An Assessment of the Distribution and Abundance of Large Carnivores in the Tarangire-West Kilimanjaro Ecosystem using Spoor Counts

July 2018

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This report is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The contents are the responsibility of the Wildlife Conservation Society (WCS), The Nature Conservancy, and its partners, and do not necessarily reflect the views of USAID or the United States Government.

Summary

This report summarizes the results of a vehicle-based spoor survey of six large carnivores (lion, leopard, cheetah, Wild dog, Striped hyaena and Spotted hyaena) in six different locations across the Tarangire-West Kilimanjaro ecosystem in the dry season of 2016. The survey results indicate that the most common large carnivore species across the ecosystem is the Spotted hyaena, followed by the Striped hyaena and leopard, all of which were recorded at all six surveyed locations. Lion were relatively uncommon and were only recorded in Tarangire National Park and Manyara Ranch. There were very few records of cheetah and Wild dog, with the latter recorded only once, in Tarangire National Park. Density estimates were produced for lion, leopard and the two hyaena species. The distribution of both lion and leopard was negatively correlated with distance to bomas, suggesting these species were actively avoiding human presence. We recommend that more surveys are carried out, with Makame WMA included in future surveys, to establish long-term carnivore population trends.

Introduction

The Tarangire-West Kilimanjaro ecosystem supports a population of over 50,000 large mammals and is an important corner-stone of the tourism industry in northern Tanzania. Indeed, the Tarangire ecosystem ranks second only to the Serengeti-Mara ecosystem for its high concentrations of migratory mammals, such as zebra and wildebeest (Ludwig et al. 2008). The area is an important stronghold for threatened large carnivore species, such as lion, leopard, cheetah and African Wild dog.

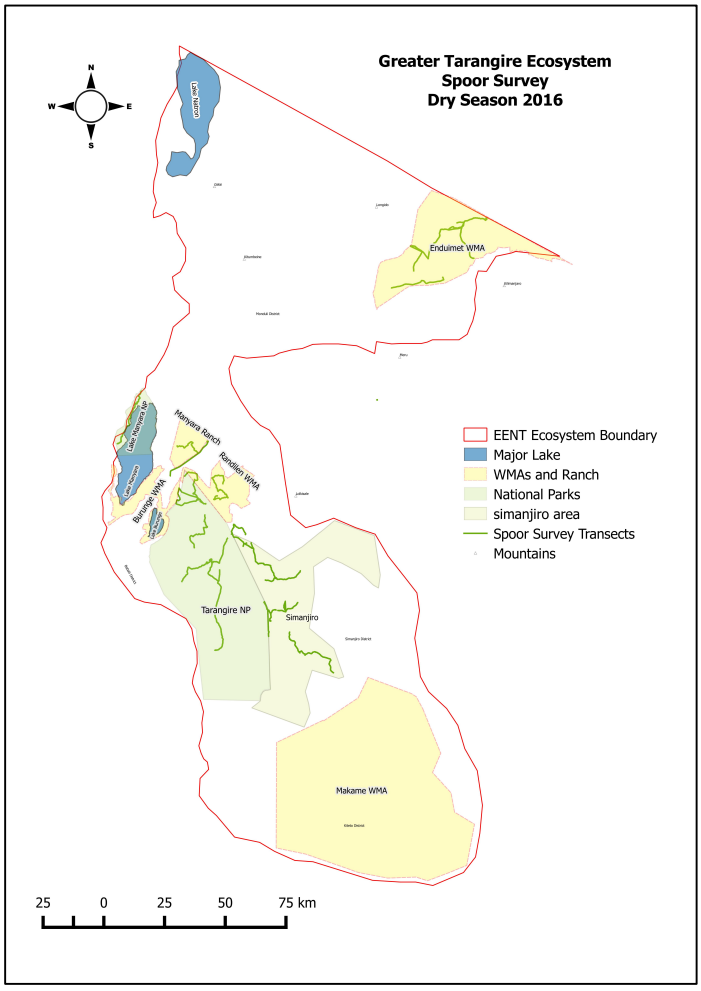
A key feature of wildlife populations across the Tarangire-West Kilimanjaro ecosystem is that they are highly mobile, often migrating large distances annually to obtain food and water (Foley and Foley 2014). The two main National Parks in the area, Tarangire and Lake Manyara, together with the four community Wildlife Management Areas (WMA) scattered across the ecosystem, protect only approximately 25% of the total range of many ungulate and carnivore species. This makes wildlife in this ecosystem highly dependent on access to community lands. The large ungulate populations disperse seasonally in response to rainfall patterns, with the key migration routes for the wildebeest and zebra lying on community lands to the north (Lake Natron area) and east (Simanjiro area) of Tarangire National Park. Several of the large carnivore populations, notably the lions, Spotted hyaena, and probably to a lesser extent leopards, follow the large ungulate movement patterns, and spend several months of the year on community lands. The African Wild dog population is mostly resident on community lands, which they rely on to provide denning sites. This often leads to conflict with humans, due to predation of livestock, including cattle, sheep and goats, and retaliatory killing either by spearing or poisoning.

While a long-term study of individually known lions has been conducted in Tarangire National Park since 1998 (Kissui 2008), large carnivore information in most other parts of the ecosystem is limited to data from non-invasive camera trapping across relatively small areas (Msuha 2009). This is in part because obtaining quantitative information on large carnivores is particularly challenging, as they are often nocturnal, rare and elusive (Durant *et al.* 2007). Because of this, indirect counting techniques such as spoor counts and camera trap surveys are increasingly being used by wildlife managers to produce indexes of abundance and density estimates of carnivore populations (Stander 1998). Spoor surveys, which can be implemented across much larger areas than camera trap surveys, are particularly useful at producing spatial distribution data across large landscapes and offer a relatively

cheap and efficient method of detecting large carnivores that can be repeated frequently to determine population trends.

In this survey we used spoor counts to assess the distribution and density of six large carnivore species (lion, leopard, cheetah, African Wild dog, Spotted hyaena and Striped hyaena) across six different parts of the Tarangire ecosystem: Tarangire National Park (NP), Lake Manyara NP, Randilen Wildlife Management Area (WMA), Enduimet WMA, Manyara Ranch, and the Simanjiro plains (see Figure 1). The two National Parks enjoy very high levels of protection, each with large numbers of well-armed rangers, and both have also been protected for over 50 years, which is far longer than the other sites. Wildlife Management Areas (WMAs) are community-managed areas with multiple land uses, which may include photographic tourism, sport hunting, and pastoralism. Enduimet WMA is in West Kilimanjaro on the border with Kenya and experiences some seasonal movement of wildlife from Amboseli NP. Randilen WMA lies on the northeast border of Tarangire NP. Both WMAs are relatively new; Enduimet was established in 2003 and Randilen in 2012, and both have small, but well-organised, anti-poaching units. Manyara Ranch was a former government cattle ranch that became a multi-use conservation-pastoralism site in 2001 and is now owned by Monduli District Government. The ranch is due north of Tarangire NP and lies on the northern migration corridor of wildlife dispersing to the Lake Natron area. The Ranch also has a small anti-poaching unit. The Simanjiro plains are community lands that lie to the east of Tarangire NP. The Simanjiro plains form the main calving grounds for large ungulates (primarily zebra and wildebeest) in the ecosystem, and a large part of the plains have been set aside as conservation easements by the two principle communities (Terrat and Sukuro) preventing agricultural activity in order to protect key dry-season grazing land for livestock. The Simanjiro plains have no official protection, although village game scouts and a Wildlife Division anti-poaching unit are based in the area.

Figure 1. Map of Tarangire ecosystem with protected areas and transect locations.



The goals of this study were to better understand how large carnivores were distributed across the ecosystem, estimate densities and indices of abundance across the different survey areas, and establish how anthropogenic variables influence the distribution of the different target species.

Methods

At the start of each transect, a personal digital assistant (PDA) Trimble unit was set up to record data using the Cybertracker software. Spoor surveys started in the early morning at first light (around 6:30am) and stopped before 11am when the sun became high and started to eliminate the shadows that facilitate detection of spoor. Transects were only driven in the morning when spoor were less likely to be covered by vehicle, foot or domestic animal tracks. Roads were driven slowly at less than 15kph, with two expert trackers (from the Hadza hunter-gatherer tribe) seated on a custom-made seat at the front of the car. Whenever spoor were detected the team would record the data on the Trimble units. The age of the spoor was assessed and was denoted as 'fresh' if it was deemed to have been left within the last 24 hours. Group size was also recorded according to the expert judgement of the trackers. If the same animal weaved on and off the track it was not recorded again, and only instances of new animals joining or crossing the track were recorded. Generally, most species could be easily identified by their spoor. However, Striped and Spotted hyaena were easily confused by the non-Hadza members of the team; in these cases, the Hadza identification was used, as the trackers were normally very confident about the species' identification. At every 100m the quality of the road substrate was graded on a scale between one and four, where one (1) represented excellent detection of spoor and four (4) where chances of detection were very poor.

Occupancy covariates

Occupancy modelling was used to analyse whether large carnivore occupancy was associated with measures of transect quality and measures of human impact and site protection status. For these analyses, transects were subdivided up into 5km subtransects, with each subtransect treated as a replication within a grid square. If a species was recorded on the subtransect, it was marked as one (1), if it was not recorded it was marked as zero (0). All occupancy modelling was conducted in PRESENCE 12.10 (Hines 2006). The basic model, which assumed constant probability of occupancy across sites and across subtransects, was fitted to all six large carnivore species to generate estimates of occupancy. We tested for the effects of three substransect covariates: the distance to the nearest boma (Distance boma); average substrate quality (Substrate); the time at the start of the subtransect (Time). We also tested for the effects of two grid square based covariates: whether the subtransect was within a National Park (NP) and whether it was within a Wildlife Management Area (WMA). Models were run with each combination of these covariates. The boma distance estimates were obtained by using QGIS software (QGIS Development Team 2013) from Google map imagery. The final model selected was the most parsimonious model based on the Akaike Information Criterion (AIC). A model with a higher number of covariates was not chosen against a more parsimonious model with a lower number of covariates unless ΔAIC >2 (Burnham & Anderson, 2003). The basic model occupancy is a modelled estimate of how widely distributed a species is across the survey area, with a value of 1.0 indicating that the species was found in all subtransects, and a value of 0.5 indicating the species was found in half of the subtransects. Naïve occupancy is defined as the number of subtransects in which spoor was recorded divided by the total number of subtransects, again with a value of 1.0 showing the species was found in all subtransects.

Density estimation

Where possible, density estimates for large carnivores were calculated for the different national parks, WMAs, and unprotected sites across the survey area. This was done using formulae that regress spoor

frequency against large carnivore density provided by Funston *et al.* (2010) and Winterbach *et al.* (2017). Only records of fresh spoor were used for these analyses (less than 24 hours old) and density was only estimated in situations where there were at least 15 observations of spoor. Ideally density estimates should be made from 30 or more records, and hence estimations from sample sizes below this should be treated with caution.

Results

A total of 449 spoor records were detected across a total of 24 transects and 353 kilometers of track driven. The most commonly recorded large carnivore species was the Spotted hyaena with 245 spoor records, followed by the Striped hyaena with 117 records (Table 1). Very few cheetah and Wild dog spoor were recorded, with only six and two records, respectively. The highest ratio of spoor/km driven was recorded in Lake Manyara NP (1.86) followed by Tarangire NP (1.52). Much lower ratios were recorded in the other areas: Randilen WMA (1.16), Enduimet WMA (1.13), Simanjiro (1.09) and Manyara Ranch (0.91).

Table 1. Spoor summary table showing breakdown of transect length by area, and spoor records by area for each of the six target species. The first figure is number of records of that species, in (brackets) is the total number of individuals recorded.

Survey area	Total transect length (km)	No. of transects	Cheetah	Spotted hyaena	Striped hyaena	Leopard	Lion	Wild dog	Total spoor recorded
Tarangire National Park	118.4	8	1	90 (112)	38 (39)	23	25	2 (8)	179
Lake Manyara National Park	15.6	1	0	13	6	10	0	0	29
Randilen WMA	31.0	2	0	25 (30)	4	7	0	0	36
Enduimet WMA	84.9	6	4 (10)	64 (99)	26 (29)	2	0	0	96
Simanjiro	87.4	6	1	49 (66)	35 (39)	10 (11)	0	0	95
Manyara Ranch	15.4	1	0	4	8	1	1	0	14
Totals	**352.7**	**24**	**6 (12)**	**245 (324)**	**117 (125)**	**53 (54)**	**26**	**2 (8)**	**449**

Lion

Lion were only recorded in Tarangire NP and Manyara Ranch. This species is known to occur in Lake Manyara NP, Randilen WMA, and parts of the Simanjiro, but was not recorded during this survey. The lion population in Enduimet WMA is very low, and believed to comprise only a few, perhaps vagrant, individuals. This survey suggests that the core lion population in the Tarangire ecosystem resides in Tarangire NP, which had a density estimate of 8.58 lions per 100 km^2. Tarangire was the only location where sufficient samples were obtained to produce a density estimate. The best model predicting lion occupancy in terms of AIC included the distance from the nearest boma as the sole variable, with lion occupancy being higher as the distance from the nearest boma increased. The inclusion of the WMA and National Park variables provided a better model than the null model, however these variables were not as good at predicting lion occupancy as boma distance. In general, National Park was associated with an increased lion occupancy and WMA with a reduced lion occupancy.

Leopard

The spoor survey indicated that leopard are distributed throughout the ecosystem with the highest spoor frequencies (independent tracks/100km) found in Lake Manyara NP (64.10), Randilen WMA (22.65), and Tarangire NP (18.45). They occurred at a density of 5.73 individuals per 100 km^2 in Tarangire NP and were the most common felid species in the Simanjiro, where they occurred at a density of 3.73 animals per 100km^2. For leopard, boma distance was the only human impact variable resulting in an improvement in the AIC figure compared with a null model, with leopard occupancy increasing as the distance from the nearest boma increased. WMA and national park parameters provided a worse fit to the null model.

Spotted hyaena

This species is the most widespread and common large carnivore in the Tarangire-West Kilimanjaro ecosystem. It was recorded in all sites, and spoor frequency was particularly high in Lake Manyara NP (83.33 records/100km), Randilen WMA (80.65), Enduimet WMA (80.36) and Tarangire NP (73.77). Only on Manyara Ranch were spoor frequencies relatively low (25.94) compared to other areas. No correlation was found between Spotted hyaena spoor and anthropogenic influences.

Striped hyaena

This species was also recorded in all surveyed areas in the ecosystem, and spoor densities were particularly high on Manyara Ranch (51.88), the Simanjiro plains (38.55), and Tarangire NP (33.15). Of the areas where there was sufficient sample sizes to estimate density, the Simanjiro plains had the highest density (13.15), while densities were also high in Tarangire NP and Enduimet WMA, with 10.41 and 10.43 animals per 100km^2, respectively. Striped hyaena distribution was best explained by the normal model.

Cheetah

There were only six cheetah spoor records found during the surveys, suggesting that the species is relatively uncommon in the Tarangire-West Kilimanjaro ecosystem. There were four spoor records in Enduimet WMA (where three different groups of three individuals were recorded) and one each in Tarangire NP and the Simanjiro. Cheetah spoor numbers were too low to provide population density estimates or to accurately assess anthropogenic influences.

African Wild dog

There were two records of African Wild dog spoor made during this survey, both of them from southern Tarangire NP. One record was of a single individual, and the other was of a group of seven individuals, including two juveniles. There were insufficient data points to calculate density figures or correlative statistics.

Table 2. Spoor frequency (number of independent tracks per 100km) with 95% confidence intervals (C.I.) for each carnivore species and each survey area.

			Lion		Leopard		Cheetah		African Wild dog		Spotted hyaena		Striped hyaena	
	Total transect length (km)	Number of transects	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Tarangire NP	118.4	8	21.5	4.0-39.0	18.5	9.0-27.9	0.91	–0.9-2.7	2.10	–0.7-4.9	73.77	52.0-95.6	33.15	14.5-51.8
Lake Manyara NP	15.6	1	0		64.1		0		0		83.33		6.41	
Randilen WMA	31.0	2	0		22.7		0		0		80.65		12.95	
Enduimet WMA	84.9	6	0		2.0	–1.9 -6.0	4.17	–1.7-10.1	0	-	80.36	11.7-149.0	24.83	12.2-37.5
Simanjiro	87.4	6	0		11.0	1.2-20.9	1.06	–1.0-3.1	0		54.33	38.8-71.9	38.50	16.6-60.6
Manyara Ranch	15.4	1	6.5		6.5		0		0		25.94		51.88	

Table 3. Large carnivore densities (per 100km^2) with 95% confidence intervals (C.I.) calculated from spoor counts.

	Lion		Leopard		Cheetah		African wild dog		Spotted hyaena		Striped hyaena	
	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Tarangire NP	8.58	0.3-16.9	5.73	2.7-8.7	NA		NA		27.97	17.3-38.7	10.41	4.7-16.2
Enduimet WMA	NA		NA		NA		NA		39.48	–4.2-83.1	10.43	1.9-18.9
Simanjiro	NA		3.73	0.2-7.2	NA		NA		22.36	11.6-33.1	13.15	4.9-21.4

Table 4. Results from occupancy analyses**.** Occupancy was analysed using three substransect covariates: (1) the distance to the nearest boma (Distance boma); (2) average substrate quality (Substrate); (3) the time at the start of the subtransect (Time). Two grid square covariates were also used: (1) subtransect was within a National Park (NP), or (2) within a Wildlife Management Area (WMA). The best model, according to the AIC, is reported in the table. Occupancy is calculated from the basic model (with a value of 1.0 being a species is present across all areas surveyed), assuming constant probability across transects.

Species	Best model	Covariates	Positive Correlation	Negative Correlation	AIC	Naïve occupancy [a]	Occupancy from basic model [b]	95% Confidence interval
African Wild Dog	Distance-boma	102.6		Boma	17.5*	0.08		
Cheetah	Basic model	-			39.6	0.21	0.62	0.4 - 0.8
Leopard	Distance-boma	379.9		Boma	91.7	0.67	0.78	0.5 - 0.9
Lion	Distance-boma	1.0		Boma	59.2	0.42	0.46	0.3 - 0.7
Spotted hyaena	Basic model	-			34.3	1.0	1.0	
Striped hyaena	Basic model				77.3	0.92	0.96	0.4 – 1.0

* Insufficient data for reliable analysis.

[a] Proportion of sampling units in which species was detected.

[b] Estimate of area occupied when accounting for imperfect detection.

Discussion

The most widespread and common species of large carnivore in the Tarangire-West Kilimanjaro ecosystem are the Spotted and Striped hyaenas. These two species (as well as the leopard) were found in all six surveyed areas, and the two hyaenas have a basic occupancy close to 1, indicating that they were located in all grid cells surveyed. Leopards had a lower basic occupancy of 0.78 and were less abundant than hyaenas. All three of these species have been recorded through other survey techniques (camera trapping) across all parts of the ecosystem including in the Lake Natron area, Gelai, and Makame WMA. The cheetah and African Wild dog were generally found to be uncommon in the ecosystem, with few records of either species noted during the survey. Lions were only recorded in Tarangire NP and Manyara Ranch. This result is probably partly linked to the fact that the survey was carried out in the dry season, when the majority of large ungulates have migrated to Tarangire NP, resulting in the lion population, which is at least partly nomadic, to be concentrated inside the Park as well. However, the absence of lion records in West Kilimanjaro suggests that human pressure may be too high for this species within that part of the ecosystem.

The Spotted hyaena is an extremely adaptable and resilient species, and – together with the leopard – is one of the few species of large predator that survives in close proximity to human settlement, including on the outskirts of Arusha and Dar es Salaam. This species has a highly varied diet, ranging from large ungulates to small mammals, carrion and human refuse, and it is likely that they alter their diet depending on food availability. While this study found no correlation between Spotted hyaena distribution and anthropogenic factors, another study conducted in the Tarangire ecosystem (Mkonyi et al 2018) found that Spotted hyaenas associate positively with higher human populations, suggesting that they may be opportunistically scavenging from human refuse in parts of the ecosystem. Spotted hyaenas are also responsible for most livestock predation events in the Maasai steppe; one study found they were responsible for 58% of all livestock losses (Kissui 2008) and another fully 70% of predation events (Mkonyi et al 2017). Both studies found that Spotted hyaenas typically kill small stock such as goats, sheep and calves, which are less valuable to the herders than adult cattle, and consequently appear to be less persecuted. They also attack at night, making it difficult for the herders to retaliate against them. This may explain why hyaenas are still relatively abundant on community lands, although there have been incidences of hyaenas being killed by poisoned bait (Kissui 2008). This species was found to be equally common in the two WMAs as in the National Parks, although densities were lower in Simanjiro and Manyara Ranch. In all areas surveyed, this was the most frequently recorded species with the sole exception of Manyara Ranch where the Striped hyaena was more frequent. The high densities of Spotted hyaena in Tarangire NP suggests that the species is not affected by the relatively high lion numbers in the Park (a possible competitor).

The Striped hyaena is a dry, open-country species, which feeds predominantly on carrion. While camera trap surveys had found that it occurs widely throughout the Tarangire-West Kilimanjaro ecosystem, this study suggests that it is far more common than previously thought. There were notably high spoor frequencies in Tarangire NP (where it is most common in the drier southern area of the Park), Enduimet WMA, the Simanjiro, and on Manyara Ranch. Because of its solitary and nocturnal habits, and its tendency to be significantly less vocal than the Spotted hyaena, this species has generally been overlooked in carnivore assessments of the ecosystem. Being mainly carrion eaters (there are reports of Striped hyaena taking sheep and goats in Tanzania, although this behavior is

rare), Striped hyaena are not actively persecuted by humans, although their feeding habits make them vulnerable to poisoning, even if they are not the intended target.

The leopard was the most widespread large felid recorded in the ecosystem and was the only felid species recorded in Simanjiro, where it is relatively common. In this survey, leopard occupancy was higher further from bomas, suggesting that they may be actively avoiding human presence. Leopards are the second highest predator of livestock in the Tarangire ecosystem, with studies showing them responsible for 17% (Kissui 2008) and 12% of all livestock attacks (Mkonyi et al 2017). Leopards targeted smaller domestic animals almost exclusively, and the majority of their kills were made at night, making it difficult for herders to find and retaliate against them. In areas where leopards coexist with humans, they generally become extremely wary and almost exclusively nocturnal, hence their ability to survive even in large cities such as Nairobi.

Lions were only recorded in two locations: Tarangire National Park, where they were relatively common with an estimated density of 8.6 individuals per 100 km2, and Manyara Ranch. The movement patterns of lion in the ecosystem mirror those of the large ungulates; lions concentrate in the Park during the dry season and follow the large ungulate herds onto community lands during the wet season (TLP 2002). This movement pattern probably explains much of the lion distribution recorded during this survey, which was conducted at the height of the dry season, when most of the ungulate herds and lions were concentrated within the Park. However, this study also found that lion occupancy decreases with proximity to bomas, which corresponds well with data from other studies in this ecosystem (TLP 2002; Lichtenfeld 2005; Mkonyi et al 2018), showing that lion density decreases outside the National Park.

No lion spoor was found in Enduimet WMA, despite intensive coverage, indicating that the lion population in the area is very low. The Enduimet lion population has suffered as a result of retaliation by Maasai for livestock predation both in the Amboseli area across the border in Kenya and in West Kilimanjaro. Persecution of lions across the ecosystem for livestock predation has been a long-standing problem that has negatively affected lion numbers. Lichtenfeld (2005) reported that nine out of eleven livestock predations by lion resulted in retaliatory killing of lions. Lions are more susceptible to herder retaliation than other species of large carnivore for a number of reasons (Kissui 2008). Firstly, lions often attack livestock during the daytime and are more likely to defend a livestock carcass against people, making them easier to find and kill. Secondly, lions kill more adult cattle, which are the most valuable livestock to Maasai, than other large predators; this creates more resentment towards lions and increases the desire for retribution. Mkonyi et al (2017), found that while lions only accounted for 7% of all livestock losses, almost 60% of their attacks were on cattle, and they were responsible for the majority of cattle losses to predators in the ecosystem. Increasingly, poison is being used to kill lions, which can have a devastating effect on both lion and other non-target species.

Killings of lions by community members is exacerbated by losses to commercial hunting in sport hunting blocks outside the National Park. The Tarangire Lion Project documented an extremely rapid turnover of lions using Tarangire during the period of 1998 to 2002, with 52% of individuals only recorded in one year during those five years (TLP 2002). The death of a pride male typically leads to the killing of all previous offspring by the new alpha male. This process of infanticide can accelerate when there is high removal of male lions from a population, and in Tarangire, 59% of cub mortality has been related to male turnover (TLP 2002). Lion populations are capable of breeding rapidly,

although the combined effect of retaliation for livestock killing, sport hunting and habitat loss, has led to a gradual decline in the lion population in the Park (Kissui pers com).

The African Wild dog and cheetah were both rare in the ecosystem, with six records of cheetah and two of African Wild dog. African Wild dog was only recorded in Tarangire NP, while cheetah was recorded at three sites, with four different records in Enduimet. Both species prey on domestic livestock, with the African Wild dog responsible for 8% and cheetah for 3% of total livestock predation events (Mkonyi et al 2017), with both species focussing mainly on small stock, although Wild dogs also sometimes take calves as well. Both species are diurnal, making them more susceptible to harassment by humans. The African Wild dog has the added disadvantage of using fixed denning sites when the pups are small, which are relatively easy to find in open savannah areas, and can be targeted for retaliation. Sighting records from local community members suggests that African Wild dogs are more common in the southern part of the ecosystem, notably the Makame WMA, which has very dense vegetation that provides excellent cover for denning sites. Both cheetah and African Wild dogs are known to avoid areas of high prey density probably because other large carnivores are found in those areas (Creel & Creel, 1996, Durant 1998). Lions will kill both cheetah cubs and adults, while Spotted hyaenas will kill cubs and steal food from cheetah (TAWIRI 2016). Both lions and hyaenas also prey on juvenile and adult African Wild dogs (Woodroffe et al., 2007), which is probably the reason why this species ranges widely and occurs at low population densities throughout its range. It is likely therefore that competition with larger predators limits their presence in Tarangire and Lake Manyara NPs.

Tarangire National Park was the only area surveyed where all species of large carnivore were recorded, highlighting the importance of the Park as a stronghold for large carnivores in the broader ecosystem. The south of the Park had a particularly high diversity of carnivores, with spoor from every target species recorded except for leopard, which was recorded visually. While all six species are occasionally found in other parts of the ecosystem, particularly in parts of Simanjiro directly east of Tarangire, and in Randilen WMA and Manyara Ranch, populations of cheetah and particularly African Wild dogs, are often transient in these areas. A camera trap survey of the Makame WMA to the southeast of the Park in September-December 2017 (also funded by USAID-EENT) recorded five of the large carnivore species (only cheetah was missing), suggesting the dense thickets found in that area may also provide an important refuge for large carnivores.

This was the first extensive spoor count survey of large carnivores across the Tarangire ecosystem, and as such provided a useful baseline for carnivore frequency and distribution. While time-consuming, this method is relatively cheap to implement, and it is recommended that a follow up survey be carried out within the next five years, and include Makame WMA, to provide a trend assessment for these species.

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