DATA HUNTERS

A Pilot Project to assess Leopard Population Densities in select hunting areas of Tanzania & Zambia

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Preliminary Results from the 2017 Hunting Season

A Leopard's visit to a bait in a Tanzanian hunting block is captured on a trail camera donated by Cabela's

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SUMMARY

Population data on leopards are urgently needed to inform on status of the species, to update non-detriment findings, and to investigate the sustainability of trophy hunting. During a pilot project to empirically assess leopard populations in hunting areas, Dr. Paula White and Dr. Arturo Caso gathered "by-catch data" consisting of trail camera photographs and camera locations from select hunting operators and professional hunters in Tanzania and Zambia. The primary goal of this study was to assess whether trail cameras set at hunters' baits could provide adequate information for rapid assessments of leopard densities in hunting areas.

To date, we have received over 23,000 photographs from the 2017 season. The data obtained from each operator varied both in quality and quantity. In sites where camera coverage was adequate (n=11) preliminary estimates of leopard population densities were obtained. Mean densities of X=4.40 leopards/100km^2 were calculated across 8 areas in Tanzania. Similar mean densities of X=4.47 leopards/100km^2 were found across 3 areas in Zambia. Mean number of days sampled per camera was X=5 days. This is far below the suggested number of 25 sampling days. Therefore, these density estimates should be considered very conservative minimums. Increased sampling time is required to more accurately detect the number of leopards and calculate final density estimates for each hunting area.

Given that 2017 was a pilot season and that most cameras operated for only a few days, the amount of data obtained was highly encouraging and suggests that this method could work well with a few modifications e.g., increased sampling time, to help ensure that statistically significant analyses could be completed. Further, this study represents a method that could potentially form the basis of a long-term monitoring program to document leopard population trends, at both a local (hunting area) level and at a countrywide scale.

This summary presents preliminary results using data sets (photographs and locations) obtained to date. More data from the 2017 season are anticipated. A final report from the pilot season will be prepared after all available data have been obtained and analyzed.

INTRODUCTION

There is urgent need for empirical data on African leopard (*Panthera pardus pardus*) populations, especially in areas where sport hunting occurs (du Preez et al. 2014). Population data are needed to inform on status of the species, to update non-detriment findings (NDFs), and to investigate the sustainability of trophy hunting. To date, there has been very limited research done on free-ranging African leopards; only a small fraction of these efforts have investigated population density (Jacobson et al. 2016). The majority of research has been carried out in fenced reserves, mostly consisting of national parks (NP) and private lands in South Africa, i.e. Phinda Private Game Reserve (Balme et al. 2009a,b), or in large fenced conservancies, i.e. Bubye Valley and Save Valley, Zimbabwe. Of the few studies conducted outside of fenced reserves, one investigated leopard densities across a mosaic of land-use patterns in South Africa's Soutpansberg Mountains (Williams et al. 2017). Others (Ray 2011; Rosenblatt et al. 2016) compared densities in NPs to portions of adjoining hunting blocks in Zambia's Luangwa Valley. One of the few large-scale field studies on wild leopards in hunting areas was research conducted in Tanzania by Dr. Arturo Caso (2003).

To address this data gap, in 2017 Dr. Paula White and Dr. Arturo Caso initiated "Data Hunters", a pilot project aimed at assessing leopard population densities within hunting areas. We gathered by-catch data from select safari hunting operators and professional hunters (PHs) in some of the most important hunting areas in Tanzania and Zambia. Data consisted of photographs obtained by trail cameras set by PHs at hunting baits during the 2017 season and location data of where the photographs were taken. These data were considered "by-catch" because trail cameras were already being deployed at baits by hunters as one means of assessing leopard visitation and trophy quality. Camera trap data was previously shown to be a robust method of estimating density in an intensively studied leopard population in South Africa (Balme et al. 2009a). By-catch data obtained from remote cameras set at water sources proved effective for occupancy modelling of leopards in Namibia (Edwards et al. 2018). The goal of the current study was to investigate whether trail cameras set at hunters' baits could provide adequate information for rapid assessment of leopard densities in hunting areas. Dr. Caso's previous field work forms a solid foundation of comparative data on leopard density that contribute importantly to the Data Hunters project.

Citing the paucity of scientific data on most leopard populations, anti-hunting and animal rights groups have escalated their efforts to end trophy hunting of African leopards (Frostic et al. 2016). Anti-hunting groups often seek to increase restrictions and regulations on trophy export/import as a means to achieving their goal of ending all hunting. NDFs are defined as "a conclusion by a scientific authority that export of specimens of a particular species will not impact negatively on the survival of that species in the wild" (InforMEA 2018). Challenging the validity of NDFs is a common strategy used to further anti-hunting agendas.

Overall, there is a call for more and better data reporting on leopard populations range wide (Stein et al. 2016). In June 2016, the IUCN Red List elevated the status of leopard from Near-Threatened to Vulnerable (Stein et al. 2016). Meanwhile, USFWS faces pressure to uplist all populations of the African leopard to Endangered on the Endangered Species Act (ESA) (Frostic et al. 2016; USFWS 2016). Currently, *Panthera pardus* is listed as CITES Appendix I, although trade in leopard trophies is permitted from 12 African range states (CITES 2018). Although carefully regulated, questions have been raised regarding the sustainability of sport hunting of leopards (Packer et al. 2011). Most NDFs for leopards have not been updated since 1982, and are considered outdated (USFWS 1982a,b). Citing lack of reliable population monitoring, the government of South Africa banned leopard hunting in 2016 (SASA 2015). In response to the growing debate, both USFWS and CITES permitting authorities have called for updated NDFs to be provided by all leopard range states seeking to obtain export/import trophy permits. Thus, updated NDFs are one aspect crucial to demonstrating sustainability of leopard hunting.

Ideally, the Data Hunters project represents a method by which data on population density can be obtained at both the scale of the individual hunting area for purposes of adaptive management, and thereafter integrated into a broader geographic scope to inform on the status of the species at the country level. Further, this method could potentially form the basis of a long-term monitoring program to document leopard population trends in hunting areas. Leopard photos obtained by trail cameras at baits and provided directly by the hunting operators to scientists and managers represents a relatively low-cost means by which large amounts of data could be obtained annually across a targeted, or broad geographic range. Population trend data are rapidly replacing population size estimates as a more robust measure of assessing population status, and population trend data are already being requested by wildlife authorities and governments as part of NDFs on trophy-hunted species. Thus, this study shows great potential to fill data gaps on a wide-ranging species that is notoriously difficult to survey.

Ultimately, a pro-active approach towards collection of scientific data coming from within the hunting community demonstrates a stakeholder commitment towards sustainability and conservation. It is this level of cooperation between hunters and scientists that underscores the value, and helps ensure the future success, of the Data Hunters project.

Methods

Hunting Areas sampled in 2017

As part of the pilot project, 11 hunting companies (n=6 operators in Tanzania and n=5 operators in Zambia) saved all photographs obtained from trail cameras set at their hunting baits during the 2017 hunting season and recorded GPS locations of the camera/bait sets. Subsequently, we received unsolicited sets of photographs from two additional operators in Tanzania. Thus, a total of 13 companies participated in the 2017 pilot season (Table 1). Because some companies operated in more than one hunting area, coverage included data from 25 sampled locations (Figs. 1a,b).

Photographic data

While a few operators were able to send photographs and location data electronically during the 2017 hunting season (e-mail, DropBox), the majority of photographs and location data were collected in person in January-February 2018 during the major annual hunting conventions in Dallas, Texas (Dallas Safari Club) and Las Vegas, Nevada (Safari Club International).

To date, we have received at least some photographic data from all 13 participating operators totaling 23,199 individual photographs; 15,532 from Tanzania and 7,667 from Zambia. Location data have also been received for 13 of the 25 sampled sites. For some other areas, location data exist only in GPS units stored in Africa during the off-season. Receipt of these outstanding data are anticipated within the next few months as hunters return to their camps in preparation for the upcoming 2018 season.

Data analyses requires examination of each photograph for presence/absence of leopards, and where leopards are detected, determination of numbers, sex, and age class of cats. Of the total number of photographs received, 9,459 (41%) contained at least one leopard in the frame (4,436 from Tanzania and 5,023 from Zambia). Many of these were cats that were photographed multiple times during one visitation to a bait. However, individual leopards are identifiable by unique spot patterns (Miththapala et al. 1989). Thus, where leopards were detected in photographs, efforts were made to determine if the animals photographed represented the same or different individuals.

Density estimate calculations

For areas from which sufficient data were obtained, density estimates were calculated using first the mean home range value of male and female leopards (obtained using GPS radio-collars) in Tanzania (Caso 2003) and in Zambia (Ray 2011). With these home range values, buffer zones (circles) were created around each bait site where at least one photograph of a leopard was obtained, and assuming that each circle represented the home range area of a leopard (Figs. 2a,b). Effective area of sampling was calculated using the total area created by all the buffer zones, with the exception that isolated bait sites, and those where no leopards were detected, were excluded from the analysis (Fig. 2b). Density was then calculated using the number of individual leopards photographed at bait sites within this effective area. Density estimation is reported as the number of leopards per 100 km².

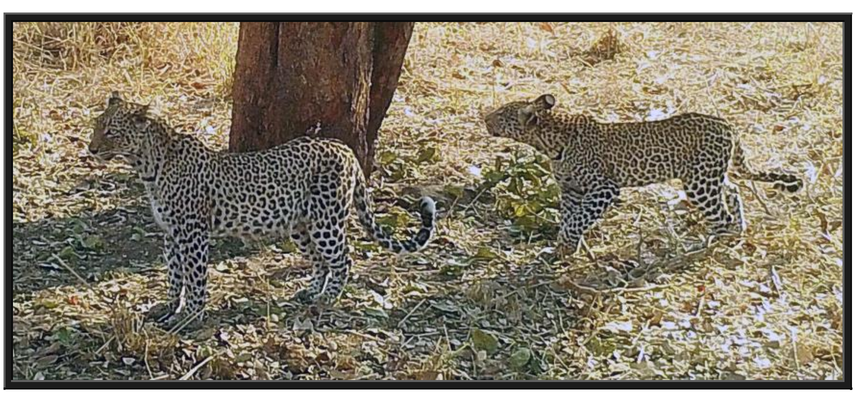
The amount of data obtained from each operator varied, and was largely dependent on 1) the number of cameras deployed (some PHs did not have enough cameras to deploy one at every bait), 2) the number of days baiting occurred and cameras were operational, and 3) the spatial array of cameras/baits. In hunting areas where camera coverage was adequate preliminary estimates of leopard population densities were obtained, while in other areas although the participants provided the requested information, the number or placement of cameras was insufficient for density estimates to be calculated. In a few areas, some of the required information has not yet been provided to the project. Calculation of density estimates are planned for additional areas dependent upon receiving the requested location data, and on availability of funding to complete data analyses.

PRELIMINARY RESULTS FROM THE 2017 SEASON

Of the complete data sets (photos and locations) received thus far, leopard density estimates have been calculated for 11 hunting areas; 8 in Tanzania and 3 in Zambia (Figs. 1a,b; Table 2). In the remaining areas (n=14), either the number of cameras was insufficient, the camera spatial array did not allow for leopard density to be estimated, or GPS locations for the camera sites have not yet been provided.

In Tanzania, the mean density of leopards was X=4.40 leopards/100km^2, range 1.87-10.9, n=8 areas. In Zambia, the mean density of leopards was X=4.47 leopards/100km^2, range 2.1-8.1, n=3 areas. The mean time over which most cameras operated was only X=5 days.

Mean overall sex ratio of leopards photographed at baits was 2 males:1 female. Female leopards with cubs were photographed at multiple bait sites. Due to the very large number of photographs obtained, and the level of effort required to detect, sex, and assign age class to all animals in photographs, analyses to determine the percentage of females and cubs have not yet been completed.



Discussion

Trail cameras set at hunters' baits performed well in capturing leopards on photographs. Trail camera photographs were generally of high enough resolution to allow for clear detection of leopards in the image, and in many instances to identify individual leopards that visited and revisited baits.

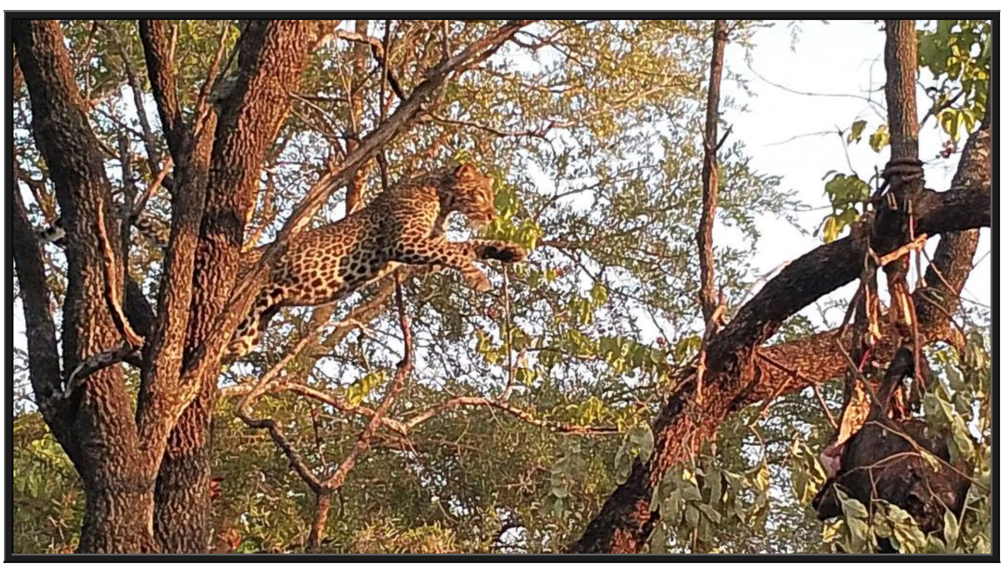
Mean densities from the pilot season were within the range previously reported for leopards. However as a species, leopard densities vary dramatically from 0.1 to 30.9 individuals/100km^2 (Jacobson et al. 2016) confounding comparisons and interpretations. Across the species' range, population density of leopards is known to track the biomass of its principle prey; namely, medium and large-size herbivores (Marker and Dickman 2005; Hayward et al. 2007). In Zambia's Luangwa Valley, one study found leopard densities to be higher in the hunting area than in the adjacent national park (4.79 leopard/100km^2 in Nyaminga GMA; 3.36 leopard/100km^2 in Luambe NP) (Ray 2011), while in another nearby study, the opposite trend was reported (5.08 leopard/100km^2 in Lupande GMA; 8.50 leopard/100km^2 South Luangwa NP) (Rosenblatt et al. 2016). In both cases, the difference in leopard densities was correlated to prey species abundance.

The mean densities reported from our pilot season were obtained during a very short sampling period. Most cameras were active for only 5 days versus the minimum recognized time period of n=25 days that camera traps (set along roads) typically need to operate to obtain statistical significance. However, the average period of time that hunters usually maintain an individual bait is much shorter in duration. This difference will need to be addressed in future. Given the very short period over which most areas were sampled in 2017, at present we cannot assume that all leopards in the area were photographed and, therefore, emphasize that the results presented in this report are preliminary estimates only; longer sampling times would be expected to produce higher density estimates.

Additional factors influence our preliminary findings. It is highly probable that a dominant male leopard will be the first to take advantage of a bait. Although multiple leopards were at times photographed at single bait sites, females and/or subadult males may rarely appear during the first few days that a dominant male is feeding, or is in the immediate vicinity of a bait. This is supported by a mean overall sex ratio of 2 males:1 female at baited sites, compared to a sex ratio of 1 male:1.7 females obtained using non-baited camera traps (Rosenblatt et al. 2016). Further, if a dominant male is taken as a trophy, then the bait is often immediately removed by the PH thereby eliminating the possibility of photographing other leopards that are in the area. For these reasons, a longer and standardized period over which trail cameras operate at baits is needed to more accurately estimate leopard densities. Thus, our density estimates should be considered as very conservative minimums.

Detection of female leopards with cubs was accomplished at numerous baits. Detection of cubs is particularly informative, as previous studies in South Africa have found that leopard cubs were rarely or never detected by camera traps set only on roads, compared to baited camera sites (du Preez et al. 2014a,b). Therefore, data obtained in this study by trail cameras set at baits may more accurately describe some parameters of leopard populations than cameras set only along roads. Final numbers and sex/age ratios will be made available in the final report once all 2017 data have been received and data analyses have been completed.

Given that 2017 was a pilot season and that most cameras operated for only a few days, the amount of data obtained was highly encouraging and suggests that this method could work well assuming that 1) the number of cameras deployed could be augmented, 2) the number of days that cameras operated could be increased and/or standardized, and 3) the spatial arrays of cameras could be refined. These changes would help ensure that statistically significant analyses could be completed in each of the sampled areas and, potentially, provide more comprehensive assessments of leopard densities at countrywide scales. Ultimately, standardized sampling accomplished through trail cameras set at hunters' baits could form the basis of a long-term monitoring tool for tracking leopard population trends thereby contributing to adaptive management, sustainability, and conservation.



Future Efforts

The Data Hunters project seeks to continue, and ultimately, expand its leopard research in the future.

First, we hope to continue by-catch data collection in the current 2018 hunting season, with participation by all or most of the same operators and PHs in Tanzania and Zambia who cooperated in 2017. Several of the participants have already indicated that they now have a more clear understanding of the data being requested. Thus, the results from 2018 are anticipated to be more comprehensive than those received in 2017. It is also hoped that photographs and especially location data from the 2018 hunting season will be provided in a more-timely manner to facilitate prompt completion of data analyses.

Depending on availability of trail cameras, it is further hoped that 1-2 operators may be willing and able to expand their camera trapping efforts by having a camera on every bait throughout the 2018 season. This would significantly increase data output and provide a robust background against which field work and ground-truthing could proceed in 2019, as described below.

Building on the results from 2017 and 2018, we are proposing a ground-truthing component in which Dr. White and Dr. Caso would perform/oversee a 30-40day field season focused within a few select hunting areas. During the proposed field season, non-baited trail cameras would be deployed in statistically designed grid arrays and operate for approximately 30 days during which time spoor counts would also be conducted. Concurrently, trail cameras would collect photographs at hunters' baits in the same areas thereby replicating the data collection methodology used in 2017 and 2018.

Ground-truthing will allow us to definitively compare the results obtained using scientifically recognized camera trapping methods i.e., grid arrays, to results obtained from hunters' trail cameras set at baits. Concurrent collection of spoor count data will allow for calibration of data collected using both sets of camera trap results (baited and non-baited) with other methods of estimating carnivore abundance, thereby increasing the accuracy of our density estimates (Gompper et al. 2006; Balme et al. 2009; Pirie et al. 2016). Ultimately, the goal is to calculate a robust correction factor that can subsequently be applied so that the data collection method of hunters using trail cameras set at baits throughout the hunting season can be used as a validated, stand-alone means of estimating leopard population densities and for monitoring leopard population trends.

To this end, we are in the initial stages of permit inquiry with the Tanzania Wildlife Research Institute (TAWIRI) regarding the 2019 field season. TAWIRI have already expressed their general interest in leopard research projects that can provide empirical data and thereby assist Tanzania in monitoring and managing their leopard population in order to ensure long-term sustainability and conservation of the species.

Table 1. Status of Data Sets obtained to date (15 May 2018).

Map Locator No.	Operator	Hunting Area	Photos	GPS	Data for Density Calculation
Tanzania					
T1	Manteakis Safaris	Lake Natron	Yes	Yes	Yes
T2	Fell Safaris	Maswa	Yes	Yes	
T3	Rungwa Game Safaris	Lokisale GCA	Yes	Yes	
T4	Rungwa Game Safaris	Lokisale	Yes	Yes	
T5	Fell Safaris	Kitiangare	Yes	Yes	Yes
T6	Bullet Safaris	Muhesi	Yes	No	
T7	Robin Hurt Safaris / A.Caso	Luganzo	Yes	Yes	Yes
T8	Fell Safaris	Kisigo	Yes	Yes	
T9	Rungwa Game Safaris	Lokisale Mpera	Yes	Yes	
T10	Tanzania Big Game Safaris	Kisigo Central	Yes	Yes	
T11	McCallum Safaris	Piti West	Yes	Yes	Yes
T12	Fell Safaris	Rungwa	Yes	Yes	
T13	Tanzania Big Game Safaris	Lake Rukwa	Yes	Yes	Yes
T14	McCallum Safaris	Lukwati	Yes	Yes	
T15	Robin Hurt Safaris	Rungwa East	Yes	Yes	
T16	Manteakis Safaris	Lukwati South	No	No	
T17	Bullet Safaris	Rungwa	Yes	No	
T18	Tanzania Big Game Safaris	Selous	Yes	Yes	Yes
T19	Alan Vincent Safaris	Selous	Yes	Yes	Yes
T20	Fell Safaris	Selous	Yes	Yes	Yes
Zambia					
Z1	Ivory Safaris	Chikwa	Yes	Yes	Yes
Z2	ProHunt	Lunga Luswishi	Yes	Yes	Yes
Z3	Tandala	Bilibili-Mulobezi	Yes	Yes	Yes
Z4	Muchinga	Chifunda	Yes	No	
Z5	Impanga Safaris	Nyaminga	Yes	No	

Table 2. Calculated leopard densities for which adequate numbers and spatial scale of photographs have been obtained to date.

TANZANIA		
Sampling Location	**Density, leopards/100 km²**	**Comments/Methods**
McCallum / Piti West	2.72	
Vincent / Selous	2.38	
TBGS / Selous	3.34	
TBGS / Lake Rukwa	1.87	
Fell / Kitiangare	5.73	
Fell / Selous	3.41	
Mankeatis /Natron	4.84	
RHS & Caso / Luganzo	10.9	25 cameras set on a grid pattern on roads and trails for 23 days
ZAMBIA		
Sampling Location	**Density, leopards/100 km²**	**Comments/Methods**
ProHunt / Lunga Luswishi	8.06	
Tandala / Bilibili-Mulobezi	2.13	
Ivory Safaris / Chikwa	3.23	

Figure 1a. Spatial array of camera trap data obtained to date from 2017 season, Tanzania.

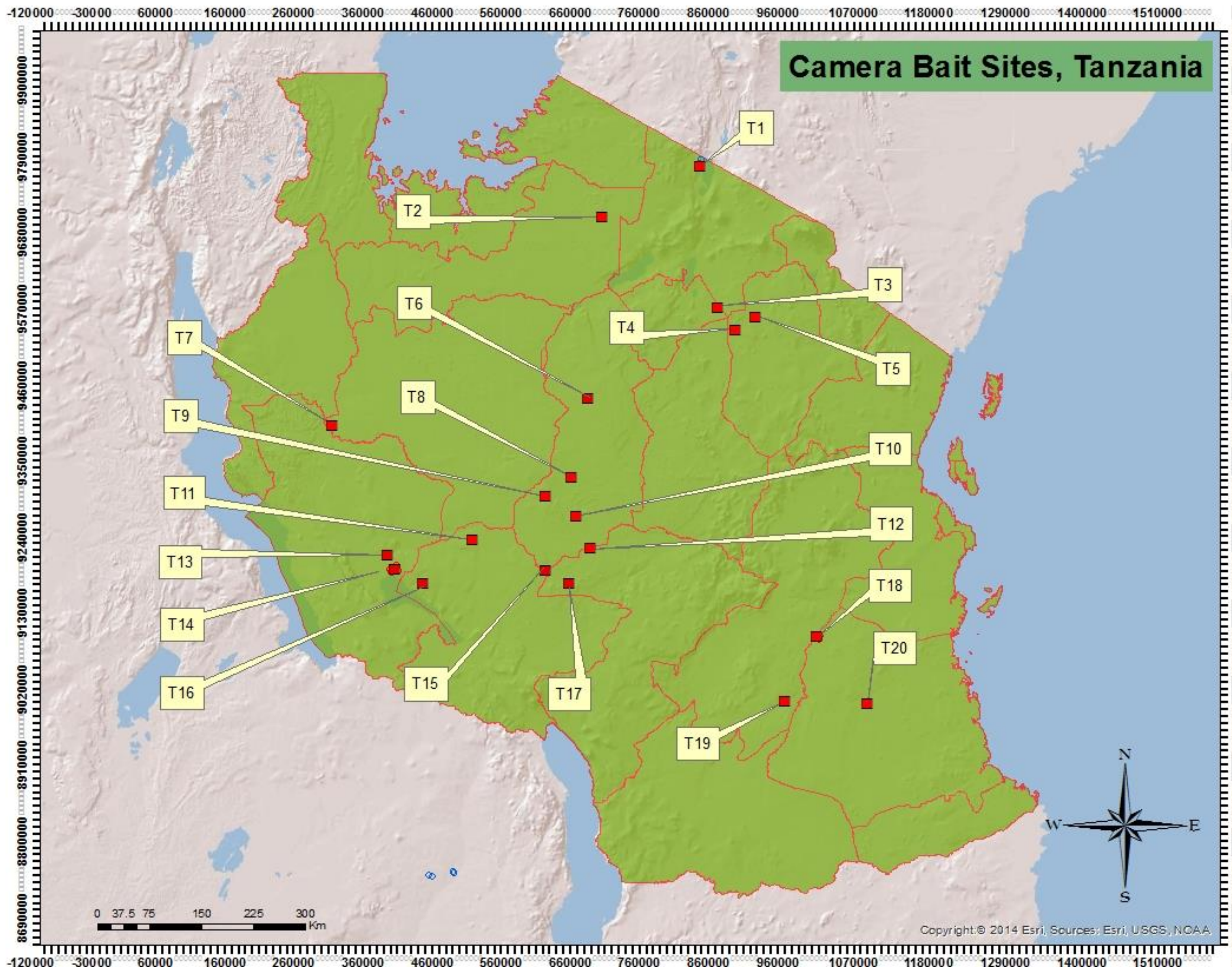


Figure 1b. Spatial array of camera trap data obtained to date from 2017 season, Zambia.

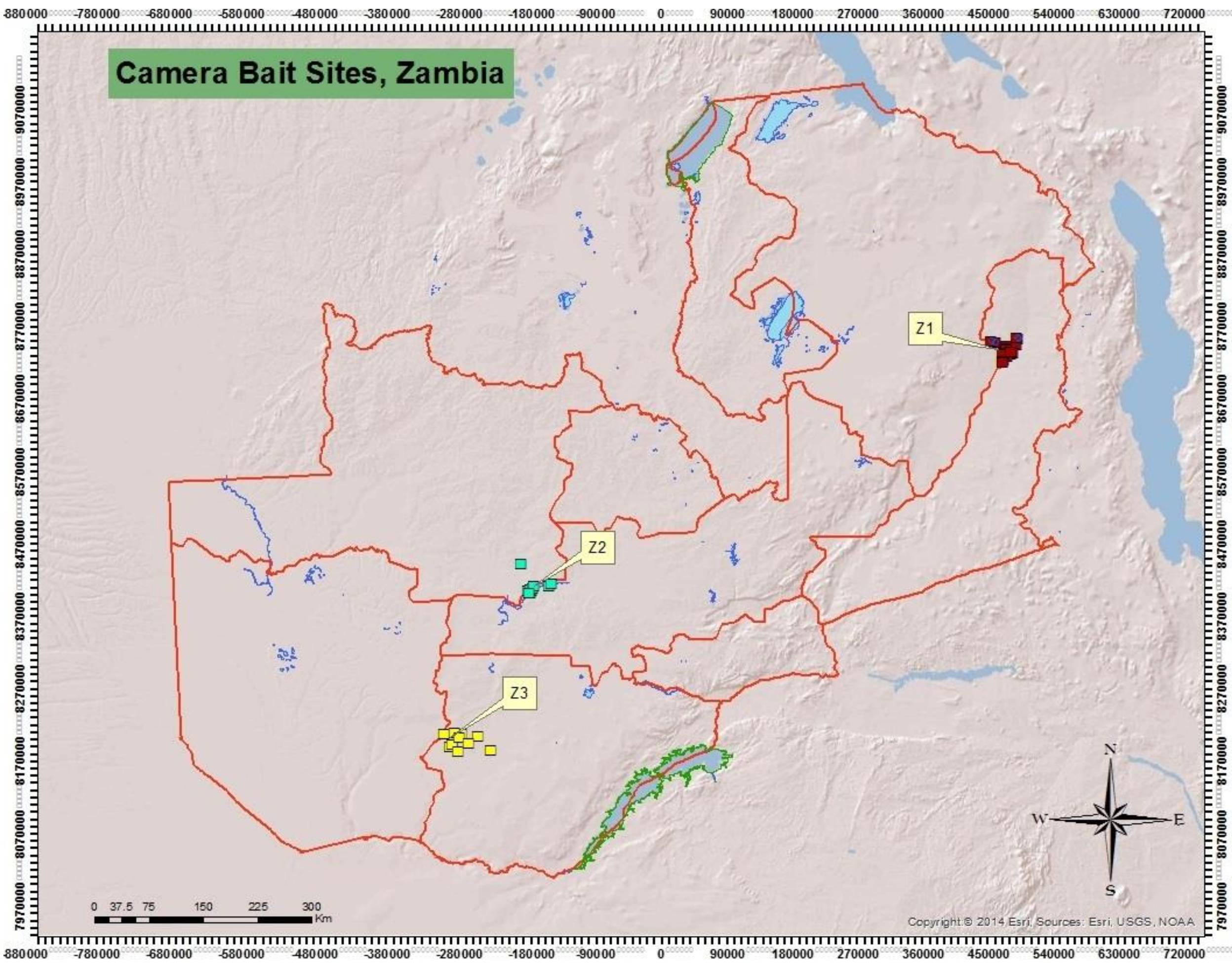


Figure 2a. Example of camera/bait sites sufficient in number and spatial array from which effective area sampling was calculated (Kitiangare, Tanzania).

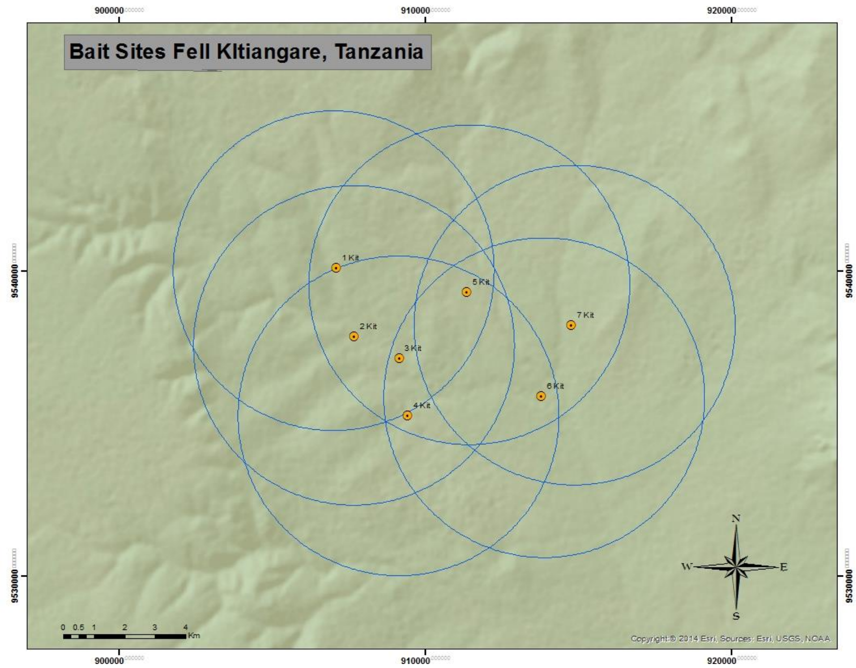
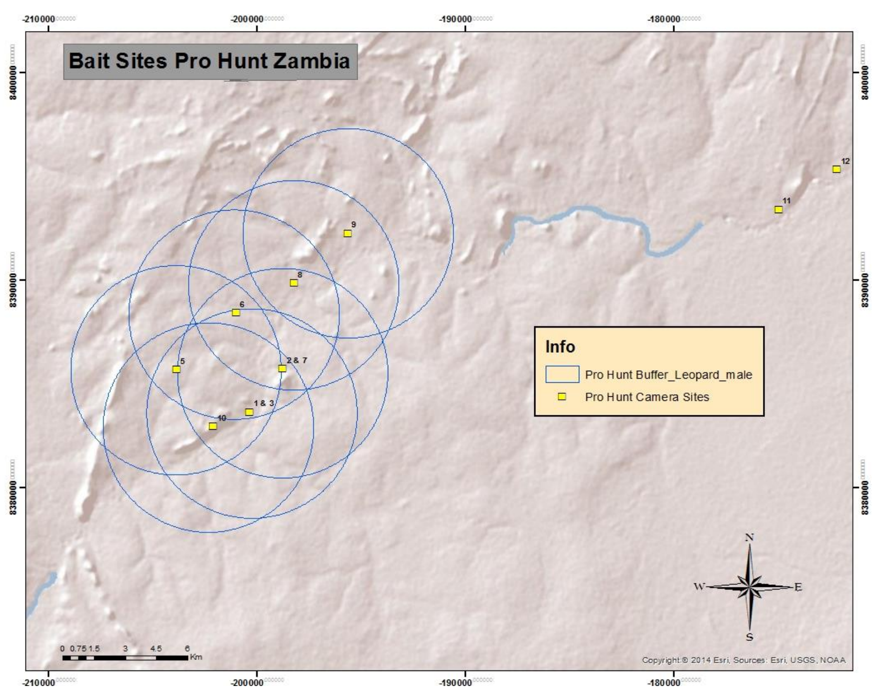


Figure 2b. Example of camera/bait sites sufficient in number and spatial array from which leopard densities were estimated. Two isolated camera sites (11, 12 shown as yellow dots in far upper right) were not included because they were outside of the effective area of sampling (Lunga Luswishi, Zambia).



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DATA HUNTERS – WHO WE ARE…

Dr. Paula White has a M.S. in Wildlife Management and a Ph.D. in Biology from University of California, Berkeley. For over 30 years, Paula has conducted independent field studies on a variety of carnivore species in North America and Africa. Since 2003, Paula has been working on carnivores in Zambia. In 2004, she formed the Zambia Lion Project and began working with the hunting community and Zambia Wildlife Authority to develop and promote sustainable utilization through age-based trophy selection. Currently, Paula is a Senior Research Fellow with the Center for Tropical Research, Institute of the Environment and Sustainability, University of California, Los Angeles.

Dr. Arturo Caso has a M.S. in Range and Wildlife Management and a Ph.D. in Wildlife Ecology from Texas A&M University-Kingsville. For over 25 years, Arturo has conducted field studies over different carnivores in the U.S. and Mexico including the jaguar, ocelot, mountain lion, and black bear. In addition, he did a leopard study in Tanzania, from 2001 to 2003 and a lion and leopard population survey in 2012. Recently, Arturo was a Research Associate at the Caesar Kleberg Wildlife Research Institute in Texas and today, he is an Advisor and Area Director at SEMARNAT (Mexico's Federal Agency for Environment and Natural Resources) and a Field Researcher for the NGO Predator Conservation, A.C.