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An analysis of the factors contributing to elephant population fluctuations in SWRA using Ranger-based knowledge and perceptions

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Abstract

This study aimed at examining local ranger-based knowledge and perceptions on explaining contributing factors to variations on elephant fluctuations seasonally and over long period in Sengwa Wildlife Research Area following a massive decline of elephant by nearly 76% after the 2014 National Aerial Survey done in Sebungwe Region, Zimbabwe. Data were collected between 1st and 20th August 2020 using a purposive sampling approach administered to questionnaire to resident SWRA rangers (n = 25). Our results show that rangers considered a combination of factors that may have affected elephant fluctuations in SWRA including poaching, migration, settlement, and impact of climate change. However, our results suggest that rangers had inadequate knowledge about elephant migration destinations. Moreover, mixed perceptions about the impact of trophy hunting, poaching and climate change induced factors were recorded from the participants. The results contribute to a growing understanding of poaching, climate change, trophy hunting and human settlement on elephant behaviour. The study recommends improvement in elephant monitoring through investments on elephant collars and radio tracking to better understand elephant daily and seasonal dispersal movements.

Keywords: Climate change; Aerial survey; Human activities; Migration; Poaching; Settlements; Sengwa Wildlife Research Area (SWRA); Surface water; Trophy hunting

Introduction

Factors that affect elephant distribution at fine scale are well known. Primary drivers are associated with food and water availability [1], with presence of humans as an additional factor [2]. Understanding the key factors that influence the potential dynamics of elephants in changing landscapes of Sengwa Wildlife Research Area (SWRA) has been at the centre of enquiry in wildlife conservation for many decades because of their importance to the ecosystem functioning and impact of human activities to its habitat [2]. Understanding the dynamics is particularly important for African elephant (Loxodonta Africana) whose population indicated a significant decline by approximately 76% over the year from 2002 to 2014 [3]. Large herbivores aerial survey was contacted in SWRA and other elephant range areas in Zimbabwe from July-September 2014.

The survey was part of a national census of the African elephants in Zimbabwe [3]. The survey objective was to monitor trends in large herbivore populations in different areas across Zimbabwe. SWRA is part of the Sebungwe region consisting of mosaic of Parks and Wildlife estate and communal areas. The SWRA area previously had physical barrier to restrict wildlife movement into the communal areas before it was illegally removed. The whole of Sebungwe Region also has no physical boundary and thus large herbivores are able to travel to other areas such as the Hwange National Park (HNP) or to Zambezi valley areas [3]. In 2014, part of the SWRA was degazzetted following promulgation of Statutory Instrument 47 of 2014 resulting in approximately 50km2 of the area parceled out for human settlement. Intense human settlement and clearance of natural vegetation for agriculture and wanton harvesting of wildlife resources on the periphery of

the protected areas were experienced [3,4]. This resulted in the reduction of wildlife habitats, thus affecting survival of wildlife species such as elephants [2].

The aerial survey of 2014 revealed a large decline of elephants in Chirisa and SWRA by nearly 76% since 2001. However, to account for the losses, the elephant all carcass 'ratio' [5] observed during the survey (density of 0.003km2) could not reveal enough evidence to account for the missing elephants in the SWRA even though it was higher compared to 2001 ratio. Total effort for SWRA in 2014 survey was 15 [3].

This study aimed to determine possible factors leading to elephant population declines in the SWRA using the knowledge and perceptions of Park Rangers about the dynamics of SWRA elephants over years. No previous research has focused explicitly on Ranger-based knowledge and perceptions about fluctuations in elephant populations, especially given the emerging conservation challenges where elephant populations are considered to be dwindling rapidly in the Sebungwe region and elsewhere in Zimbabwe. Hence the main objective of this research was to gather baseline knowledge and perceptions of Rangers in with respect to the possible factors responsible for the fluctuations and declines in elephant populations in SWRA over the last several years and suggest ways to maintain a good elephant population.

Materials & Methods

Study area

The SWRA is situated in the southern end of the Chirisa Safari Area (CSA), Zimbabwe 18010´S; 28015´E, (Figure 1). It covers an area of 373km2. The SWRA is separated from the surrounding communal lands on the south, east, and west by a clear road with no physical barrier and in some areas, over-populated and families live within 200m of the boundary. Encroachment into the buffer zone occurs. A well-defined scarp running northeast/southwest divides the area into two levels. The altitude varies from about 800m to 1037m. Three major rivers, Sengwa, Manyoni and Lutope dissect the sandstone escarpment. The vegetation is generally described as deciduous miombo savanna woodlands on the upper sandy soils and dry early deciduous savanna woodlands dominated by Colophospermum mopane on the lower heavier soils (Taylor, 1991). Broad vegetation types are shown in (Figure 1).

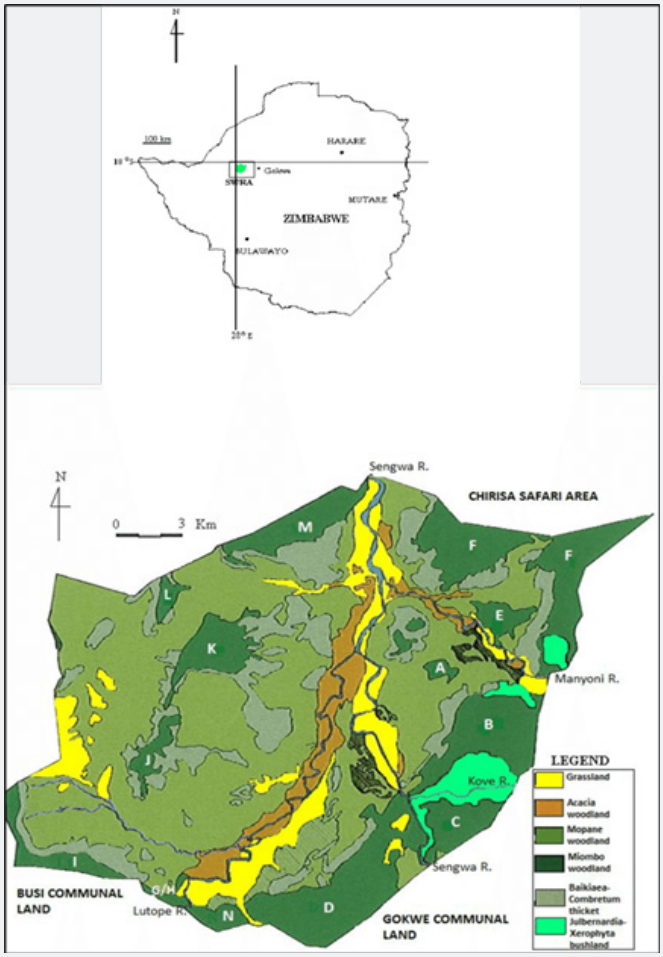

Figure 1: Map showing location of SWRA and vegetation map showing different vegetation types found in the study area.

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Three seasons are experienced: a hot wet (November to April), a cool dry (May to July) and a hot dry (August to October) season. The mean annual rainfall for the past 55 seasons measured in the area is 612mm [6]. The rainfall patterns for the period from 1965 to 2019. The mean annual temperature is 22.2 °C and highest temperatures occur in October and the lowest in July [6].

The SWRA has a diverse of large mammal community of seven species of carnivores and 18 species of large herbivores [7]. The elephant population, which exceeded the carrying capacity since 1965 is currently hovering above density of 2 elephants/km2 but is recommended to be stabilized at about 250 animals (Figure 2). The first major reduction (through culling) in elephant numbers took place around 1975, then a 82% reduction between 1980 and 1982 followed by a 60% reduction in 1992 [8].

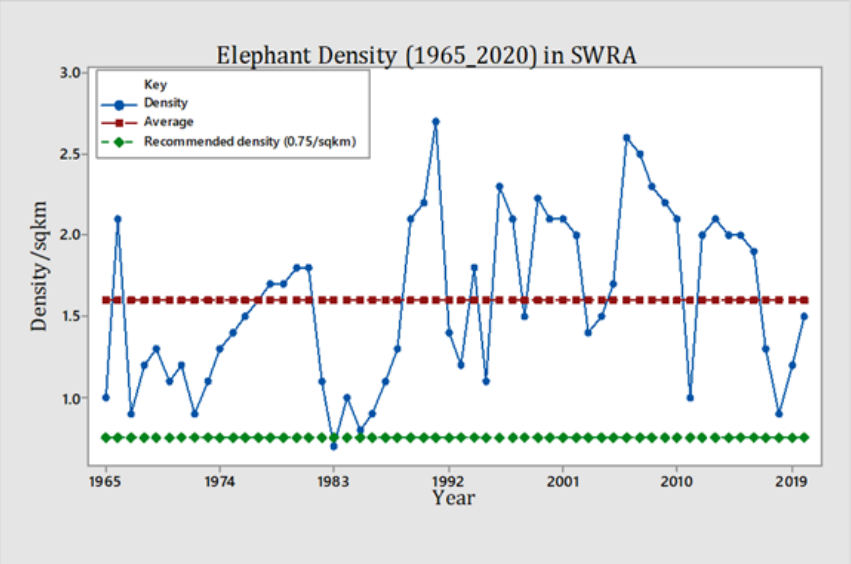

Figure 2: Trends in elephant density in SWRA from 1965 to 2020 based on data obtained from ground transect surveys.

Data Collection and Analysis

Purposive sampling was used to select Rangers based on years a participant stayed at SWRI. Rangers who stayed at least 10 years were selected including current and former Rangers who may have been-transferred too elsewhere. Each Ranger was given an open-ended questionnaire to fill in. A total of 25 participants were selected basing on their historic experience with elephant fluctuations in SWRA. The questionnaire included both open ended and fixed response questions. The questionnaire was designed to evaluate their knowledge on previous and current elephant status and suggest major drivers of population dynamics over time. Pre-testing of the questionnaire was undertaken at CSA where five Rangers were selected and given sample questionnaire to fill in and later give comments on the quality of the questionnaire and adjustments were made. All the questionnaires were electronically administered by the resident Ecologist to transferred staff while current staff were served with hard copies. The survey was contacted from 1st to 20th August 2020. The respondents were given one week to complete the questionnaire.

Data were grouped and summed by response category. Qualitative method was used to analyze the data after categorization and unitizing. Where multiple responses were possible on an open-response question, data were presented as the percentage (%) of respondents giving each response.

Results

Rangers' knowledge and perceptions on elephant population trends

A high proportion (80 %) of respondents largely (n = 25) showed that poaching, migration, and trophy hunting were the main contributors in elephant population reductions between 2009 and 2016. Surface water availability and increase in severe droughts in recent years were resulting in drying up of springs, forage shortage were all attributed to climate change impacts. Human settlements in buffer zones and along the hard edge and degazettement of part of SWRA under Statutory Instrument 147 of 2014 were other factors raised (Table 1).

Proposed management measures

Ranger perceptions highlighted the need to intensifying patrols across Sebungwe landscape to increase ground coverage, suspend trophy hunting in SWRA, argument surface water through drilling boreholes, adaptation of new elephant tracking technologies such as the use of GPS enabled collars, encourage and working with stakeholders for the establishment of community conservancy in adjacent previously buffer zones for the expansion of elephant habitats and providing incentives to local communities towards promoting stewardship and discourage elephant poaching (Table 2).

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Table 1: Ranger-based perceptions on the causes of elephant dynamics in SWRA.

Response	Percentage of respondents (%)	Suggested cause of elephant decline in SWRA
Poaching	30	Poaching was at peak between 2009 and 2016 with majority of poached elephants being male adults (approximately 95%), sub-adult bulls/cows (5%). The existing herds of elephants were observed to be very nervous and frighten followed by quick movement of long distance when disturbed in an area if any suspicious sound is heard.
Migration	30	Seasonal movements to higher grounds and other areas in search of forage and to avoid muddy areas during rainy season. Migration consisted of cyclical dispersal by resident herds and long-distance migration to other protected areas such as Chizarira and HNP. Local cyclical migration consisted of movements from one side of the park for few days such as moving from Manyoni area to Malundi ridge. Immigration of elephants into SWRA was high during the dry season, from April to end November whilst emigration was observed at the start of each rain season.
Trophy hunting	8	Adult bulls were targeted including tuskless elephants thus increasing pressure on elephant population and reduce recruitment in baby elephants.
Settlement	8	Population pressure and increase in demand for land for farming, settlement along the buffer and in Manyoni area resulted in illegal encroachment into the buffer zone and more recently degazettement of part of the SWRA by government hence habitat loss and fragment believed to drive elephants away and killing of as part of controlling human wildlife conflict in these newly settled areas.
Climate change	24	Drying up of water sources and increase in average temperatures and severe droughts in recent years resulting in elephants moving to boarder areas in the Manyoni and Binga Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) where surface water is available in Malundi and Manyoni River. During dry season, concentration of elephant around water holes in SWRA used to be high in areas such as Ketsanga, Siamlambo, Chenzembwe, and Chemhondoro springs and in pools along Sengwa River. Persistence drought in recent years and poor rains resulted in prematurely drying up of water sources as early as June.

Table 2: A summary of ways to manage elephant populations in SWRA based on ranger knowledge and perception.

Number	Ways to improve elephant population in SWRA
1	Intensifying monitoring patrols throughout Sebungwe Landscape: The use of Geographic Information System (GIS) and Global Positioning System (GPS) technologies allow patrols to become more systematic, improving coverage and efficiency in a way that causes would-be poachers to think twice or risk being arrested. This can be done through adoption of 'smart patrol' techniques, such as Management Information System Technology (MIST) and the Spatial Monitoring and Reporting Tool (SMART), in which patrolling rangers collect and record data on signs of poaching activity that can be used as intelligence and be used to gauge wildlife distribution for patrol and management purposes.
2	Spot hunting which was introduced in 2003 on experimental basis need to be terminated. This will allow elephant and other animals to move back to the area.
3	With severe droughts, some waterpoints dried up and there is need to drill boreholes and scoop water pans to allow permanent water throughout the year. Surface lure water dependent animals and reduce distance moved to search for water from forage sites.
4	Improve monitoring of elephant dispersal through GPS collars so that seasonal and daytime movement is established. This helps to track elephant movement and improve their habitats, corridors and water provisioning and it increase monitoring of their movement.
5	Establishment of community conservancy in adjacent communities will help to increase habitat size and reduce fragmentation due to illegal settlement in and along the SWRA boundary. This will also help to re-establish buffer zone where elephants and other animals previously occupy.
6	Community benefits: Benefits provided by SWRA from employment and revenue sharing from sale of park products are perceived to be inequitably to by adjacent communities. Increasing incentives for stewardship, mitigating against human wildlife conflict, and strengthening disincentives for poaching were all sighted as ways to a comprehensive response to reducing elephant and other animal poaching in SWRA.

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Discussion

Our results from ranger-based knowledge and perceptions emphasised anthropogenic factors as the key contributor to elephant dynamics in SWRA. There was general suggestion by participants on major factors affecting elephant population dynamics in SWRA. Participants highlighted that SWRA proximity to communal areas may have resulted in complex encroachment by settled people. Studies had shown that human presents and settlements close to protected areas influence elephant movements [2,4] and unavailability of physical barriers to restrict elephant movement, elephant populations can be compromised through poaching, habitat deterioration, migration, and human encroachment. Natural death due to environmental factors can also affect elephant population in a protected area [2,9,10].

Human settlement and encroachment

Habitat loss through opening of agricultural lands caused by settlement through promulgation of statutory instrument 47 of 2014 and illegal hunting in SWRA may disrupt and destroy elephant societies [2]. In turn, these disruptions can limit the adaptive value of animal social relationships or alter the structure of genetic variation in animal populations and thus resulting in elephant migration and or mortalities which may negatively affect its population [11]. Dudley [12] reported that elephant dynamics within the semi-arid woodland's landscapes including in SWRA, are modulated by human influences on elephant population density and distributions. The findings were supported by Mpakairi et al. [2], who highlighted those human settlements drives elephant movements in Sebungwe region in their study carried out in the Kavango-Zambezi Transfrontier Area (KAZA).

Presently, elephant conservation is faced with many challenges. In many areas, a major threat to elephants is the increasing proximity and, in most areas, actual encroachment of human settlement and activities into SWRA (Ranger observation). The human population has continued to increase and thus exert great pressure on the limited natural resource base. Consequently, conservation areas that were once large and surrounded by adequate buffers zones have increasingly been fragmented and the wildlife populations compressed leading to overcrowding and habitat degradation. This may have resulted in competition for resources and thus may led to intense human-elephant conflicts around SWRA [12]. In SWRA elephants are now confined to a small area and the previous buffer zones which used to help stabilize the protected area now occupied with very limited parches still standing (Ranger observations).

The only prevailing model of interaction between elephants and humans (Parker and Graham 1989) proposes that elephant distribution is the inverse of human distribution, and that elephant abundance is dependent upon human abundance, based on relative densities at a given scale. This was supported by Mpakairi et al. [2], who observed that human settlement drives the potential distribution of elephants in the Sebungwe Region (test AUC = 0.95), and patches from the model were on average <1.5 km2. This is supported by ranger-based knowledge and perception who outlined those recent settlements and encroachment by local communities into the buffer zone could have contributed to elephant decline in SWRA.

Elephant trophy hunting and poaching

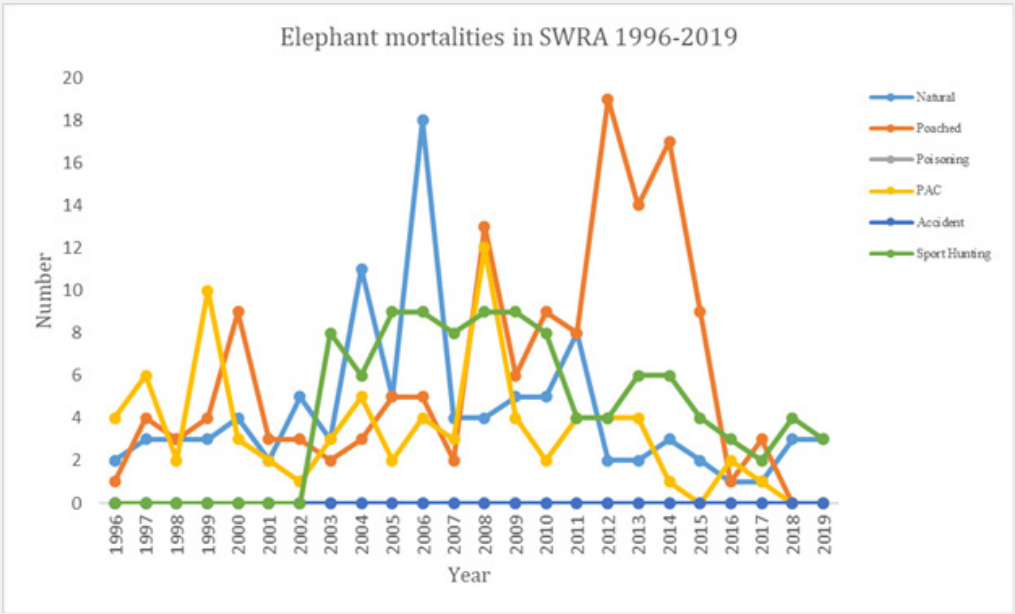

Figure 3: Trend in elephant mortalities based on different methods from 1996 to 2019. Poaching and natural mortalities have the highest numbers with death due to accident maintained at zero.

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In SWRA and other areas in Zimbabwe, hunting selectively remove older bulls with large tusks [13] and recently had been seen targeting tuskless elephants. Such is also the case with consequences of these effects for elephant societies [14]. Poaching from 2008 to 2016 was on the rise in a number of elephant populations [15,16]. In SWRA, rangers highlighted that between 2010 and 2016, poaching dominated all other mortality forms (Figure 3). Wild elephants are also facing new threats from habitat loss and human-wildlife conflict exposing them to illegal killing and elimination as a mitigation measure by relevant Authorities, which is a direct respond to increasingly constrained smaller areas where there is growing contact with humans [14].

Poaching removes older animals and kin from elephant populations, with important consequences for females and males [14]. For females, the loss of important social partners may decrease female fitness, which may influence population growth rates. For males, poaching seems to increase reproductive skew, which may increase the rate at which genetic diversity is lost from natural populations [17,18]. Station records indicate that 95% of poached elephants in SWRA were adult bulls with the remaining 5% being sub-adult bulls or old cows. Literature highlighted that reducing the number of breeding males will decrease the effective population size of elephant populations and increase the rate at which genetic diversity is lost [17].

The level of poaching, although it appears to have decreased over the last 4 years in SWRA, may have an impact on the demographic status by selectively targeting mature adults. The ranger knowledge and perception coincided with the results of aerial survey done which indicated a major decline in elephant bulls while cow populations were constantly increasing over the years in SWRA (Table 3).

Table 3: Trends in elephant population density of bulls and cows following aerial survey of 1997, 2002 and 2014.

Population estimates and statistics for elephants in SWRA								
	Year	Estimate	No. Seen	Variance	%CI	Lower CL	Upper CL	Density
Bulls	2014	90	17	1165	81.3	17	163	0.24
	2002	183	30	18974	170.3	0	495	0.49
	1997	229	53	2528.5	45.9	123.7	333.5	0.6
Cows	2014	768	145	94866	86	145	1429	2.06
	2002	738	121	203027	138.1	0	1757	1.97
	1997	574	133	33071.1	66.1	194.2	952.9	1.5

75 percent of the participants indicated that frequent encounter with elephant sightings during patrols were biased towards cows and occasionally subadult bulls in family herds. 50 percent of participants indicated also that earlier to 2009, encounters with large bulls were equally the same with cows during which poaching was very low in SWRA.

Respond from participants indicated that the quota allocated for trophy hunting was high and argue the need to stop trophy hunting in SWRA. Rangers who participated in trophy hunting admitted there was a significant decrease on trophy quality of elephants. This was supported by finding by Ngorima [19] who did an analysis on trend in trophy quality from 2003 to 2013 on elephants in SWRA and reported a significant decrease on trophy quality for elephant and further indicated that hunting success rate declined with each passing hunting season. Analysis on annual trophy hunting also indicated poor utilization of allocated trophy quota with constant review downwards. Trophy hunting of bull elephants were almost 90 percent success prior 2009. However, since then it was reduced to almost 10 percent success with only hunting of tuskless elephants been successful.

However, the decline in trophy quality could not be attributed directly to decline in elephant population in SWRA since density of elephant cows increased from 1.5 to 2.06 in 1997 and 2014 respectively [3]. Thus, selective hunting (Both spot hunting and poaching) could have contributed to decline in adult elephant bulls in SWRA from participant's perception. However, indirectly trophy hunting may negatively affect breeding herds and thus affect elephant population according to [20] in his paper "Retrospect of trophy hunting now and the future in SWRA".

The decline in success rate in trophy hunting for elephants could have also been affected by trophy hunting taking place in adjacent hunting areas (Ranger observation). SWRA share elephants with other adjacent areas, and this means the same elephant herds were targeted for trophy hunting and poaching in these adjacent areas. Ranger knowledge and perceptions highlighted pressure on elephant bull hunting was multifaceted both for spot hunting and illegal poaching (Ranger observations).

Climate change

Ranger based knowledge from the survey support the findings by Kupika et al. [21] who highlighted those common effects of climate change on wildlife include changes in life- history events, effects on demographic rates and reductions in population size as well shifts in species distributions. Climate change poses direct and indirect effects on wildlife [22] through changes in the fitness, survival, and reproductive success [23]. In semiarid ecosystems, climatic changes in frequency and severity of droughts are likely

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to exacerbate the effects of drought on forage availability, which can feed back to regulate reproduction and offspring recruitment among ungulates [24]. Forrest et al. [25] highlighted that climate change is likely to affect the persistence of elephants through habitat shifts loss and fragmentation supporting the observation from ranger knowledge and perception.

Thus, climate-induced extreme events could have also threatened survival of elephants in SWRA through reduced surface water and drying up of springs and recent increase in temperature [26] noted that climate change is predicted to affect both the mean annual rainfall and its seasonal distribution over the African continent. Thus, climate warming has a potential to directly affect wildlife resources through shifts in onset and duration of rainy seasons and drought on wildlife species, reduction in species distribution ranges, alteration in abundance and diversity of mammals, changes in calving and population growth rates, changes in juvenile survival of most ungulates [27]. Temperature and rainfall display complex temporal variation changing from place to place across the earth. These key climatic factors determine plant productivity and hence animal food availability [28]. Rainfall controls primary production [26] and ungulate grazer populations across the African savannah.

Rainfall in SWRA is characterized by monthly and intra-annual variability with a mean annual rainfall of 612mm. Rainfall variability has a distinct effect on the primary productivity of the area and hence the wildlife that it can support. Apart from seasonal drying up, the quantity and quality of water at some sources have changed (Ranger observations, 2015) probably due to prolonged drought periods. For example, participants indicated that some springs such as Kamashaboya and Sijamba Spring which used to provide water for wildlife had in recent years dry up earlier due to severe droughts experienced in recent years and may have impact on elephant population in SWRA and elsewhere.

Rainfall also is variable at SWRA, and this could have an effect on the abundance and distribution of elephants elsewhere. An analysis of the annual rainfall data for SWRA shows a high of over 1000 mm and a low of slightly below 190mm in 1996/1997 and 2012/2013 annual rain season. Large herbivores, in particular, elephant, could be under threat from the periodic droughts. Noticeable changes in large mammal populations in the riverine woodlands and adjacent areas due to drought have been observed along Sengwa, Lutope and Manyoni rivers. Ranger knowledge and perception supported the findings by [29] that SWRA is a semi-arid ecosystem with low and regular rainfall, high evapotranspiration, and cyclical droughts. High evapotranspiration mean soils dry up quickly reducing amount of water available for plants as well surface water. Some rise in local temperatures have been noted at the Institute with current average temperatures over 55 years recording 26.3° Celsius (SWRA Metrological record). However, this shows a rise in temperature since 1965 when average temperatures were recorded to average 22.2°Celcius [30,31].

Drought-related mortality of elephants has also been observed in SWRA in 1994-1995 [32]. revealed that high-density aggregations of elephants around limited water sources during the dry season in HNP may result in the depletion of local food resources. Additionally, elephant herds were forced to travel long distances between water and forage during which the elephant calves die [32].

Migration

Ranger knowledge indicated that SWRA elephants appear to show a wet season dispersal pattern, moving outside the central area of the study area to the periphery or to adjacent parks (end November through to April each year). These movements are believed necessitated to avoid low laying muddy areas which effect their movement. Partial movement on elephant had been reported elsewhere and was noted to be influenced by some environmental variables [33].

The SWRA elephants were reported to exhibit a pattern common to many other African elephant populations: a wet season migration, and a dry season concentration around permanent water sources [34]. The SWRA elephants maintain their core home range in the park, but execute frequent and short migrations to the Chizarira, CAMPFIRE and Chirisa (Ranger observation) searching for safe areas and water as well forage during the dry season.

A characteristic of the African savanna ecosystem is the spatial and temporal variation in resource availability due to periodic and irregular rainfall. This variation forces savanna wildlife to move to where food and water can be obtained [35]. When key essentials for survival are inadequate migration may become a successful strategy for coping with resource scarcity in highly seasonal environments. Response from participants indicated that seasonal migration of elephant could have been attributed to these factors.

Participants also suggested migration in elephant bulls which coincided with hunting seasons. Although hunting season become very active between May and October each year, it was noted during this period, sightings of adult bulls everywhere was rare. At the start of the season elephant bulls could move out of the area. Bull migration in relation to first hunts since poaching peaked from 2009 to 2016 (Ranger observation).

Even though migration was mentioned as a factor contributing to elephant decline in SWRA, participants admitted that it was difficult ascertain the destination although this can be verified through evidence of heavy flocking in of large herds of elephants soon after the wet season. Some participants highlighted that during wet season there was time when elephants were not seen for days. The fact was validated through law enforcement reports where it was noted that from 2009, between January and end March recording of elephants sighting was very low. In SWRA, wet

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season migration have also been attributed to poaching to some extend during the rainy season. Poaching of elephants in SWRA was noted to be significant during the wet season [4]. Elephants had been observed to avoid their previous wet season territories maybe because of constant disturbance by illegal hunter who target elephant in thick areas when they will be avoiding low laying muddy sites (Ranger observation). In recent years, rangers indicated low sightings of elephants in the northern side of the park especially in previously known poaching hotspots such as in Musamba Jesse and upper Samapakwa ridge.

Rangers suggested that where poaching occurs, the elephants' herds targeted regularly hear gunshots, encounter poachers and elephant carcasses and witness the death of conspecifics, including close associates and family members and as such, savannah elephants alter their behaviour when exposed to these threats; they immediately shift to more nocturnal activity patterns, and increase flight behaviour as well migrating to safer areas [23]. In order to engage in risky behaviour such as crop raiding, elephants wait until darkness falls, and avoid moonlit nights, before leaving secure areas [36] into the communal area searching for forage and water, the case of Malundi water point adjacent to SWRA.

Even though the 2014 Aerial survey highlighted massive elephant decline in Sebungwe, Rangers expressed possible sources of bias could have resulted in poor sightings of elephants in SWRA during the census sighting choice of survey technique, climatic conditions and vegetation cover may have impacted the results. For more accuracy results all participants proposed data should be collected by a wildlife management authority using standardized methods for collecting, recording, and analyzing data which also supports the ideas of [37]. They recommended combining data from different types of surveys including data from patrol reports in estimating elephant population in SWRA. Seasonal and cross-boundary movements of elephants was considered as one factor that could have affected elephant sightings in SWRA. Ranger observations also suggested increase in search effort during aerial counts determine the elephant carcass densities (no./km2) in SWRA, supporting suggestion by [2,38]. The Search effort of 15 for SWRA was suggested very low and could have contributed to underestimate of the area elephants [39-43].

In a nutshell, Rangers admitted a marginal decline in elephant population in SWRA and suggested improvement in law enforcement, surface water, engage local adjacent communities, suspend trophy hunting and increase habitat size by assisting communities to form community conservancies. New technologies to identify individual animals, follow their movements, identify, and locate animal and assess the status of their habitats remotely have been suggested for better, faster, and cheaper approaches in monitoring elephant dispersal and control poaching in SWRA. Rangers suggested this can be strengthened by law enforcement, increasing awareness and environmental education, and developing mechanisms to reduce human-wildlife conflicts to further minimizing illegal hunting activities. This suggestion support findings in Southeast Low Veld, Zimbabwe by [9] who indicated the need to engage local communities in law enforcement activities [44-46].

The use of Geographic Information System (GIS) and Global Positioning System (GPS) technologies can allow patrols to become more systematic, improving coverage and efficiency in a way that causes would-be poachers to think twice or risk being arrested. Rangers encouraged the adoption of 'smart patrol' techniques, such as the Spatial Monitoring and Reporting Tool (SMART), in which patrolling rangers collect and record information on signs of poaching activity that can be used as intelligence. Another recommendation from the survey was through establishing community engagement by improving livelihoods. Understanding the impact of poaching on affected populations, and engaging with local communities on enforcement activities, can both facilitate greater understanding and support for local law enforcement efforts, as well as promote intelligence-led activity. In recognition of the pivotal role of local communities in efforts to halt projects can be initiated by SWRI for local communities to benefit from leaving with the resources as well supporting locals in establishing Conservancy areas hence increasing elephant habitat sizes and support from adjacent communities [47].

Conclusion

Our survey results reveal patterns of elephant fluctuations in relation to effects of poaching, migration, climate change and human activities on elephant social relationships based on ranger knowledge and perceptions. Poaching and trophy hunting may have disrupted elephant organization by removing older animals and kin, which can limit the adaptive value of female relationships. In this study rangers disputed the method used for the 2014 National Elephant survey as well the timing of the survey sighting observed changes in elephant behaviour of occupying thick bushes and less active during the day to avoid humans. Elephant bulls were noted to decrease over the years with density of 0.6 to 0.49 and 0.24 per km2 from 1997, 2002 and 2014 respectively and was attributed to selective hunting from ranger perception. Cow density however significantly increased during the same time. Human settlements were also suggested to have caused result migration to adjacent protected areas such as Chizarira, Hwange National Park as well as occupying other safer undisturbed habitats. Participants highlighted the need to intensify patrols throughout Sebungwe Landscape by investing in integrated technologies such as the use of Unmanned Aerial Vehicles (UAV) together with the use of Spatial Monitoring and Reporting Tool (SMART Technology), suspend trophy hunting in SWRA to restore elephant social relationship between elephant herds and reduce nervousness, improve game water provisioning, and improve technology to monitor elephant seasonal dispersal. Proper land use planning and development of community conservancy, buffer zones as well compatible land use is recommended to maintain elephant habitat in SWRA.

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