immediate habitat and animals surrounding the road, bias of observer effort, and variability of sighting due to observer ability and vegetation variability. Other implications was that in previous years not as many transects were driven in certain concession areas and some of the transects (and their distances) changed each semester. Even though the data was adjusted to compensate for these differences by finding the average of sightings per transect drive, these differences do provide inconsistencies in the study.

For future practice of this study, transect routes should be attempted to be more consistent in number of times a transect is driven, which transect is driven, and the length of the transect driven. This will ensure better comparable data throughout seasons and concessions.

Conclusion

For the observed five selected species, our results showed a stable trend in the number of sightings throughout the majority of seasons and concession areas. The results of no significant decreases or increases in number of sightings could indicate that the hunting ban of 2013 has yet to have any obvious effects on wildlife counts in this particular study. Sample size of this study may need to be larger in order to see significant trends in wildlife sightings and habitat usage. Therefore, continuous wildlife monitoring over additional seasons is necessary to obtain more conclusive results and make any inferences relating to species population size.

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Appendix

Appendix 1. Total average sightings per transect drive of the selected five species in NG 18/19 (Khwai) throughout the four seasons.

	Concession NG 18/19 Khwai (Weighted)			
	Dry 2013	Wet 2014	Wet 2015	Dry 2015
Elephant	6.87	17.17	4.71	7.83
Giraffe	5.13	3.00	4.17	3.46
Kudu	4.65	2.67	3.88	6.79
Zebra	6.39	9.83	10.17	7.54
Impala	63.39	80.83	76.17	77.58

Appendix 2. Total average sightings per transect drive of the selected five species in NG 33/34 (Sankuyo) throughout the four seasons.

	Concession NG 33/34 Sankuyo (Weighted)			
	Dry 2013	Wet 2014	Wet 2015	Dry 2015
Elephant	11.75	1.50	8.83	12.29
Giraffe	2.25	10.50	9.67	9.07
Kudu	1.00	2.33	2.50	5.00
Zebra	0.25	0.67	10.83	5.36
Impala	45.50	31.00	74.83	84.29

Appendix 3. Total average sightings per transect drive of the selected five species in CH 1 (Chobe Enclave) throughout two seasons.

	Concession CH 1 Chobe Enclave	
	Wet 2015	Dry 2015
Elephant	0.17	3.833333333
Giraffe	2.25	1
Kudu	0.50	1.316956719
Zebra	12.17	1.166666667
Impala	4.17	3.166666667

Appendix 4. Total average sightings per transect drive of the selected five species in NG 41 (Mababe) throughout the four seasons.

	Concession NG 41 Mababe			
Species	Dry 2013	Wet 2014	Wet 2015	Dry 2015
Elephant	14.77	22.83	7.17	22.25
Giraffe	1.54	3.17	6.25	5.83
Kudu	2.23	1.33	0.00	4.58
Zebra	1.00	22.67	53.58	1.67
Impala	48.15	73.00	30.75	83.67

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