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Mammal species composition and diversity of the Nyae Nyae Communal Conservancy, Otjozondjupa Region, Namibia

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Abstract

The emergence of the communal conservancies in Namibia contributed to community-based conservation approach outside protected areas. This study was conducted to establish the status of biodiversity conservation of the Nyae Nyae Conservancy by analysing the mammal species composition and diversity changes for 13 years. The long-term wildlife count data were obtained from the conservancy in Tsumkwe, Otjozondjupa region. A total of 20 mammal species, comprising of ungulates and predators, were recorded from 2001 through 2013. The overall trend of the mammal species population sizes was positive, though not statistically significant (r = 0.477; t10 = 1.574; P = 0.145). In addition to the stable species composition over the years, the mammal species diversity in Nyae Nyae conservancy was high (Simpson Index of Diversity, SID = 0.81). However, a significant decline in the diversity of mammal species (SID = 0.72) was detected in 2013 evident from the low species count data. This low diversity may be attributable to many factors including but not limited to the effects of severe drought which may have led to the emigration of some species, reduction in the abundance of some species due to deaths from drought and low reproductive output. Hence Nyae Nyae Conservancy, though an open unfenced system, serves as a good example in which a community-based natural management program outside protected areas contributes not only to the conservation of natural resources including wildlife but also utilisation of these resources for the benefit of local community members.

Keywords: Conservancy, wildlife, composition, diversity, Nyae Nyae.

1. Introduction

For many years, the conservation approaches in Africa and elsewhere in the world were based on protected-area management (Pimbert & Pretty, 1997; Brook, Sodhi, & Bradshaw, 2008). However, many protected areas over the years have become too small and highly isolated to conserve biodiversity (Hayes & Hayes, 2013) effectively. Acknowledgement of the need to involve local communities in the conservation of biodiversity (Kiss, 1990; Songorwa et al., 2000) gave rise to new conservation approaches, mainly the Community Based Natural Resources Management (CBNRM). The CBNRM approach has been introduced in different Southern Africa countries. It enables the devolution of rights to rural communities, allowing them to manage, utilise and benefit from the wildlife resources (Jacobsohn & Owen-Smith, 2003; Silva & Mosimane, 2014) outside government-protected areas. CBRNM approach is based on the premise that communities would manage local resources, including wildlife sustainably if they are allowed to exert reasonable control

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over the management and use of the resources in a manner that also allows them to benefit from such management (Jones, Hulme, & Murphree, 2001; Taylor, 2009; Child & Barnes, 2010). In Namibia, for example, the enactment of the Nature Conservation Amendment Act of 1996 has granted partial rights to communities in communal areas to manage and benefit from wildlife resources through the establishment of conservancies.

Communal conservancies are defined as "legally-recognised, geographically-defined" institutions, formed by communities, designed to conserve natural resources including wildlife while enabling sustainable utilisation of these resources to the benefit of resident communities (NACSO, 2014, Silva & Mosimane, 2014). Conservancies are registered through the Ministry of Environment and Tourism (MET) as legal entities that serve as important partners in the biodiversity initiative to protect landscapes, ecosystems, species and genes, as well as improve the rural economy (NACSO, 2014).

Nyae Nyae Conservancy, located in the east of Namibia in Otjozondjupa region, is one of the first four (the other 3 being Salambala, ≠Khoadi-//Hôas and Torra) conservancies that were gazetted in Namibia in 1998. Following the success of the conservancy model that has given rise to the improvement of conservation of natural resources including wildlife and economic benefits for local communities, many other communities in Namibia embraced the approach and increasing the number of conservancies. At the end of 2016, 82 communal conservancies were established, covering 19.6% of the country's surface area (www.nacso.org.na).

This study was conducted to establish the status of biodiversity conservation of the Nyae Nyae Conservancy by analysing the wildlife species composition and diversity changes for 13 years (2001–2013) following its establishment in 1998. The results of the study provide empirical evidence of the extent of recovery and stability of wildlife species composition and species diversity as an index of success of community-based natural resources management through the conservancy model of natural resources management and utilisation by local communities outside protected areas.

1. Methodology

2.1 Study area

The study was conducted in the Nyae Nyae Conservancy (Fig. 1), located (at 20° S, 20° E) in the north-eastern part of the Tsumkwe Constituency of the Otjozondjupa region in Namibia covering land that is under the jurisdiction of the Ju/'hoansi (San) community. The Nyae Nyae Conservancy was registered in 1998 with MET. The conservancy has an area of 8,992 km^2 (NACSO, 2004). The Nyae Nyae Conservancy is also characterised by a very low human population density as villages outside the main Tsumkwe settlement have a population density of less than 1 person/km^2 (Weissner, 2004; Biesele & Hitchcock, 2013). At the time of the present study, approximately 3,000 people were living in the 38 villages of the Nyae Nyae Conservancy, ranging between 15 and 20 households per village (Hays et al., 2014).

Hunting-gathering was a dominant livelihood activity among the San community during the 1950s, but by the 1970s, only a few households (about 5%) depended on hunting and gathering as a primary livelihood (Suzman, 2001). After Namibia's independence in 1990, almost all households among the San community in the Nyae Nyae area did not solely depending on hunting and gathering for their livelihood. New livelihood options including but not limited to eco-tourism, small-scale agriculture and government grants and drought relief programmes (Biesele & Hitchcock, 2013) were introduced. Wildlife in this conservancy is either found to be free-roaming in open landscapes or the enclosure, the Buffalo Camp. The Camp was established in 1996 to accommodate the sensitive buffalo that were found in the area to avoid close contact with other species in the conservancy as buffalo are susceptible to foot-and-mouth disease. The camp was expanded from its initial size of 2400 ha to 9600 ha during 2006/7 to make it a viable habitat for the species found inside it. This camp contains mainly ungulate species, such as buffalo, black rhinoceroses, kudu and eland. The predators found in

the camp were only those that slipped into the area through the fences (Pers. comm. Peters, WWF in Namibia).

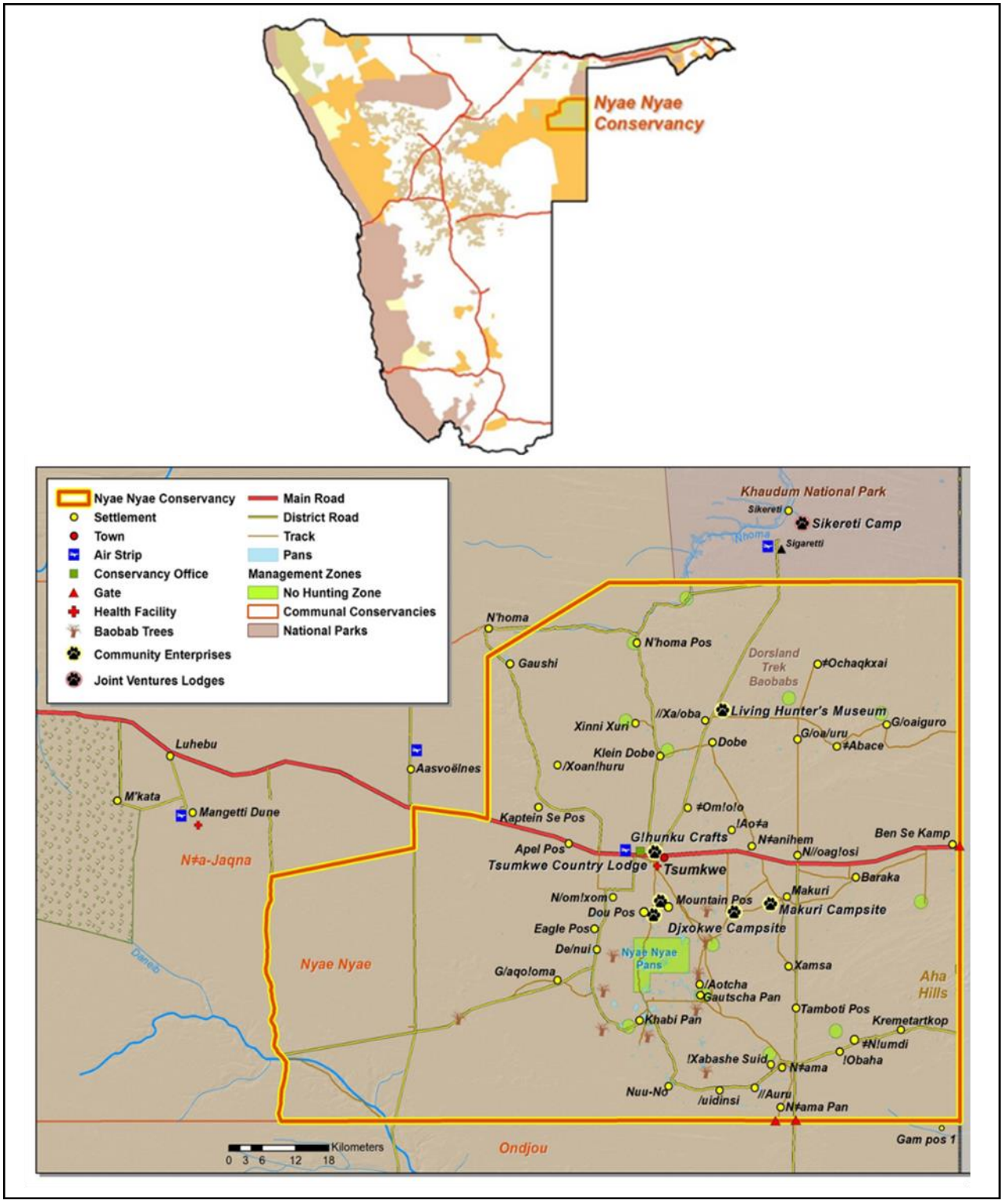

Figure 1. The Map of the Nyae Nyae Conservancy and location in Namibia. Source: WWF in Namibia/NACSO (2016).

2.2 Data collection

This study mainly utilised secondary monitoring data for wildlife that is collected annually for the Nyae Nyae Conservancy. The CBNRM programme through the Ministry of Environment and Tourism and the Namibia Association for CBNRM Support Organisations (NACSO) network has been supporting the

conservancies in carrying out annual game counts either as individual conservancies or as groups of neighbouring conservancies to assess wildlife growth and trends in these locally-managed areas over the years (NACSO, 2013). The Nyae Nyae Conservancy has consistently implemented the annual water-point counts since 2001.

The 48-hour, annual waterpoint count (2001–2013) for the Nyae Nyae conservancy was obtained from the NACSO office with the permission of the Nyae Nyae Conservancy and the MET under the terms of the research permit. These annual water-point counts of wildlife in the Nyae Nyae Conservancy were carried out during the full-moon period in September annually. The process of collecting these data involved teams of 2-persons at each water point for 48 hours. At each water-point, the species, number of individuals and groups sizes that visited the water point was recorded. Data used in the present study were collected for 13 years from 2001 to 2013 (excluding 2006 when no data was collected due to severe flooding). It is noteworthy that although the dataset used contained data on mammal species in the Nyae Nyae Conservancy, other essential parameters such as age and sex of the species were not recorded. Lastly but not least, these data were only collected during the dry season.

2.3 Statistical Analysis

Trends of all the wildlife species recorded in the conservancy from the water-point count database were tested in R using a Spearman correlation test to assess if the changes in population sizes over the years were statistically significant. A Hierarchical Cluster Analysis (HCA) was run in R to establish groups or clusters among wildlife over the years, using the presence/absence of species from the water point count data of 2001–2013. The sighted wildlife species were categorised into the size and functional groups or classes of species to provide an understanding of the kind of wildlife species found in the conservancy. The large and small ungulates were distinguished, based on the species' average body mass where large ungulates weigh between 100 kg to more than 5,000 kg, while small ungulates weigh between less than 5 kg and 100 kg (Stuart & Stuart, 2014). The third category comprised of the predators found in the conservancy. Simpson's Index of Diversity (SID) was calculated for the diversity of wildlife species in the conservancy, using the long-term water-point count data. SID is a measure of diversity which takes into account the number of species present, as well as the relative abundance (or evenness) of each species (Keylock, 2005). The value of the species diversity index (represented by 1-D) ranged between 0 and 1 (Keylock, 2005). As species richness and evenness (proportional abundance) increase, so does diversity (1-D). High values of the diversity index represent high diversity of species in a community. Turkey's Pairwise Comparison was performed to find the source of the significant results by comparing the species diversity over the years. The species diversity was also analysed for the different landscapes, classified as open landscapes and the enclosure, the Buffalo camp.

2. Results

3.1 Species composition

A total of 20 species, comprising of ungulates and predators, were recorded between 2001 and 2013 from the annual water-point count data (Table 1). The total number of species observed over the years at the water points were primarily ungulates (N = 15, 75%) which consisted of small ungulates (N = 4, 20%) and larger ungulates (N = 11, 55%). The rest of the species were predators (N = 5, 25%). The results from the One-way ANOVA revealed that the mean frequency of sightings for the different species over the years under the three classification groups were not statistically different ($F_{2, 17} = 1.06$, $P = 0.368$), meaning that the annual species (species richness) detected from the different classes did not significantly change during this period.

Table 1: The common and scientific names, classification (size [large/small] and functional [predator / non-predator]) and the mean (±SE) number of animals sightings at water point during the counts of 2001–2013

Common Name	Scientific Name	Mean (±SE)	No. of sightings of individuals of each species	Frequency of sightings
Large Mammals, Non-predator				
Buffalo	*Syncerus caffer*	92 ±19.6	2931	32
Elephant	*Loxodonta africana*	64±10.7	9554	148
Blue Wildebeest	*Connochaetes taurinus*	45±6.9	3605	80
Kudu	*Tragelaphus strepsiceros*	19±1.9	2589	140
Eland	*Taurotragus oryx*	14±2.8	341	25
Girraffe	*Giraffa Camelopardalis*	3±1.6	14	5
Red hartebeest	*Alcelaphus buselaphus*	9+1.3	324	35
Roan	*Hippotragus equinus*	9+1.4	547	60
Oryx	*Oryx gazella*	7±1.5	310	43
Small Mammals, Non-predator				
Springbok	*Antidorcas marsupialis*	58±11.8	1691	29
Warthog	*Phacochoerus africanus*	6±0.6	551	89
Black Rhino	*Diceros bicornis*	4±1.0	71	16
Steenbok	*Raphicerus campestris*	3±0.4	249	88
Duiker	*Sylvicapra grimmia*	2±0.4	68	32
Burchell's Zebra	*Equus burchelli*	2±0.0	2	1
Predators				
Wild Dog	*Lycaon pictus*	9±2.5	327	35
Jackal	*Canis mesomelas*	5±0.5	496	102
Spotted Hyena	*Crocuta crocuta*	4±0.6	570	130
Leopard	*Panthera pardus*	2±0.1	92	59
Lion	*Panthera leo*	2±0.5	9	5

Source of data: Waterpoint count data from the Nyae Nyae Conservancy (2001–2013).

Trend analysis was performed in R using the Spearman's Correlation Test based on individuals sighted for each species between 2001 and 2013, including species size / functional groups (large ungulates, small ungulates and predators) and also for all the species combined. A positive trend in abundance was observed for all the sighted species combined over the period in the conservancy, although it was not statistically significant (r = 0.477; t_{10} = 1.574; P = 0.145). The overall trends in the frequency of sightings for all large ungulates (r=0.266; t_{10}=0.872; P = 0.404) and the small ungulates (r = 0.334; t_{10} = 1.122; P = 0.288) were positive over the period though not statistically significant. The results revealed a negative trend in the frequency of sighted predators over the years, though it was not statistically significant (r = -0.199; t_{10}= -0.642; P = 0.535).

According to Table 1, species such as the elephant, the buffalo and the blue wildebeest were sighted in large numbers and these species showed positive trends in the numbers sighted over the years (r = 0.588; t_{10} = 2.300; P = 0.044), (r = 0.707; t_{10} = 3.164; P = 0.010) and (r = 0.099; t_{10} = 0.3145; P=0.760), respectively. The sightings of these species were the highest during 2013 and have influenced the difference between this year and the rest of the years. The dendrogram (Fig. 2) showed two groups or clusters consisting of the year 2013 and the other group consisting the rest of the years. However, the degree of dissimilarity at 0.14 is also quite low, suggesting little variations in wildlife species sighted between the two groups.

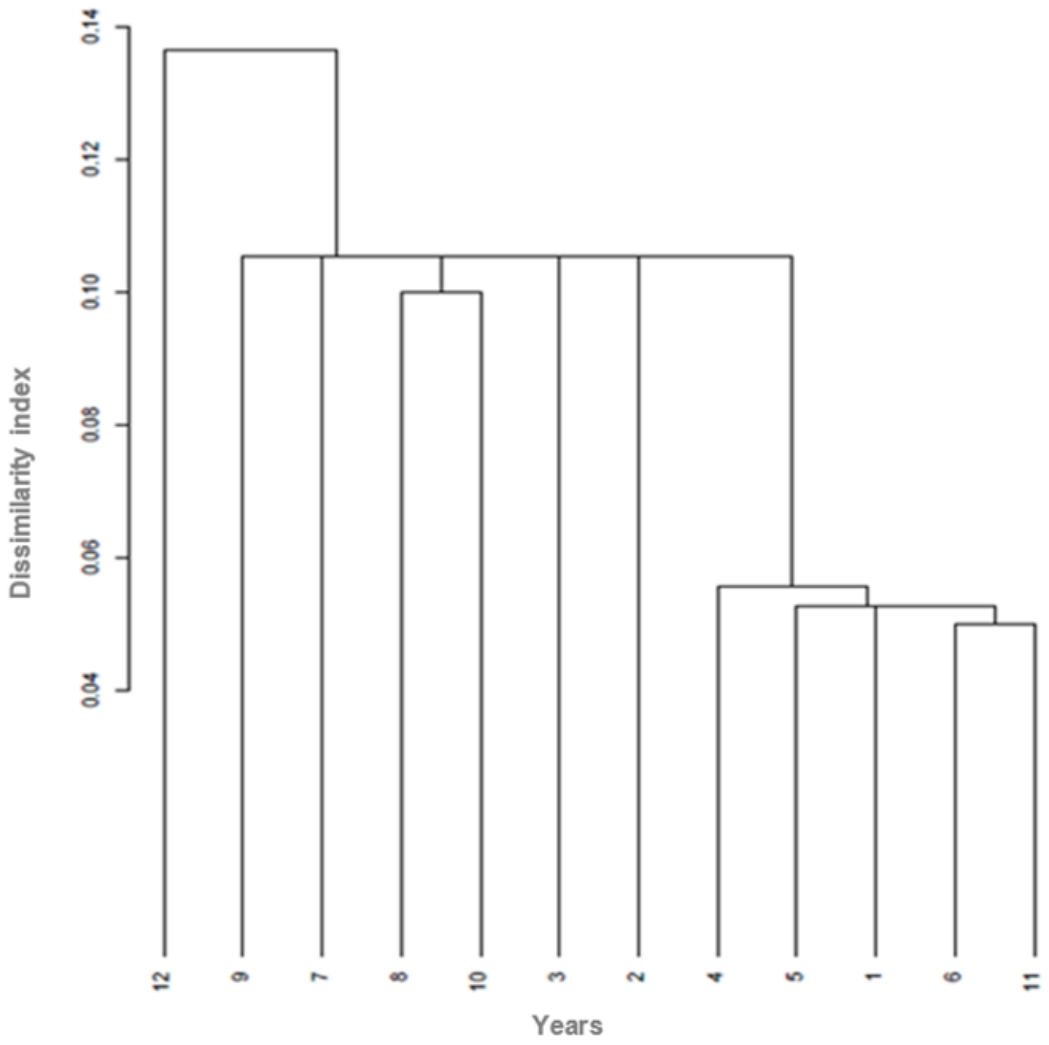

Figure 2. Dendrogram resulting from cluster analysis of visits of different wildlife species between the years of 2001 to 2013 excluding 2006 (1 represents 2001–12 representing 2013. Source of data: Water-point count data (NACSO).

3.2 Diversity of wildlife species

Although the Nyae Nyae conservancy displayed a high overall average mammal species diversity (SID = 0.811) of based on the annual counts (Fig. 3) from 2001 to 2013, Kruskal Wallis test revealed a significant decline (X^2_{11} = 19.06; *P* = 0.001), being highest in 2001 (SID = 0.851) to lowest in 2013 (SID = 0.720). The value of SID ranged from 0 (complete homogeneity or complete uniformity) to 1 (high heterogeneity or highest diversity) (Keylock, 2005). Turkey's pairwise comparison revealed that the diversity of wildlife during 2001–2013 was most significantly lowest in 2013 in comparison with 2001 diversity.

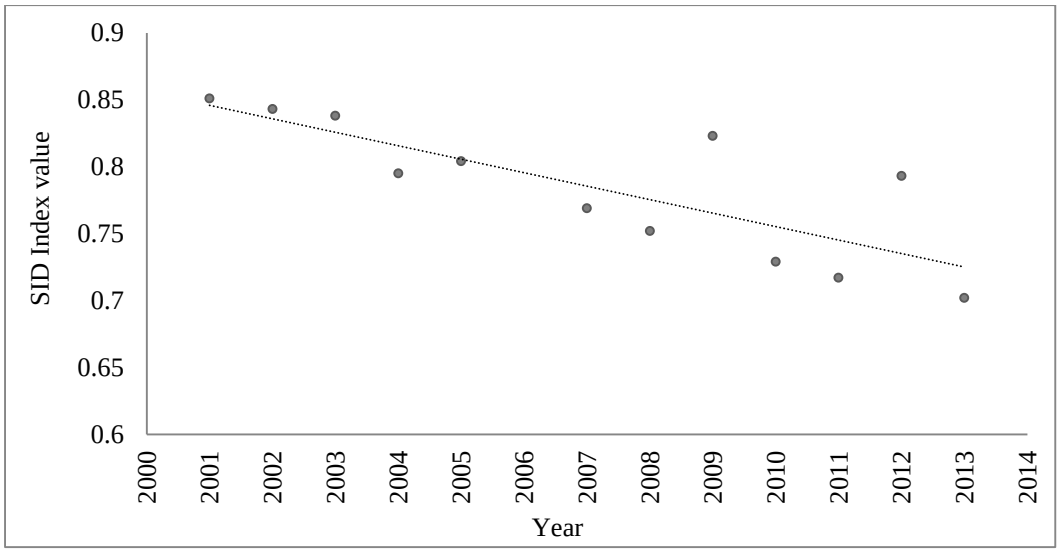

Figure 3. Simpson's Index of Diversity (SID) for all the sighted wildlife species in the conservancy for 2001–2013.

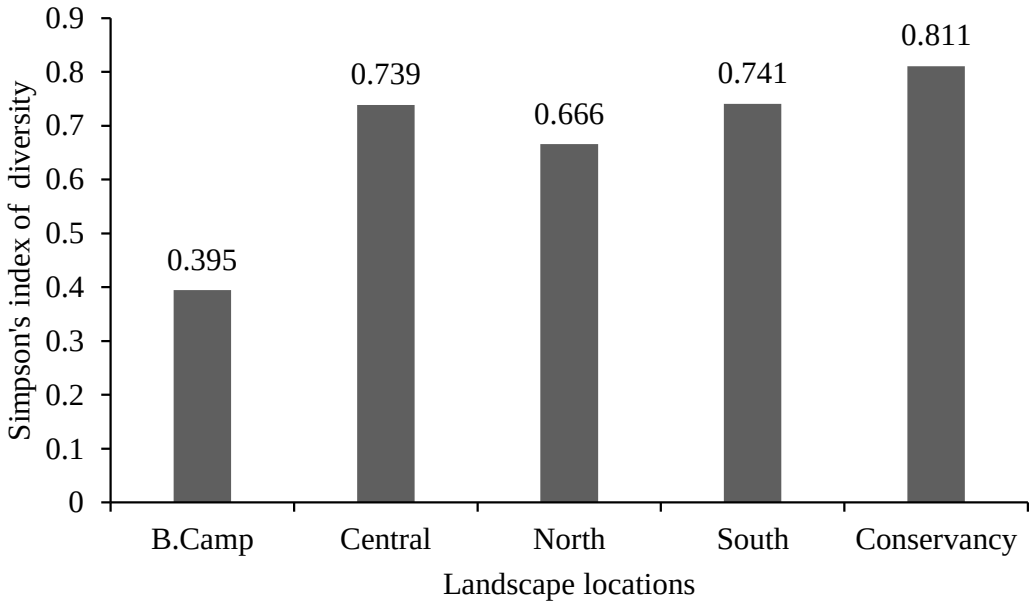

Figure 4. Simpson's Index of Diversity (SID) for the sighted wildlife species within different landscapes across the conservancy observed between 2001 and 2013.

Comparison of species diversity of mammals in different parts of the conservancy was carried out using the SIDs for each landscape (Fig. 4). The open landscapes of the conservancy including the central [0.739] southern [0.741], and northern part [0.666] had higher SIDs while the Buffalo Camp (a wildlife camp) [0.395] had the lowest diversity of mammals species. Open landscapes, in the context of this paper, denote habitats that were not camped off and contain free-roaming species. They were classified based on the operations of the rangers, where some rangers were responsible either for the south, the north and the central parts of the conservancy, which was useful because the location of the water points in the conservancy is within these operational areas. Although located in the central part of the conservancy, determining the diversity of wildlife species at the Buffalo Camp was done separately because the Camp contained wildlife species not found elsewhere in the conservancy.

Furthermore, the wildlife numbers were regularly adjusted to the carrying capacity of the area. The comparison was made to determine differences in the level of diversity of wildlife species in different parts of the conservancy. The Buffalo Camp is also a critical wildlife enclosure in the conservancy, where buffaloes and other sensitive species are protected. It was expected that the diversity of the species in the camp would be lower when compared to other areas, as this camp is smaller in size and only had a few selected species.

3. Discussions

The consistent composition of wildlife species in any protected area is mainly attributed to the capacity of the habitat to sustain different groups of species (Leuthold, 2012). The results of this study demonstrate little variations among mammal species detected in the Nyae Nyae Conservancy between 2001 and 2013 with the ungulates dominating. These findings are not exceptional to the Nyae Nyae conservancy as it has been well-documented that ungulate species make up the largest proportion of animals in most protected areas in Africa (Sinclair & Arcese, 1995; Griffin, 1998; Ottichilo et al., 2000; Owen-Smith, 2008; Western et al., 2009). Humans control numbers of predators if they pose a threat to humans (Williams, Williams, Lewis, & Hill, 2017). The fact that the composition of the species in the Nyae Nyae conservancy is comparable to other conservation areas (Leuthold, 2012), reflects the ecological importance of this conservancy to contribute to sustainable conservation in the country. In addition, a low fluctuation in species composition over the years (Table 1; Fig.3) is an important finding that reflects the ability of this habitat to retain species in an open system, like a communal conservancy. This result reveals the importance of conservancies in creating home ranges for wildlife outside protected areas, promoting connectivity between conservation areas.

The co-existence of ungulates and predators in any conservation area is vital for ensuring the ecological functions necessary to maintain the integrity of the habitat (Leuthold, 2012). Community-based conservation programs in Namibia and Botswana have been documented to have attracted wildlife populations into these areas and contributed to increasing wildlife numbers outside protected areas (Thakadu, 2005). Retaining wildlife populations also reflects the significance of habitat value as Galvin et al., (2018) attributed wildlife assemblages in a particular area to the habitat environmental qualities and relative carrying capacity. Therefore, sustainable conservation would require that habitats are well-maintained and their integrity protected to retain wildlife.

The relatively stable species composition of mammals in Nyae Nyae Conservancy (Table 1; Fig. 2) may be attributed to the heterogeneity of habitats in the study area. This conservancy has diverse landscapes with different habitats, including grasslands, shrubs, less and high dense forests (Mendelsohn & El Obeid, 2002, 2005). Healthy and heterogeneous habitats are essential to maintain a high diversity of animal species and safeguard species richness (Tews et al., 2004; Waltert et al., 2009; Kiffner, Wenner, La Violet, Yeh, & Kioko, 2014). The Nyae Nyae Conservancy showed a relatively stable species richness as revealed in annual sighted mammal species. High species richness strengthens habitats and increases the tenacity of the ecological community against environmental and anthropogenic stresses (Luck et al., 2003). The relatively stable mammal species composition and richness in this conservancy could be attributed to the low human population diversity, and the historical co-existence between wildlife and people in this area as the area is predominantly inhabited by traditional hunter-gatherers (Biesele & Hitchcock, 2013).

The positive trends in the abundance of selected sighted ungulate mammal species (Table 1) in Nyae Nyae Conservancy reveal the potential of the conservancy towards wildlife recovery, conservation and utilisation benefits that may be derived therein. Water-dependent species, such as the elephant, buffalo, blue wildebeest and black rhino (Hayward & Hayward, 2011; Roodt, 2011), showed positive trends in abundance of species that were sighted at water points during the period of the study. Also, the abundant species, such as kudu, springbok and oryx, that are not necessarily water-dependent (Hayward & Hayward, 2011), despite regularly drinking when water is available, showed positive trends over the years. Historically, these species are also amongst the most abundant species in Namibia, as they are well-adapted to the conditions of the country

(Shortridge, 1934; van der Walt, 1989; Griffin, 1998). Despite the stable richness and composition of mammal species in Nyae Nyae Conservancy between 2001 and 2013, there was, however, a significant decline in species diversity of mammal species (Fig. 3). This decline is unexpected because, during the period when these data were collected, some wildlife species were translocated into Nyae Nyae Conservancy (Weaver & Skyer, 2003). This decline may be ascribed to the significant decline in the abundance of individual sighted animals in some species given the properties of the diversity index used. Generally, SID is an index that takes into consideration the species richness and relative abundance (evenness) of individuals (Keylock, 2005), of the species found in an area. Since the analysis of data revealed that there were no significant changes in species richness and composition of mammals sighted, over the years, a decline in species diversity of mammals could imply that there was a decrease in the abundance of individuals in different mammal species in Nyae Nyae Conservancy. It is equally possible that the data collection method, employed in the study; using water-points may also have constrained or influenced the abundance of mammal counts. It is also suggested that the decline in species diversity of mammals were generally negatively affected by drought or water scarcity over the years. The significant decline in SID was mainly influenced by the 2013 severe drought that had serious implications on water, animals and food security (Kapolo, 2015). The drought of 2013 affected different parts of the country, contributing to limited water availability in the country (Schnegg & Bollig, 2016). The diversity of wildlife species is affected because of the tendency of some species congregating at water points, especially the water-dependent species. Hence, though the diversity and abundance of mammal species data collected at water points may generally be a good indicator of species diversity and composition of mammals in the conservancy, the data collection method used in this study biased slightly towards water-dependent species which revealed positive trends in diversity. In this study, water-dependent species such as elephant, buffalo and blue wildebeest were counted in high numbers during 2013.

The species that showed negative trends in population sizes (30%) included some large ungulates such as the eland and red hartebeest, some smaller ungulates such as the steenbok and duiker and some predators that did not require drinking water regularly. Being not water-dependent cannot sufficiently explain the general decline in species diversity of mammals in this study because of the long-term nature of the data. Therefore, the declining in the abundance of these species could be an indication that there might be environmental or anthropogenic factors which affected these species negatively in the conservancy.

4. Conclusions

The study has shown that the Nyae Nyae Conservancy is home to a diversity of mammal species and an area with high conservation potential. Despite being an open system, that is not fenced and is inhabited by local communities, Nyae Nyae Conservancy retains mammal populations of different guilds. The positive trends in the abundance of these mammal species suggest that they can survive and reproduce in Nyae Nyae, implying that conditions are suitable for them. However, two notable declines were detected during the analysis. First, a decline in species diversity over the years was mainly due to changes in the relative abundance of individuals of certain species and not necessarily to species richness, as the composition of the wildlife species in the Nyae Nyae conservancy remained more or less constant over the years. There was a third of species that showed a decline in their trends. There is a need for further, more detailed research to establish the causal factors of the decline in species, to allow for effective adaptive management in these community-led conservation areas. The results of this study also clearly reflect the vital role which conservancies have to play in the sustainable biodiversity conservation in Namibia by providing key habitats to wildlife species outside protected areas.

References

Biesele, M., & Hitchcock, R. (2013). *The Ju/'hoan San of Nyae Nyae and Namibian Independence*. Berghahn Books.

Brook, B.W., Sodhi, N.S. & Bradshaw, C.J.A., 2008. Synergies among extinction drivers under global change. *Trends in Ecology and Evolution*.

Child, B. & Barnes, G., 2010. The conceptual evolution and practice of community-based natural resource management in southern Africa: past, present and future. *Environmental Conservation*, *37*(3), 283–295. Available at: http://www.journals.cambridge.org/abstract_S0376892910000512 [Accessed August 30, 2014].

Galvin, K. A., Beeton, T. A. and Luizza M. W.. (2018). African community-based conservation: a systematic review of social and ecological outcomes. *Ecology and Society*, *23*(3), 39. https://doi.org/10.5751/ES-10217-230339

Griffin, M. (1998). The species diversity, distribution and conservation of Namibian mammals. *Biodiversity and Conservation*, *7*, 488–494.

Hayes, W. & Hayes, F. (2013). How does human activity affect species extinctions? *The Journal of Adventist Education*, pp23–29.

Hays, J., Thiem, M., & Jones, B. T. B. (2014). Otjozondjupa region. In U. Dieckmann, M. Thiem, E. Dirkx, & J. Hays (Eds.), *Scraping the Pot: San in Namibia two decades after Independence*. Windhoek, Namibia: Legal Assistance Centre and Desert Research Foundation of Namibia.

Hayward, M. W., & Hayward, M. W. (2011). Using the IUCN Red List to determine effective conservation strategies. *Biodivers Conserv*, *20*, 2563–2573. http://doi.org/10.1007/s10531-011-0091-3

Jacobsohn, M., & Owen-Smith, G. (2003). Integrating Conservation and Development: A Namibian Case-study. *Nomadic Peoples*, *7*(1), 92–109.

Kapolo, I. N. (2015). Drought conditions and management strategies in Namibia. *Windhoek, Namibia*.

Keylock, C.J. (2005). Simpson diversity and the Shannon-Wiener index as special cases of a generalized entropy. *Oikos*, 109(1), pp.203–207. Available at: http://doi.wiley.com/10.1111/j.0030-1299.2005.13735.x [Accessed April 3, 2016].

Kiffner, C., Wenner, C., LaViolet, A., Yeh, K., Kioko, J. (2014). From Savannah to farmland: effects of land-use on mammal communities in the Tarangire-Manyara ecosystem, Tanzania. *African Journal of Ecology*, *53*(2), 156–166.

Kiss, A. (1990). *Living with wildlife: wildlife resource management with local participation in Africa.*, Washington DC.

Leuthold, W. (2012). *African Ungulates: A Comparative Review of Their Ethology and Behavioral Ecology*. Springer Science & Business Media.

Luck, G. ., Daily, G. ., & Ehrlich, P. (2003). Population diversity and ecosystem services. *Trends in Ecology and Evolution*, *18*(7), 331–336.

Mendelsohn, J. M., & El Obeid, S. (2002). *The Communal Lands in Eastern Namibia*. Windhoek, Namibia: Raison.

Mendelsohn, J. M., & El Obeid, S. (2005). *Forests and woodlands of Namibia*. Raison.

NACSO. (2013). *Namibia's Communal Conservancies: A review of the progress and challenges in 2011*.

NACSO. (2014). *Community conservation in Namibia: A review of communal conservancies, community-forests and other CBNRM initiatives*. Windhoek.

NACSO. (2004). *Namibia's communal conservancies: A review of progress and challenges in 2003*, Windhoek.

Ottichilo, W et al. (2000). Population trends of large non-migratory wild herbivores and livestock in the Masai Mara ecosystem, Kenya, between 1977 and 1997. *African Journal of Ecology*, *38*,.202–216.

Owen-Smith, N. (2008). The comparative population dynamics of browsing and grazing ungulates. In I. . Gordon & H. Prins, eds. *The Ecology of Browsing and grazing*. Springer, 149–177.

Pimbert, M. & Pretty, J. (1997). Parks, people and professionals: putting "participation" into protected area management. *Social Change and Conservation*, 297–330.

Roodt, V. (2011). *Mammals of Botswana and surrounding areas*. Hartebeespoort SA, Veronica Roodt Publications.

Schnegg, M., & Bollig, M. (2016). Institutions put to the test: Community-based water management in Namibia during a drought. *Journal of Arid Environments*, *124*, 62–71.

Shortridge, G. (1934). *The Mammals of South West Africa*, London: William Heinemann.

Silva, J. A. & Mosimane, A., 2014. "How Could I Live Here and Not Be a Member?": Economic Versus Social Drivers of Participation in Namibian Conservation Programs. *Human Ecology*, *42*(2), 183–197. Available at: http://link.springer.com/10.1007/s10745-014-9645-9 [Accessed August 12, 2014].

Sinclair, A. R. E. & Arcese, P. (1995). *Serengeti II: Dynamics, Management, and Conservation of an Ecosystem*. University of Chicago Press. Retrieved from

https://books.google.com/books?hl=en&lr=&id=YV5Qg2GSyWwC&pgis=1

Songorwa, A., Buhrs, T., & Hughey, K. (2000). Community-Based Wildlife Management in Africa: A Critical Assessment of the Literature. *Natural Resources Journal*, *40*, 603–643.

Stuart, C., & Stuart, M. (2014). *Stuart's Field Guide to Mammals of Southern Africa: Including Angola, Zambia and Malawi* (5Penguin R). South Africa. Retrieved from http://www.amazon.com/Mammals-Southern-Africa-Struik-Publishers-ebook/dp/B00A3S3HFO

Suzman, J. (2001). *Regional Assessment of the Status of the San in Southern Africa An Assessment of the Status of the San in Namibia*.

Taylor, R. (2009). Community-based natural resource management in Zimbabwe: The experience of CAMPFIRE. *Biodiversity and Conservation*, *18*, 2563–2583.

Tews, J. et al. (2004). Animal species diversity driven by habitat heterogeneity/diversity: the importance of keystone structures. *Journal of Biogeography*, *31*(1), 79–92. Available at: http://doi.wiley.com/10.1046/j.0305-0270.2003.00994.x [Accessed October 15, 2015].

Thakadu, O. T. (2005). Success factors in community-based natural resources management in northern Botswana: Lessons from practice. *Natural Resources Forum*, *29*, 199–212

van der Walt, P.., (1989). Chapter 7: Namibia. In R. East, ed. *Antelopes: Southern and South-Central Africa*. IUCN/SSC Antelope specialist group, IUCN, pp. 34–40.

Waltert, M., Meyer, B., & Kiffner, C. (2009). Habitat availability, hunting or poaching: what affects distribution and density of large mammals in western Tanzanian woodlands? *African Journal of Ecology*, *47*(4), 737–746.

Weaver, L. C., & Skyer, P. (2003). Conservancies: Integrating wildlife land-use options into the livelihood, development and conservation strategies of Namibian communities. In *the Fifth World Parks Congress: Animal Health and Development (AHEAD) Forum* (p. 40 pp). HEAD Forum.

Weissner, P. (2004). Owners of the Future: Calories, cash, casualties and self-sufficiency in the Nyae Nyae area between 1996 and 2003. *Visual Anthropological Review*, *19*(1–2), 149–156.

Western, D., Russell, S. & Cuthill, I. (2009). The status of wildlife in protected areas compared to non-protected areas of Kenya. *PloS one*, 4(7), p.e6140. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2702096&tool=pmcentrez&rendertype=abstract [Accessed July 18, 2014].

Williams, S., T, Williams, K., S, Lewis, B., P, Hill, R. A. (2017). Population dynamics and threats to an apex predator outside protected areas: implications for carnivore management. *R. Soc. open sci.* **4**: 161090. http://dx.doi.org/10.1098/rsos.161090

Appendix 1: Turkey's pairwise comparison output for wildlife species diversity between the years

	2001	**2002**	**2003**	**2004**	**2005**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
2001		1	1	1	0.9988	0.5802	1	0.9997	1	1	1	0.0019
2002	0.4639		1	1	1	0.8015	1	1	1	1	1	0.0072
2003	0.7677	0.3037		1	1	0.9039	1	1	1	1	1	0.0159
2004	0.9195	0.4556	0.1519		1	0.9388	1	1	1	1	1	0.0231
2005	1.322	0.8578	0.5541	0.4022		0.9872	1	1	1	1	0.9992	0.0578
2007	3.052	2.588	2.285	2.133	1.731		0.8728	0.9713	0.9439	0.7981	0.6148	0.696
2008	0.6609	0.1969	0.1068	0.2587	0.6609	2.391		1	1	1	1	0.0121
2009	1.133	0.6692	0.3655	0.2136	0.1886	1.919	0.4723		1	1	0.9998	0.0382
2010	0.9462	0.4823	0.1786	0.0267	0.3755	2.106	0.2854	0.1869		1	1	0.0247
2011	0.4556	0.0083	0.3121	0.4639	0.8661	2.597	0.2053	0.6776	0.4906		1	0.0070
2012	0.0667	0.3972	0.7009	0.8528	1.255	2.986	0.5941	1.066	0.8795	0.3888		0.0023
2013	5.876	5.412	5.108	4.956	4.554	2.824	5.215	4.743	4.93	5.42	5.809	