
Zambian
CARNIVORE PROGRAMME
DEPARTMENT OF NATIONAL PARKS & WILDLIFE
DNPW
"CONSERVE WILDLIFE"
2018
Annual Report

Lions from the Nchindeni Pride and their cubs in the Luangwa Valley's Lower Lupande Game Management Area.

Table of Contents

Zambian
CARNIVORE PROGRAMME

Zambian Carnivore Programme
PO Box 80, Mfuwe, Eastern Province, Zambia
www.zambiacarnivores.org

DEPARTMENT OF NATIONAL PARKS & WILDLIFE
DNPW
"CONSERVE WILDLIFE"

Cover: Cheetah 180 and her cubs survey the plains of Liuwa. As the second-largest cheetah population in Zambia, Liuwa Plain is of key importance for the country and for the Liuwa-Mussuma Transfrontier Conservation Area with Angola. *Photo: Daan Smit*

The Year in Review

By any measure 2018 was a very productive year for our collaborative conservation work. As a field-based organization working across the country's major ecosystems, our teams logged over 2,700 person days in the field, covering nearly 37,000 km^2 across three ecosystems and monitoring nearly 1400 individuals in the country's major populations of large carnivores in collaboration with the Department of National Parks and Wildlife (DNPW) and an array of local and international partner organizations and institutions.

Our intensive long-term studies continued to provide high-quality scientific guidance for policy and management for carnivores, their prey, and ecosystems at large, both for Zambia and the region. In addition we expanded our collaborative work with an emphasis on the links between watersheds and wildlife with our project partners in all sites. We provided science-based evaluations on an array of topics ranging from demography, genetics, predator-prey dynamics, poaching, and human encroachment. We also expanded our new collaborations on anti-trafficking work in large carnivores. Our field teams continued to help protect large carnivore populations through collaborative anti-snaring work, and the presence of field-based Zambian wildlife vets was again essential for rapid response. We also began a new carnivore conflict mitigation programme as part of our response to changing threats to wildlife and people in our study areas.

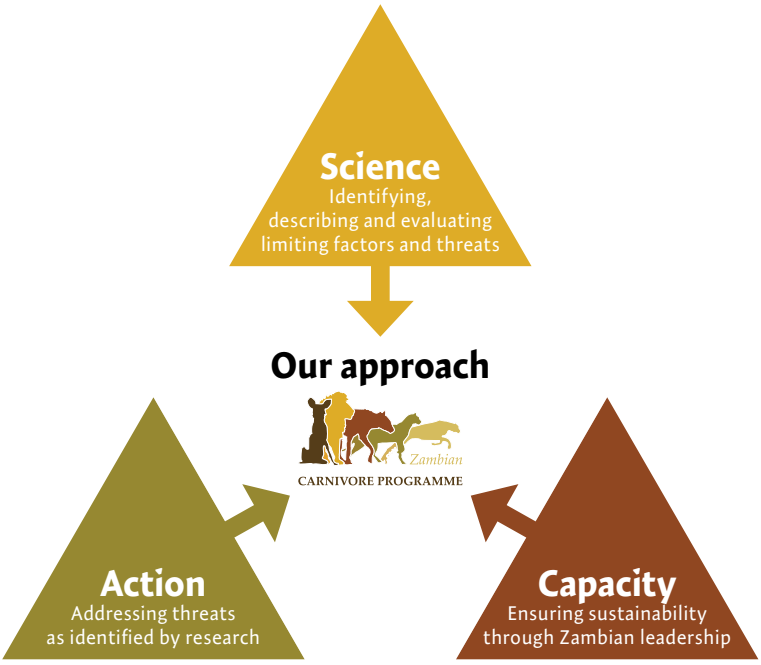
We expanded our Conservation Capacity work with an array of educational and community outreach work, growing all our Conservation Club and training programmes and taking on two Zambian graduate students. Interest in conservation careers among Zambia's future generations remained unprecedented, in no small part to training, mentoring and inspiration provided by our current local team members and their work across the country.

Appropriately coinciding with the BBC's release of the "Dynasties" series that featured fantastic footage of wild dogs in Zimbabwe, 2018 saw the end of the Hot Springs Pack dynasty in the Luangwa. This extraordinary pack and its exceptional alpha male (Wild Dog 73) survived for over a decade in the most unlikely of circumstances, where heavy snaring pressure took its toll every year on the pack. Nevertheless with our collaborative work with the DNPW and Conservation South Luangwa the pack persisted, and in 2018 the alpha male passed away at over 12 years of age, matching the oldest wild dog in the wild that we know. The legacy of this exceptional pack and dog is still seen in the abundant wild dog numbers we continue to enjoy in the Luangwa. It is a tribute to the resilience and intrigue of this endangered species and to the efforts of all the women and men working to save them.

No one accomplishes anything on their own in conservation; it is a team effort and our work reflects the collective commitment, passion and expertise of dozens of indivduals, partners and donors who collectively have helped make this happen. Thanks again for all your support and collaboration. We look forward to a great 2019 for Zambia's carnivores, people, and ecoystems.

Dr. Matthew Becker
Chief Executive Officer

Our Approach



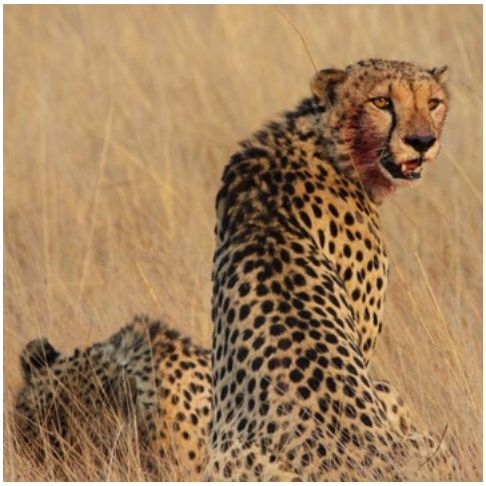
The Zambian Carnivore Programme (ZCP) follows a three-tiered interdisciplinary approach of Conservation Science, Conservation Action and Conservation Capacity to fulfill its goal of conserving large carnivores and ecosystems.

The success of this work fundamentally rests on our diverse and effective collaborations with local, national, and international partners, agencies, organizations and institutions that collectively provide the expertise, resources and energy to address the myriad conservation challenges facing Zambia.

Why Carnivores?

Umbrella species
Carnivores need space, and lots of it; protecting them protects an array of other species in an ecosystem.

Indicator species
Carnivores are very sensitive to human impacts and are often some of the first to disappear from ecosystems.



Keystone species
Carnivores have an ecological influence disproportionate to their abundance.

Flagship species
Carnivores are charismatic and generate lots of public interest and support for conservation.

Conservation Science

Fundamental to effective conservation is accurate and current information to guide actions and science-based management decisions. Given that very little is known about most of Zambia's wildlife species, research and monitoring programmes are of paramount importance. Identifying, describing and evaluating dynamics, limiting factors and threats to species and ecosystems entails variable scientific investigations, ranging from population dynamics, genetics, and disease, to predator-prey dynamics, behavioral and landscape ecology.

Conservation Action

Our conservation initiatives address the immediate threats to species and ecosystems as identified by our research, with the goal to reduce current, and help reverse past, negative impacts on large carnivore populations and ecosystems across Zambia. ZCP collaborates with local partners to ensure that threats are addressed in a timely manner, through initiatives ranging from supporting anti-poaching and land-use planning work to species reintroductions, to mitigating human-wildlife conflict and reducing disease threats from domestic animals.

Conservation Capacity

Too often the sustainability of research and conservation efforts is compromised because local communities are not effectively involved. We undertake a comprehensive multi-level approach to help ensure sustainability by training, educating, sponsoring, and employing young Zambian wildlife professionals from the secondary school level through to international graduate programs. Collectively, this helps to ensure that Zambia's best and brightest have the opportunity to contribute their talents to wildlife conservation now and into the future.

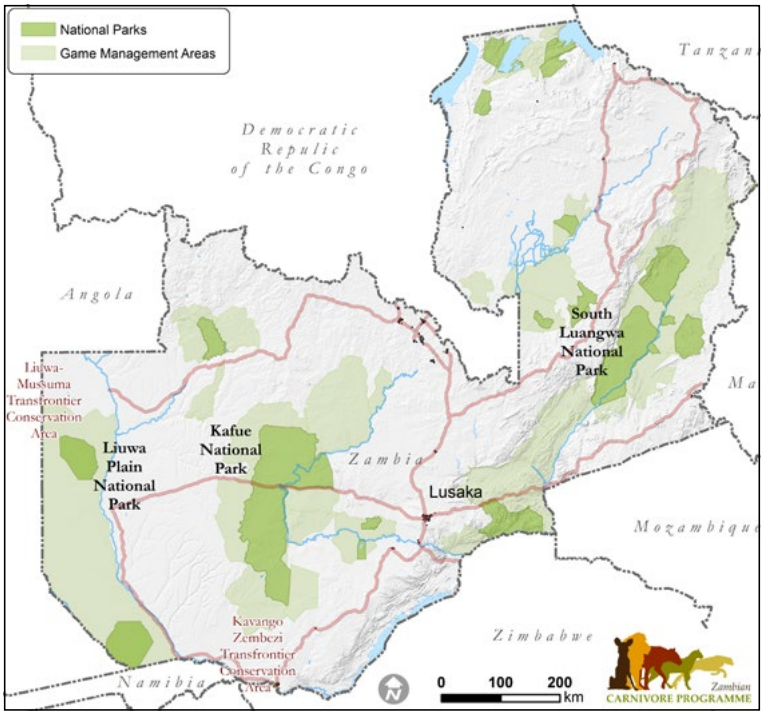
Where we work

Zambia – the crossroads of connectivity

Connects eastern and southern African wildlife populations

Heart of the Zambezi river watershed, draining much of the region

Large-scale ecological processes (migration, dispersal, flooding, etc.) still occur



Borders 8 countries with multiple transfrontier conservation areas

Multiple areas of unfenced, contiguous land over 70,000 km²

Over 30% country managed as protected area complexes

ZCP Study Areas

The Zambian Carnivore Programme's work centers primarily in three main ecosystems, namely the Luangwa Valley, Greater Kafue Ecosystem and Greater Liuwa Ecosystem. All of these areas consist of a matrix of national parks and Game Management Areas (GMAs), which collectively comprise the majority of Zambia's large carnivore populations and are part of three Transfrontier Conservation Areas (TFCAs).

The Luangwa Valley currently contains the country's largest carnivore populations; Greater Kafue contains Zambia's second-largest carnivore populations and its largest cheetah population as well as an incredible diversity of ungulates; and Greater Liuwa contains recovering populations of all carnivores and important populations of cheetah and wild dog as well as Africa's second-largest wildebeest migration.

Dogs play in a newly-formed pack in South Luangwa. After years of stable to increasing growth in part due to collaborative anti-snaring work between ZCP, DNPW, and CSL, the Luangwa Valley is now estimated to hold the country's largest dog population.

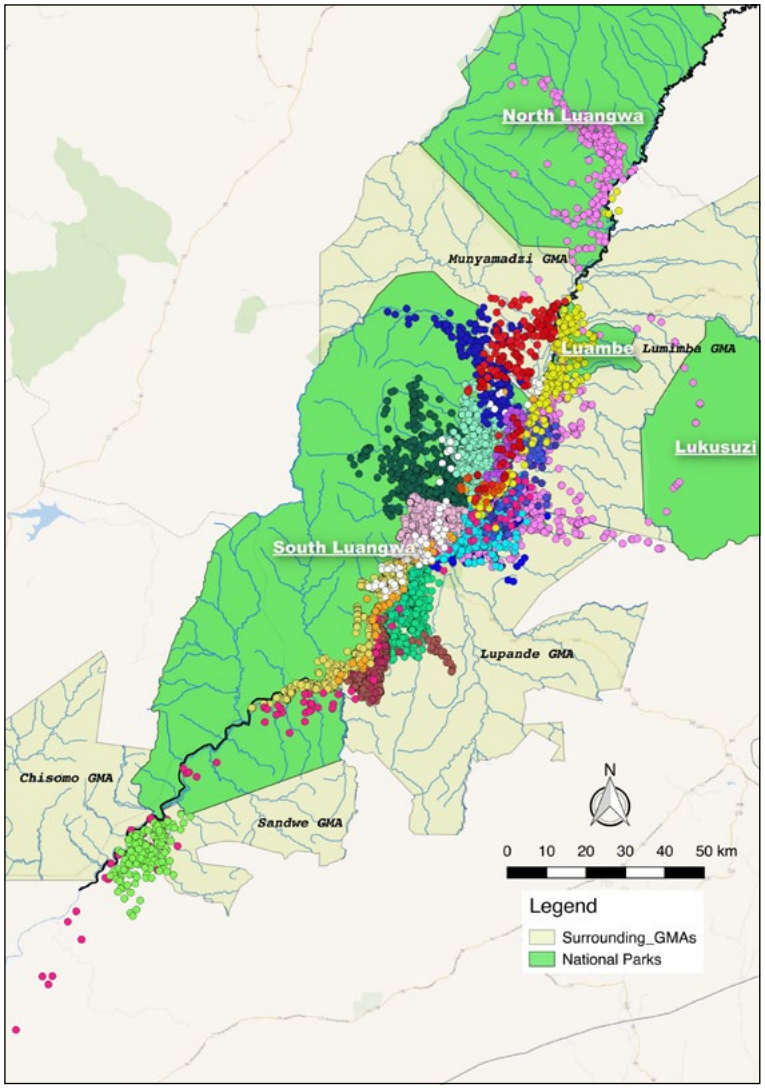
Field Reports

Luangwa Valley

African Wild Dogs

We continued our long-term wild dog conservation work in 2018, significantly extending its scope with wild dogs in North Luangwa and over 30km south of South Luangwa, as well as into Luambe National Park and all the adjacent Game Management Areas (GMAs). Our intensive studies monitored 185 dogs in 13 packs and dispersing groups. Pup production was lower than prior years likely owing to the dissolution of the long-standing Hot Springs Pack (see below) and multiple dispersals and new pack formations during the denning season. These transitions continued through most of the year, and following the 2019 breeding season during the rains, it will be clearer which packs become established and resident. We continued to document long-distance dispersal throughout the valley and the establishment of packs from South Luangwa dispersing dogs in areas such as Sandwe GMA and North Luangwa.

While wild dog populations can fluctuate significantly—particularly due to human impacts—the species has enjoyed multiple years of stable and increasing numbers in its core population in and around South Luangwa National Park, due in large part to the collaborative conservation efforts of the DNPW, Conservation South Luangwa, and ZCP. The naturally-low density and wide-ranging behavior of dogs make them particularly prone to



Wild dog locations from 2018 demonstrate the importance of large landscape connectivity.

snaring by-catch from poachers, which is currently considered to be the most immediate threat to the Luangwa population. Long-term collaborative conservation work has enabled the mitigation of snaring impacts on wild dogs. DNPW-ZCP teams intensively monitor approximately 150-180 dogs in typically 10-12 packs year-round through ground-based field crews, aerial tracking, and satellite-GPS collar technology. These field efforts (over 1,000 person days per year) have allowed teams to detect snared dogs, and then to treat them for injuries through field-based local vets from ZCP/CSL and DNPW. In addition the data provided by collared dogs is provided to anti-poaching patrols, which target snare removals in areas of high usage and high snaring risk for dogs (See Conservation Action Section).

While considerable work remains, these efforts have demonstrated success in that ZCP now estimates the Luangwa to be the country's largest wild dog population at approximately 350 adults and yearlings.

The Hot Springs Dynasty (2008–2018)

The 2018 year was poignant in that it marked the passing of a wild dog dynasty in the Luangwa, that of the Hot Springs Pack and its alpha male, Wild Dog 73. While the duration of most wild dog packs is several years and the oldest recorded wild dog in a natural ecosystem is to our knowledge 12 years old, the Hot Springs Pack defied these odds in one of the most unlikely places.

We first documented this pack in the South Luangwa's Nsefu sector and Upper Lupande Game Management Area in 2008, and the Wild Dog 73 was a young dog of at least two years of age. In 2014 73 lost his mate and several pack members to poaching snares in the rains, but a dispersing group of females from the Mwasauke pack joined him just before the denning season and they successfully bred for four more years. The 2014 season was particularly bad for snaring, and most of the adults and yearlings in the Hot Springs pack had been snared. ZCP-DNPW-CSL teams managed to rescue most of them, including 73 when he was mortally wounded in a snare that encircled his front leg, cutting into his armpit and neck. Fortunately field teams were actually with the pack at the time it occurred and were able to successfully de-snare him. In 2018 he again lost his mate in the rains (this time a suspected natural death due to lions) and he roamed with his 14 offspring for several months, turning 12 years old in the process, before passing away in July of 2018.

Following his death, 9 of his sons dispersed north to form the Chikwenda pack in the Luambe National Park, while his daughters joined with several new dispersing males to form the Miloyti pack, which continues to roam throughout the former range of their father and the Hot Springs Pack. At the time of this writing the offspring from this dynasty have created at least 10 additional packs and 136 pups, grandpups and great-grandpups throughout the Luangwa. While we mourn the loss of 73 and the Hot Springs Pack, their legacy is a testament to both the challenges facing wild dogs in a rapidly changing world, but also to the perseverance of one of Africa's most intriguing and unique species.

From top: A) The Hot Springs Pack and Wild Dog 73 (collared) B) Marking as a young alpha male with his mate C) Wild Dog 73 at 12 years of age.

Rescuing 73 from a deadly snare (L). The alpha male and his final litter of pups in 2017.

Luangwa Lion Summary

In 2018 we completed our 11th year of collaborative lion conservation work in the country's largest population, and one of ten remaining lion strongholds on the continent. We intensively monitored 215 individuals in 19 prides and 17 coalitions across South Luangwa National Park and the adjacent Lupande and Lumimba Game Management Areas. We also expanded work northwards in response to changing spatial dynamics by some study prides and conducted additional survey and monitoring work in collaboration with the DNPW.

Together with the DNPW we published a peer-reviewed paper in 2018 in the scientific journal PLOS1, evaluating 8 years of Luangwa lion demography, spanning both the three year hunting moratorium and five years prior. The paper—entitled "Quantifying lion demographic responses during a three-year moratorium on trophy hunting"—used long-term demographic data from 386 lions to estimate the effects of hunting on lion survival, recruitment, and abundance. Sigificant positive changes in male survival, cub recruitment and overall population size supported the moratorium decision by the DNPW. Continued monitoring coupled with continued changes in hunting management to improve the viability of trophy hunting will be necessary, concurrent with ongoing anti-snaring efforts by Conservation South Luangwa, DNPW and ZCP, in order to maintain the current population levels of lions.

Because nearly all of our study prides and coalitions used both the strictly protected national park and the GMA buffer zones as their range, we continued to work on evaluating the impacts of protection gradients on lion dynamics, as human impacts are highest in the buffer zones and wire-snare poaching continues to present a serious threat to both lions and their prey. We continued to deploy satellite collars on remote GMA prides particularly susceptible to snaring, and combined this with ground and aerial monitoring and coordination with CSL-DNPW patrol teams (see Conservation Action). In addition with changing human demographics in the surrounding chiefdoms the incidences of lion-livestock conflict have increased, and in 2018 we began a human-lion conflict mitigation programme (see Conservation Action).

Reuben Kabungo records lion demography data at a sighting. A DNPW researcher attached to ZCP, the work of Reuben and other field teams provides vital data on Luangwa lions and other carnivores.

Leopard

We completed our seventh year of camera-trap based studies in the Luangwa's leopard stronghold, conducting work on leopards and their prey across the gradient of protection between South Luangwa National Park and the adjacent Game Management Areas. There is an increasing array of human impacts on leopard populations in the Luangwa and the region, including encroachment, prey depletion from poaching, an emerging illegal trade in leopard skins and parts, as well as a legal offtake from trophy hunting. Consequently an understanding of leopard dynamics is ever more important in these populations. In 2019 we will be working with DNPW Ecologists (see Conservation Capacity) to begin evaluating leopard dynamics in Zambia and the factors affecting them.

Herbivores

Large herbivores have significant influence on ecosystem functioning and are essential as prey for large carnivores, making understanding their dynamics extremely important for conservation and management. In collaboration with the DNPW we continued our long-term work on these species in 2018, completing the seventh year of seasonal ground-based surveys for all species across both South Luangwa National Park and the adjacent Game Management Areas (GMAs), while also implementing surveys in Luambe National Park. These surveys provided estimates of density, distribution, and the human and ecological factors affecting them, across the strong gradients of protection between national parks and GMA buffer zones where human habitation occurs. In addition we continued our long-term demographic studies of the geographically-isolated Luangwa giraffe population, using photo monitoring to identify and estimate survival and reproduction for over three hundred individuals across the South Luangwa area. With analyses still underway we intend to complete the first comprehensive demographic analysis in the coming year.

Greater Kafue

Cheetah

Conservation work on Zambia's largest cheetah population in the Greater Kafue Ecosystem (GKE) made big strides in 2018 with intensive monitoring of 23 cheetah in the study area via satellite collar technology and ground-based fieldwork, along with citizen science initiatives through lodges and guides. Unlike our Liuwa work, where we have studied primarily females, there is a particular lack of knowledge on breeding female cheetah in the GKE. In 2018 we were able to better document breeding success of females and monitor multiple young females as they dispersed and began to establish home ranges.

Dr. Kambwiri Banda attends to an immoblized cheetah for radio-collaring as part of our long-term collaborative cheetah conservation work.

Cheetah continued to exhibit very large-scale movements, and often ranged throughout very remote areas well away from roads and often in high snaring risk areas—for example a trio of dispersing females resided much of the year in the Chibembe area and ranged within 1.5 km of a 16-snare set that was detected and removed by ZCP-DNPW monitoring teams. Coordination with partners DNPW and Panthera (see Conservation Action below) is therefore vital to minimize snaring by-catch threats. While we documented cheetah reproductive success, unfortunately one dispersing female lost her first litter of three cubs to a human-caused bushfire of unknown origin. Because cheetah cubs are typically born in tallgrass areas during the sedentary two-month denning period when the cubs are not mobile, cheetah reproductive success is likely influenced by the widespread presence of bushfires and these data provide valuable insights for management and conservation of GKE cheetah. Continued monitoring of established breeding females and dispersing females seeking out and setting up homeranges will provide vital information on reproductive success and cub survival, as it has with lions.

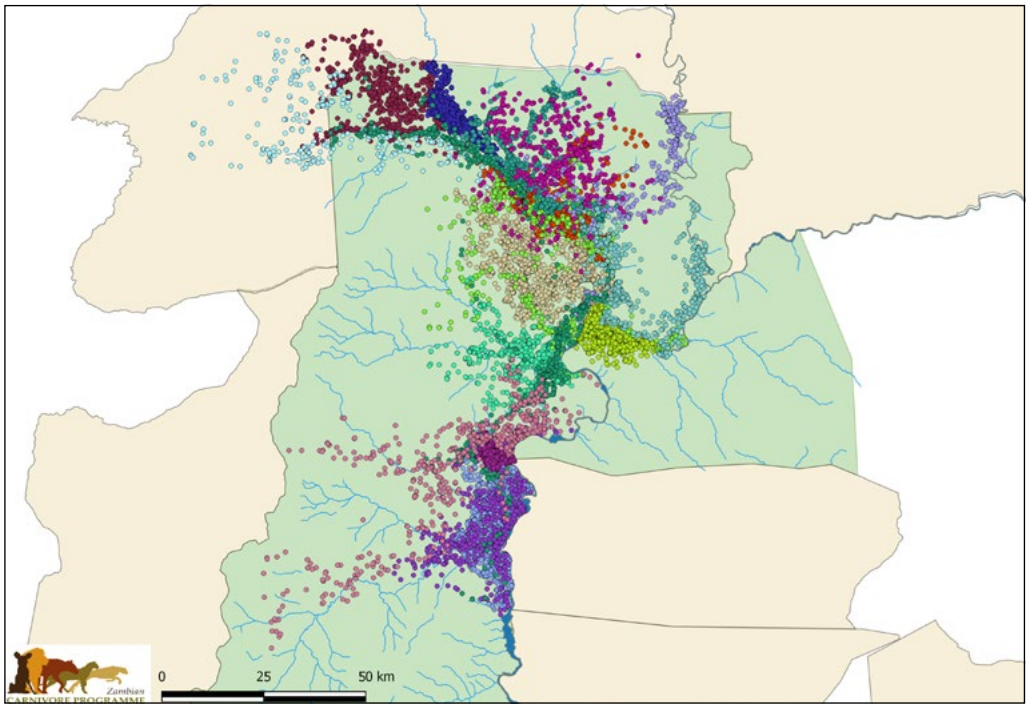
In the coming year we will begin to analyze our long-term cheetah demographic data from intensive monitoring and Citizen Science initiatives, and in collaboration with the DNPW and Panthera begin evaluating cheetah spatial data from the GKE and Liuwa to construct resistance layers to movement from human and ecological influences; these findings will in turn help to inform protection efforts for cheetah and for corridors and connectivity between populations in the Kavango-Zambezi (KAZA) Transfrontier Conservation Area and elsewhere.

Wild Dog

We continued our long-term intensive work on the Greater Kafue's wild dog population in 2018, completing our eighth year of work and monitoring 133 dogs in 13 packs throughout the system. An intensive field effort, satellite collar technology, a field-based wildlife veterinarian and effective citizen science programmes in collaboration with Panthera, DNPW, lodges and guides continued to improve our collective ability to monitor and conserve this key population.

Of particular importance this year was the development of a new collaboration with DNPW anti-poaching patrols supported by Panthera. Using the same model found to be successful in the Luangwa (see Conservation Action below), field teams regularly coordinated with DNPW-Panthera teams to provide carnivore data and help direct patrols to areas of high snaring and high use by dogs and other carnivores. The results indicate significant successes in that no snared dogs were reported in 2018 after multiple years of higher snaring by-catch.

Unfortunately Kafue dog populations were still subject to an array of negative human impacts. In July, despite efforts by ZCP and DNPW to contain it, we lost the Lushimba Pack to a disease outbreak suspected to be canine distemper, which rapidly killed all dogs in the pack in a



Locations from cheetah, wild dog and lion groups across Northern and Central Kafue in 2018.

The alpha female of Shishamba pack nursing her pups at the den.

matter of days. While distemper can break out naturally in wild carnivore populations, the Lushimba Pack regularly frequented areas near communities where contact with unvaccinated domestic dogs was likely, and anti-poaching patrols frequently encountered poacher's dogs throughout the GMA; thus domestic dogs likely pose a serious disease transmission threat to wild carnivores. Luckily, and perhaps owing to the low density of carnivores in the GMAs—we did not detect any additional disease outbreaks in any other carnivores in the area, but continued anti-poaching efforts coupled with domestic dog vaccination programmes are of critical importance to avoid a more catastrophic outbreak in the future. While the Lushimba pack was lost during the denning period overall it was a good year for dog reproduction, with all other monitored packs successfully denning and raising pups. In the coming year we will begin to analyze the long-term wild dog demography data to evaluate survival, reproduction and population trends, as well as the anthropogenic and ecological factors affecting them.

Given wild dogs require immense areas for viable populations we continued to document promising signs that the GKE serves as a large, connected population. In addition to our intensive work, several long range dispersals were recorded through the help of citizen science, such as two females from the Central Kafue's Chunga pack that ranged from their natal home-range all the way up to the Busanga plains where they were seen (77km). Other large dispersal events were also recorded such as a dog from the Ila pack that was last seen in 2016 near hook bridge, now seen in a breeding pack up near Kafue River lodge (64km). Similarly a member of the Mapunga Pack (natal range mapunga area) was seen down near Kasabushi with a new pack (43km). These not only highlight the importance of large landscape connectivity for wild dogs, but also the importance of citizen science and working closely with other stakeholders in the area to record these large-scale and long-term movements.

Lions and Hyena

Continuing work begun by the Kafue Lion Project in 2010, we completed our seventh year of long-term lion conservation, intensively monitoring 15 prides and 15 coalitions totaling 173 lions across Northern and Central Kafue in 2018. We added three previously unknown prides to our study this year, with lions in both the park and adjacent Game Management Areas (GMAs). Particularly exciting was the successful collaring of the Kasonso Pride, located in the remote Kasonso-Busanga GMA. This important area has been heavily depleted from poaching but has seen substantial investment and recovery through the work of Ntengu Safaris. Given the impacts of protection gradients on lions and other large carnivores, having intensively-monitored collared prides outside strictly protected areas is of key importance in both assessing human impacts on lion populations and in helping to mitigate lion deaths from poaching snares. In addition through the assistance of National Geographic's Big Cats Initiative we were able to support anti-snaring work through our partners DNPW and Panthera to target areas of high-snaring risk for big cats (see Conservation Action below).

Lion prey selection continued to consist primarily of mid-sized herbivores such as puku, impala, warthog and lechwe, with larger items such as buffalo not as prominent. While the GKE has a very diverse herbivore assemblage, the abundance and distribution of many species are significantly affected by poaching. While prey depletion from poaching is recognized as a serious threat to large carnivores, the actual impacts are complex and not well-understood, as depletion is not uniform across species and has an array of direct and indirect effects on herbivores and carnivores. As part of our assessment and recommendations on these issues we published a study in the Journal of Applied Ecology entitled "Changes in large carnivore diets over the past half-century reveal depletion of large prey." Using our long-term data on cheetah, lion, wild dog and leopard diets we

Mukambi River Pride feeding on a male puku.

compared these to a study by Mitchell et al. 1965 and found that large carnivore diets—particularly lions—had significantly fewer large prey items such as buffalo in the diet, which reflected changes in the abundance of such species as reflected in our herbivore surveys. The consquences of such diet changes from prey depletion are fourfold:

1. Lion pride sizes are likely to be smaller given the decreased amounts of food, particularly for cubs and younger animals
2. Lion energetics are likely to be altered as a consequence of reduced food intake
3. Competition between larger carnivores (i.e. lions and hyenas) and smaller subordinate competitors such as cheetah and wild dog is likely to increase with increased diet overlap, and
4. Snaring by-catch mortality of carnivores is likely to increase as snare sizes decrease to reflect the decreasing sizes of the target herbivore species available.

While snares for large herbivores such as buffalo typically do not catch carnivores, snares for mid-size to small antelope can easily entrap big cats, wild dogs and hyenas with devasting impacts. To further complement this study we are currently evaluating the dynamics of Kafue's preybase (see Herbivores section below) and utilizing long-term lion demography data to estimate survival, reproduction and population trends, as well as the ecological and anthropogenic factors affecting them. While hyena numbers continue to appear to be the lowest of all the GKE's carnivores, we nevertheless have identified and monitored 19 individual hyenas from five clans in 2018, with 44 animals monitored to date, and we are working to assist in the IUCN Redlist update for this important but poorly understood species.

Leopard

Despite being one of the two largest populations of leopards in Zambia there is little known about this threatened cat population in the Greater Kafue Ecosystem. We continued individual monitoring and camera-trap based work on leopard in Northern and Central KNP, while also collecting data on competing predators, prey and mesocarnivores. With 6 seasons of data collection completed we are now analyzing leopard density and survival, and evaluating the effects of ecological and anthropogenic factors on leopards, their competitors and prey.

We currently have 62 individual leopards in our database from this work spanning northern Kafue and the Musekese area, and will be collaborating with Panthera and DNPW to contribute to system-wide assessments of this important big cat population.

Herbivores

The GKE has some of the most diverse herbivore populations in Africa but is seriously threatened by depletion from poaching and the bushmeat trade, and this has an array of ecological and economic impacts. In 2018 we continued herbivore monitoring with the completion of our annual early dry and late dry season surveys, and we began evaluating the ecological and anthropogenic factors affecting the density and group size of ten species (impala, puku, warthog, common duiker, reedbuck, wildebeest, hartebeest, roan, waterbuck, and zebra). We published a study in the Journal of Applied Ecology entitled "Changes in large carnivore diets over the past half-century reveal depletion of large prey," that compared Kafue large carnivore diet data from 2012-2017 to a study from Mitchell et al. 1965 . Comparisons revealed concerning shifts in carnivore diets, particularly with lions, with small prey becoming much more prevalent in the diet than they were historically. Concurrent herbivore surveys demonstrated that larger species such as buffalo are now less prevalent and these dynamics have an array of consequences for lion group size and energetics, competition between smaller carnivores such as cheetah and wild dog, and increased susceptibility to snaring by-catch for carnivores as snare sizes decreases to reflect the body sizes of the preybase. Expanded herbivore monitoring into additional areas of the GKE is planned for 2019.

Large herbivores such as buffalo are of key importance to lions in Kafue and elsewhere and should be a focal point for herbivore protection and restoration efforts.

Greater Liuwa

Spotted Hyena

We completed the 9th year of our long-term studies of one of Greater Liuwa's apex predators, and its most abundant—the spotted hyena. With minimal competition from lions, an abundant preybase, and limited conflict with livestock and people, the Liuwa clans continued to exhibit high survival and reproduction as in previous years. One unique highlight was the birth of hyena triplets in the Mutata Clan, something previously unrecorded in our work. With most animals in the study now being of known age we continue to gain invaluable insights on the population dynamics of Liuwa's most abundant predator, as well as their impacts on competing predators such as lion, cheetah and wild dog, and on the herbivore communities, particularly the ecosystem's keystone species, the wildebeest (see wildebeest section below).

Members of Liuwa's South Clan interacting and playing with the cubs at a communal den.

Prior survey work and our long-term intensive studies in the southern portion of the ecosystem indicated a significantly lower population of hyenas in the northern portions of Liuwa; however the dynamics of the carnivore community in the northern and north-central portions of the park and the Upper West Zambezi GMA are still poorly understood. Consequently in 2018 we focused the bulk of our dry season carnivore monitoring work on the wildebeest winter range in these areas. We established a northern dry season base in the GMA to intensively monitor this area and the northern and central portions of the park to better quantify carnivore population dynamics, predation and competition in these areas. Furthermore in concert with the wildebeest work this base will help quantify the respective impacts of encroachment, poaching and other human barriers to wildebeest migration and carnivore dynamics in this important, unprotected area that forms the connection between Angola for the Liuwa-Mussuma Transfrontier Conservation Area.

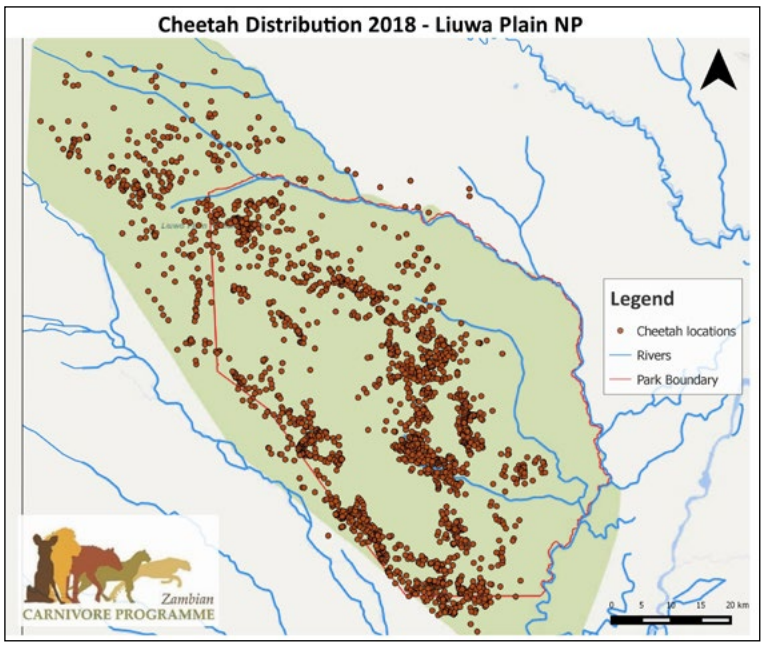
With hyena being the most abundant predator species in Liuwa, they have the strongest impact on wildebeest; however given the significantly lower predation pressure on wildebeest in their winter range there is increasing evidence that predation and predation risk effects may strongly influence why wildebeest migrate. With the new focus on wildebeest winter range in 2018 we have collected data on 3 newly discovered clans and monitored 281 animals in nine clans. Northern clans, as expected, are significantly smaller than those comprising our long-term studies in the

south. An increased emphasis on hyena dynamics in the wildebeest winter range in the park and GMA will be the focus of work for 2019, with more clans monitored.

Of the five large African carnivores (lion, cheetah, wild dog, leopard, hyena) all except the spotted hyena are species of concern due to increasing human impacts on their habitats and populations. Despite being as susceptible or more to the array of human threats facing the continent's big cats and wild dogs, hyena are currently listed by the IUCN as a species of Least Concern, likely due to lack of public interest and support for hyena conservation and a lack of data on hyena dynamics. Utilizing data from Liuwa and our other sites we hope to contribute to current efforts to bring attention and support to the plight of this unique and important top carnivore.

Cheetah

We continued long-term cheetah conservation work in 2018, collecting demographic, spatial and ecological data on the country's second-largest population through the monitoring of 15 cheetah in eight different groups across the Greater Liuwa Ecosystem. Three dispersal groups were able to be tracked with satellite-GPS collar technology and their movements increasingly support the possibility that the Liuwa population is transboundary with Angola, and underscore the critical importance of increased protections for the Upper West Zambezi GMA to allow for connectivity and protection of cheetah and their



Cheetah locations from 2018 continue to demonstrate the importance of the areas outside the national park providing critical habitat and connectivity.

preybase. The cheetah's diet continued to consist primarily of small antelope such as oribi and duiker, with wildebeest calves and scrub hare continuing to be important as well.

Liuwa cheetah continued to reproduce well in 2018. The two adult females that lost litters to severe floods in their denning areas in December 2017 bred again and gave birth to subsequent litters by the start of the dry season, with three cubs surviving to date. A three year-old dispersing female also denned in October and produced three cubs. While Liuwa's cheetah population obviously has adult males, prior to 2018 we had yet to detect any males that we had not monitored since birth, presumably due to their apparent shyness and wide-ranging behaviour. In July, Liuwa's first known male cheetah coalition was discovered, consisting of three animals. Two of the males are new to our study and the third is a young dispersing male from a May 2016 litter. The coalition is regularly seen and seems to stay in the park; collaring one of these males to enable large-scale monitoring of their movements and identification and evaluation of limiting factors and threats to Liuwa cheetah is high priority. In 2018, one of the dispersing females died from probable poaching—the second such animal in two years—and snaring continues to pose a threat for all wildlife in the ecosystem.

Liuwa's first known male cheetah coalition begins a stalk on a wildebeest herd.

Lion

Following a tumultuous year in 2017 where the Liuwa pride lost both its adult females Lady Liuwa and Sepo, the inexperienced, young animals remaining managed to survive and breed. Lioness 282 gave birth to a litter of three cubs, while her sister (lioness 281) already had three cubs that were born in November 2017. The two young sub-adult males born in 2017 survived with the pride for most of the year though occasionally ranging out by themselves and with the introduced Kafue male. The Liuwa pride at the end of 2018 was twelve lions strong and mostly utilized the central sector of the park before moving north in the late dry season and returning with the wildebeest migration to the south. Unlike the other carnivore populations, lions primarily remained on the woodland edges and woodland areas in the dry, likely owing to the difficulties in hunting wildebeest in the burned shortgrass plains comprising much of their winter range in the northern park and GMA. Such ranging has implications for lion diet selection in the dry season and potentially impacts on other herbivore species.

The four-year old Kafue male, translocated to Liuwa in 2016, remained inside the park for most of year, however in June he ranged out of the park and far into Angola, covering over 800 km, before returning to Liuwa for the remainder of the year. Toward the end of the year the male killed one of the pride's six-month old cubs. Such infanticide behaviour is not uncommon for lions, particularly for incoming males looking to breed with females in a pride.

Given the presence of cattle in and around the park such natural ranging behaviour, particularly for subadult and young adult males, will result in increased livestock conflict and necessitates increased attention to livestock conflict mitigation to adjust to a growing Liuwa lion population. Together with African Parks, the DNPW and the Barotse Royal Establishment, lion management plans that include significant livestock conflict mitigation efforts are underway and expected to be implemented in 2019.

Wild Dogs

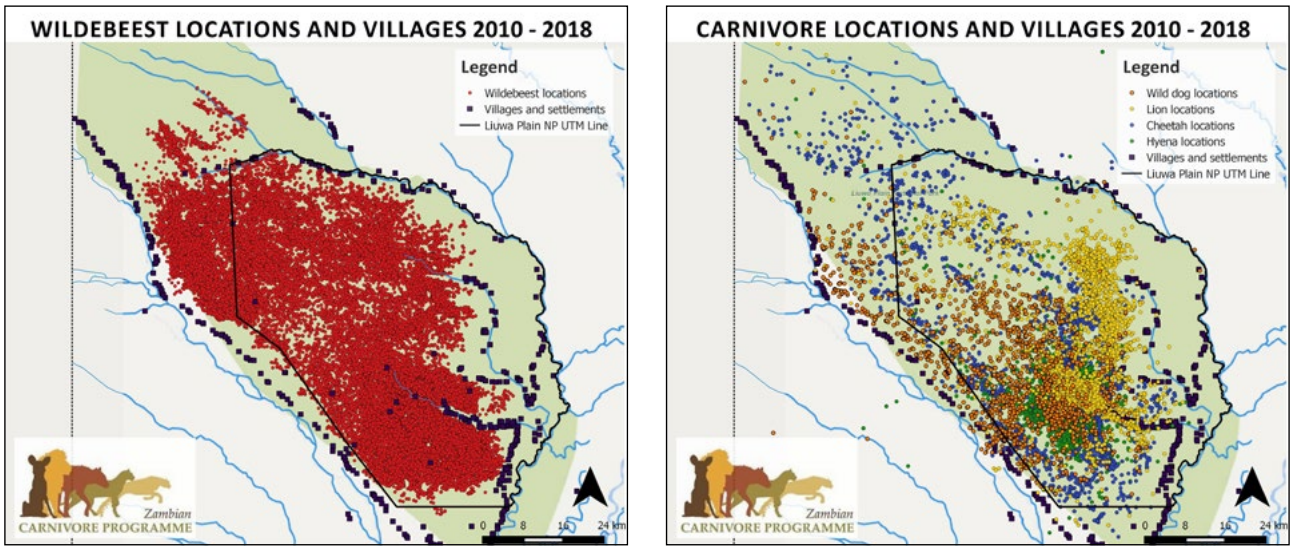
Wild dogs continued to remain absent from the southern portion of Greater Liuwa in 2018 but sightings continued to be reported in the more outlying areas, particularly in the north, but could not be verified. As a small recovering population in a grassland ecosystem dominated by a relatively homogenous (i.e. wildebeest) preybase, Liuwa's wild dogs were subject to increased competition from hyenas and lions and avoided areas of high lion use. While these dynamics limited wild dog populations, multiple rabies outbreaks in the domestic dog populations in and around Liuwa for the last four years continue to preclude the likelihood of new packs re-establishing in the park through dispersal or reintroduction. With the Liuwa human population increasing to 17,000, the domestic dog population is estimated to be between approximately 5400-7500 animals, most of which are currently unvaccinated and therefore a threat to both people, wildlife, and the economic value of Liuwa as a wildlife-based economy.

In late 2018 a meeting between African Parks, DNPW and all local Indunas and Chiefs was held to address this issue and recommend a way forward to re-establishing wild dogs in Liuwa through intensive vaccination programmes of the domestic dog population. The meeting resulted in strengthened partnerships between community leaders and partners and a commitment to restoring Liuwa's wild dog populations. While domestic dog vaccination will be of key importance, protection of the connectivity between LPNP, Upper West Zambezi GMA and the adjacent Mussuma area of Angola will be even more critical in maintaining populations of rare carnivores such as wild dogs and cheetah by allowing dispersal, population exchange, and recolonization of areas should disease or other threats reduce local numbers. In 2019 teams will continue to survey remote areas in northern Greater Liuwa to document wild dogs and are working with African Parks and DNPW to develop a wild dog management plan for the ecosystem.

Herbivores

The continuation of our collaborative long-term wildebeest work led us to completion of our seventh season of intensive research work with the monitoring of 34 radio-collared adult female wildebeest and their calves across the GLE. Demographic and spatial data was collected through intensive monitoring of collared females tracked throughout the year, with 800 locations and over 900 herd composition counts conducted in addition to fine-scale spatial data from GPS and satellite telemetry. As a continuing result of carnivore recovery in Liuwa, the wildebeest population continued to be strongly limited by the growing predator populations with very high survival and reproduction and a high kill rate (sometimes 4-5 kills per night).

With the 2018 season we also completed our first analysis of factors limiting wildebeest demographic recovery. While there are numerous ideas as to what may be limiting GLE wildebeest populations—and this in turn impacts the management and conservation actions prescribed—our data and analyses provided the



Wildebeest (Left) and Carnivore locations in the GLE indicating extensive use of the ecosystem well beyond the protected area boundaries for wildebeest. Migration outside the southern area of the park is thought to be in part driven by an avoidance of predation during the winter and calving periods. Village locations also indicate high potential for transmission of rabies and other diseases from unvaccinated domestic dogs.

first rigorous evaluation of wildebeest dynamics in the GLE, and one of the first individual-based long-term demographic study of wildebeest in general. Migratory herbivores are significantly more abundant than resident populations across the earth's ecosystems; while the factors driving migrations are poorly understood, across Africa and the world migratory populations suffer severe declines when their migrations are impeded. Migratory behaviour is poorly understood but is thought to be related to resources and predation, and understanding these factors has been identified as one of the critical knowledge gaps for conservation of the world's remaining ungulate migrations.

Analyses of Liuwa wildebeest survival demonstrated a strong effect of age (expected in these long-lived species), but also variable survival depending on if they were in the high or low predator density areas, where survival was lower and higher respectively. Migration at the end of the rains out of the park to the northwest and northcentral portions of the GLE, is where predator density is substantially lower. Thus predation and predation risk effects are likely strong drivers in wildebeest migration, and we are increasingly compiling evidence in support of this. The conservation relevance for these findings is that increased protection of the Upper West Zambezi Game Management Area is perhaps the most critical need for protection of the GLE's keystone wildebeest herds, the predators depending on them, and the persistence of a wildlife-based economy in and around Liuwa Plain National Park. Elimination of these key wintering grounds outside the park is likely to result in severe declines of wildebeest should they be forced to become resident.

With the completion of our first demographic analysis our focus is now on quantifying the impact of flooding and fire and wildebeest movements. Because of all the ecological (predation, predation risk effects, flooding, fire, vegetation, competition, etc.) and anthropogenic (encroachment, poaching, etc.) factors affecting movements and migration it is critical to have data across a range of each variable over a time series (for example capturing drought years and years of above average rainfall).

Predation and Predation Risk Effects

A fundamental aspect of all ecosystem functioning is predation, and almost all species face some form of it. While direct predation—or killing by predators—is typically the focus of predation studies on ecosystems, the presence of a predator can also influence the behavior, habitat selection, nutrition, reproduction, and ultimately the fitness of a prey species. These "predation risk effects" are increasingly studied, and their presence has been well-demonstrated by a multitude of experiments and some field studies, but little is known about their importance for conservation and management in African ecosystems.

Our long-term conservation work of both large carnivores and large herbivores has provided a good platform for evaluating the importance of predation and predation risk effects, and a multitude of investigations under the direction of Dr. Scott Creel and with the support of the National Science Foundation have been conducted and are ongoing. In 2018 we produced four peer-reviewed studies on predation and predation risk effects and their relevance for conservation and management. The first study by Dr. Creel, entitled *"The Control of Risk Hypothesis: Reactive vs. proactive anti-predator responses and stress-mediated vs. food-mediated costs of response"*, developed the Control of Risk Hypothesis. This hypothesis predicts that proactive responses to predictable and controllable aspects of predation risk generally have costs that relate to nutrition and access to food, while reactive responses to predation risk generally have costs related to stress.

The second study, entitled *"What explains variation in the strength of behavioral responses to predation risk? A standardized test with large carnivores and ungulate guilds in three ecosystems"* looked at the relationship between anti-predator responses and direct predation with ten herbivore species and five large carnivore species across three ecosystems. The study found no relationship between the amount of direct predation a prey species receives and the amount of anti-predator response it exhibits, and it found responses were best predicted by whether an herbivore was a browser/mixed feeder, indicating potential trophic cascades with these species in the absence of large carnivores.

The third study, entitled *"Response of wildebeests (Connochaetes taurinus) movements to spatial variation in long term risks from a complete predator guild"*, looked at how wildebeest respond to variable predation pressure across the landscape, with animals moving slower and being more vigilant in areas of high predation risk. The fourth study also looked at wildebeest and was entitled "Foraging investment in a long-lived herbivore and vulnerability to coursing and stalking predators." Using measures of tooth wear of adult wildebeest predated by coursing (hyena and wild dog) and stalking (lion) predators, the study found differential investment in foraging and subsequent suspectibility to these different predators within and across bull and cow wildebeest.

Collectively this work built on our existing understanding of predation and risk effects and how they impact ecosystems. In an era of rapid, human-induced ecological change the loss—and in some cases the restoration—of large carnivores and large herbivores will have considerable ecological impacts that we are still trying to understand.

Conservation Action

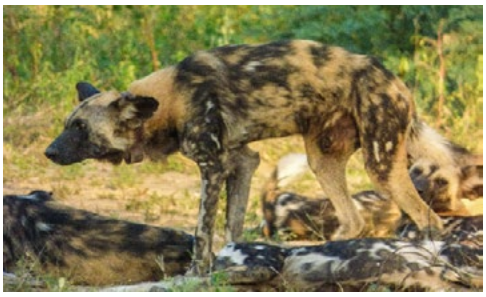
Anti-Snaring

Bushmeat poaching with wire snares continues to pose one of the greatest threats to large carnivores in Zambia, both in its impacts on prey populations, and in snaring bycatch of wild dogs, big cats and hyenas. In addition ZCP-DNPW research indicates that prey depletion is not likely to be uniform, but rather impacts the larger species first, resulting in a progressive decrease in snare sizes to target increasingly smaller herbivore species. While larger snares for buffalo and other species are unlikely to pose as much of a threat for large carnivores, smaller snares are much more likely to catch, maim, and kill. In addition in 2018 we found the first evidence of snares designed to catch big cats, presumably for the illegal skin and parts trade (see Wildlife Crime). Collectively snaring can have severe impacts on ecosystems, and as a consequence our collaborative anti-snaring programmes comprised a central component of our work.

In the Luangwa we continued to work with Conservation South Luangwa (CSL) and the DNPW to mitigate snaring by-catch through intensive monitoring of collared wild dog and lion groups through ground, aerial and satellite/

How Much Is One Dog's Life Worth?

At Least 10 Additional Packs formed from Dispersing Offspring



Packs have populated throughout the Luangwa Valley

WILD DOG 73
Rescued from a lethal snare in 2014

At least 136 pups, grand-pups and great-grand pups

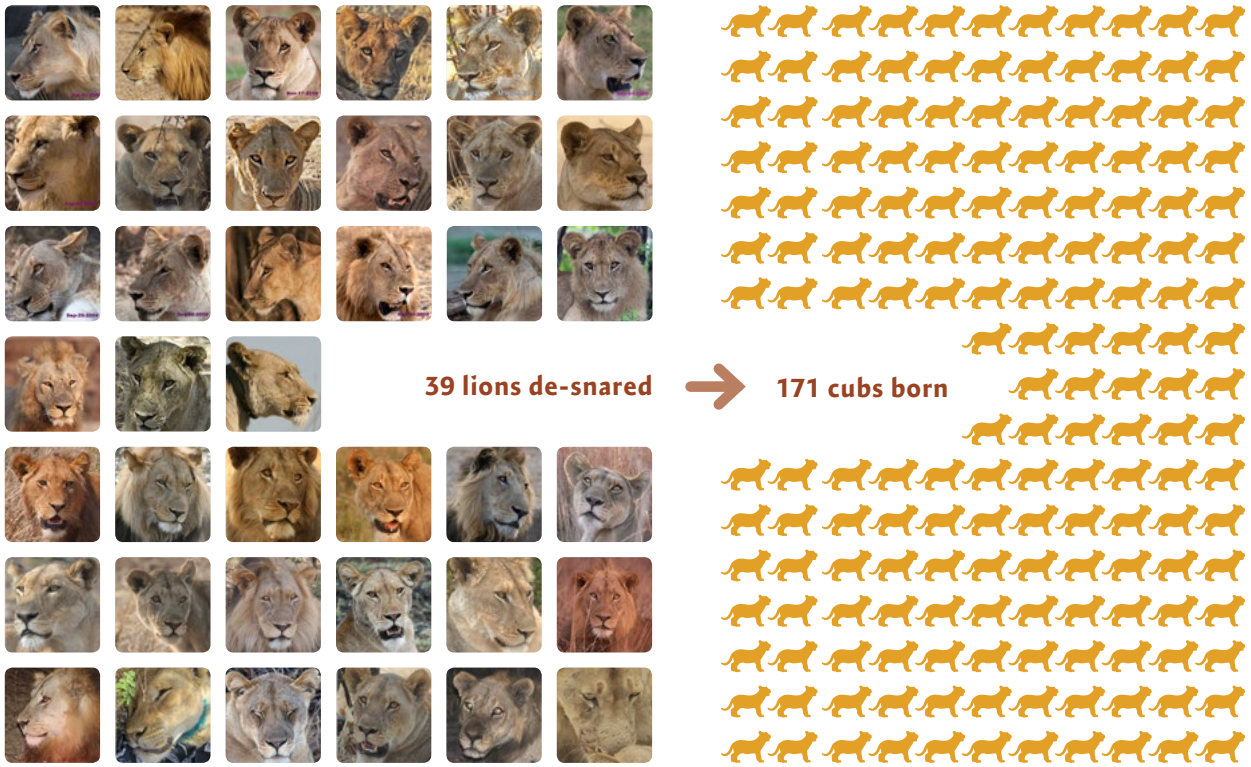
The oldest known dog in the wild was 12 years of age. The Hot Springs Pack's alpha male was born in 2006 at the latest, making him over 12 years old when he died in 2018. As alpha male his pack endured severe snaring impacts and he was dying from a snare himself but was rescued by the collaborative work of ZCP, CSL and DNPW. His legacy is found in all the dogs populating the Luangwa with ties to the Hot Springs pack, and his life is a testimony to the value of this work.

ZCP and DNPW teams de-snare a lethally-snared lion in the Luangwa. Shortly after the lion was recovered and mating (Right).

GPS tracking, coupled with data-directed anti-snaring patrols, field-based veterinarians. DNPW-ZCP teams intensively monitored 185 dogs in 13 packs, as well as 215 lions in 19 prides and 17 coalitions in 2018, logging over 1200 person days in the field. Five wild dogs, three lions, and 1 hyena were snared, with four wild dogs, 2 lions and 1 hyena successfully darted and rescued by ZCP/CSL and DNPW Wildlife Veterinarians. The data collected by field teams was also provided daily to anti-snaring teams which targeted areas of high risk and high use by large carnivores, and this support assisted in the removal of 478 snares. Despite the high snaring year, 2018 ended on a high note with the Luangwa wild dog population still remaining at record highs, and now estimated to be the country's largest population.

Similarly in the Kafue we adopted the successful Luangwa model in working with the DNPW and Panthera and their newly-formed anti-poaching units, as well as with anti-poaching units with Musekese Conservation and Ntengu Safaris. Field teams intensively monitored satellite collared groups of wild dogs, cheetah and lions across

Population effects from snared lion rescues



Demographic impacts of de-snaring on lions in the Luangwa and Kafue projects. Such collaborative work is greatly facilitated by radio collars allowing for frequent detection and monitoring of prides and desnaring.

northern and central GKE, and provided these data to the anti-poaching units that would then target these areas of high risk and high use for snare removal and other anti-poaching work. The results of this work are extremely promising, with no confirmed reports of snared carnivores in 2018, and one lion treated for an old snare injury—a testament to the need for increased anti-poaching resources in the GKE to combat bushmeat poaching impacts.

A dog from the remote Mupamadzi pack is de-snared by ZCP, DNPW and CSL teams. We de-snared dogs from four packs in 2018, most of which would never have been detected without intensive monitoring.

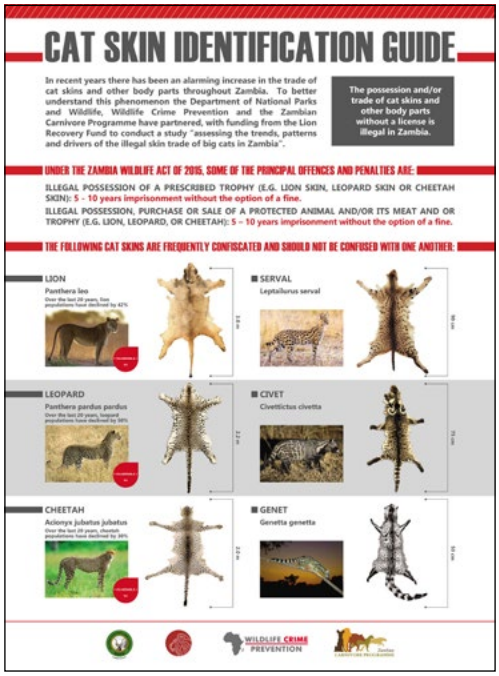
Wildlife Crime and Trafficking

The majority of anti-trafficking work in Zambia rightfully focuses on ivory, bushmeat, and pangolins; however there is increasing evidence of an alarming rise in the trafficking of big cat skins, bones and body parts across the range states for these species. Unfortunately very little is known about the drivers of the trade itself, as well as its routes, dynamics, and impacts on already imperiled populations of top carnivores. Without good knowledge of the source populations for this trade effective law enforcement and protection efforts are hampered, and currently there are no available means for authorities to trace trafficked big cats to their source populations.

In 2018 we continued work with the DNPW and Wildlife Crime Prevention (WCP) to evaluate the origins and impacts of illegal trade in big cats in the region, and to assist in anti-trafficking efforts . After training all 39 Intelligence and Investigations Units in sample collection and identification in 2017, we are now undertaking genetic analyses of these samples in combination with over a decade of genetics data from our long-term studies. Given how rapidly the field of conservation genetics is developing and the large combined ZCP-DNPW datasets for big cats in Zambia, we are currently training a DNPW Ecologist, Clive Chifunte (see Graduate Students), to serve as a genetics specialist for the Department. Clive will be conducting his Master's Degree research on leopard and lion genetics in Zambia with ZCP, looking at an array of questions on both species relevant to their conservation.

In November 2018 ZCP was invited to attend the Lion Traceability Meeting in Pretoria, South Africa to address anti-trafficking efforts. The meeting brought stakeholders from key lion range states in Eastern and Southern Africa and called for the urgent development of genetic systems for lion traceability to be used by law enforcement.

In 2019 we are continuing to work with DNPW, WCP, CSL and other partners in anti-trafficking efforts, and we are planning additional work with our new partner TRACE, to assist government in developing in-country genetics and forensics capacity for effective prosecution of big cat trafficking.



Intelligence and Investigations Units from DNPW get trained on sample collection from trafficked cats.

Large Landscape Conservation

Zambia lies between Eastern and Southern Africa, borders 8 countries, contains multiple transfrontier conservation areas, has large tracts of connected and unfenced protected area networks and is the source of important watersheds such as the Zambezi and Luangwa. Consequently it could be considered the Crossroads of Connectivity and large landscape conservation. Large carnivores require vast amounts of space to persist, given that they are naturally low density and wide-ranging, and thus the connection between large carnivores and large landscapes drives the array of initiatives we continued to contribute to in 2018.

Our long-term intensive studies of wild dogs, cheetah and lions continued to demonstrate landscape scale movements through dispersal and ranging, with animals regularly moving between national parks and Game Management Areas and traveling across large distances up to several hundred kilometres—even across borders in the case of Liuwa Plain.

We continued to work with partners to collaboratively protect and promote the Kavongo-Zambezi (KAZA) TFCA with Kafue, attending multiple conferences and meetings on this work in both Livingstone and the Kafue as part of the Kafue Carnivore Coalition led by Panthera and DNPW. In addition we continued to contribute with DNPW and African Parks to the advancement of the Liuwa-Mussuma TFCA between Zambia and Angola, with our long-term carnivore and wildebeest data supporting the need for increased protection of the Upper West Zambezi GMA that provides key connectivity between the countries.

In January ZCP attended the IUCN's Transportation Working Group meeting in Kenya to discuss issues of linear infrastructure such as roads and dam development on ecosystems. We also continued to assist WWF-Zambia and partners in promoting additional protection for the Luangwa River and watershed and began a new initiative in collaboration with WWF on the Upper Zambezi watershed, focusing in particular on the Liuwa and Kabompo watersheds. We continued and expanded human encroachment analyses in our focal ecosystems and began collaborative data collection to construct climate change models able to assess various scenarios of change across these areas.

ZCP's Thandiwe Mweeta (R) and Kachama Banda (2nd from left), and CSL's Billy Banda meet with a farmer in the Luangwa to discuss lion conflict.

Human-Carnivore Conflict Mitigation

Prior ZCP-DNPW work across our study sites indicated that human-carnivore conflict was not a primary issue facing carnivores and communities, largely due to the lack of livestock in the Luangwa and Kafue, and to effective husbandry techniques in Liuwa. However changing human demographics in the Luangwa have resulted in increasing numbers of cattle, goats and pigs in several chiefdoms, and a subsequent increase in lion conflicts with livestock. Similarly a growing lion and human population in Liuwa has resulted in the need for increased human-wildlife conflict (HWC) mitigation programmes.

With support from the Lion Recovery Fund in 2018 we are implementing a HWC mitigation programme in the Luangwa in collaboration with Conservation South Luangwa and the DNPW, aimed at reducing lion conflicts with livestock in the chiefdoms surrounding South Luangwa National Park. In addition we are working with African Parks and the DNPW to help mitigate HWC from lions and livestock in Liuwa Plain.

To assist in the development and implementation of these programmes in 2019 we will also be utilizing the skills and experience of two conservation organizations specializing in human-lion conflict mitigation, namely the Ruaha Carnivore Project and Lion Guardians.

Disease Control and Mitigation

Given people and domestic animals inhabit much of Zambia's Game Management Areas, and some of national parks like Liuwa Plain, disease transmission between domestic and wild carnivores is a continual concern. In Kafue's Kosonso Busanga GMA we documented a disease outbreak suspected to be canine distemper that resulted in the deaths of multiple wild dogs in a resident pack, and in Liuwa outbreaks of rabies in the domestic dog population in and around the park continue to threaten communities and large carnivores.

In the Luangwa we continued with vaccination, spaying and neutering work through CSL/ZCP vet Dr. Mwamba Sichande, who operates a clinic at the CSL base and works with DNPW and Veterinary Department vets and personnel to conduct vaccinations across much of the South Luangwa area. In Liuwa we continue to work with African Parks, DNPW, and the Barotse Royal Establishment to mitigate the increasing threat of rabies from unvaccinated domestic dogs throughout the area, both to protect communities and their livestock, and to assist in the re-establishment of wild dogs from northern Greater Liuwa to the south, following rabies outbreaks from 2014-2018. In Kafue there is a need for vaccination programmes in the GMA communities and we are currently seeking options for supporting these activities.

Conservation Capacity

Primary and Secondary School Programmes

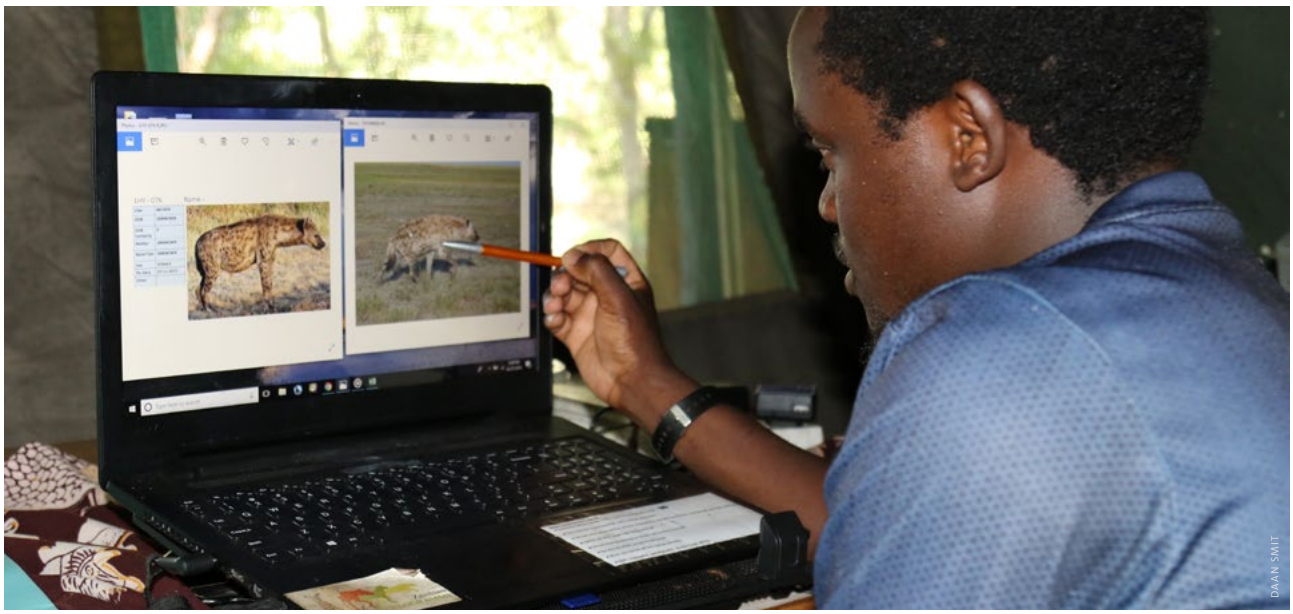
We continued to expand our secondary and primary school programmes in 2018, with the work collectively emphasizing our multiple objectives of student engagement and education in conservation issues, 'adventure-based learning' programmes with students conducting their own field research, and the acquistion of key skills in technology, computer literacy, and critical thinking, writing and public speaking. In concert these objectives helped equip students for advanced education and employment following graduation. We conducted 60 school programmes to 1120 students across our three project sites.

In the Luangwa, in collaboration with Chipembele Wildlife Education Trust, we continued intensive work with 35 students from Mfuwe Day Secondary School's Conservation Club, conducting 31 programmes using science as a means of generating interest in conservation and acquiring key vocational skills. The overall theme of the 2018 Chipembele Conservation and Chongololo Club lessons was raising awareness about aquatic ecosystems of the Luangwa River and their importance to people and wildlife; thus we designed our science-based learning project around these topics. Starting in Term 2, the Mfuwe Day Secondary School Conservation Club students got the opportunity to learn more about river systems and how they impact species diversity and distribution. With particular focus on the Luangwa River—one of Africa's last remaining free flowing rivers—the students conducted a field research project to explore the effect of seasons and the physical characteristics of rivers on wildlife density and diversity in an area. Throughout 2018, the students visited two

ZCP Luangwa and Chipembele teams work with students to collect field data as part of their research projects.

Students from Mfuwe Conservation Club present their research to Mambwe High School.

ZCP Liuwa's Shadrach Mwaba (second from right) and members of the Mishilundu Conservation Club prepare for Debate practice.



Former ZCP Conservation Club graduate and Conservation Biologist Trainee Peter Musenge identifies hyenas as part of his training in demographic studies.

different sites along the Luangwa River and collected wildlife data using camera traps, observation and other tracks and signs. Data analysis and presentation will occur in Term 1 of 2019.

In Liuwa we conducted 9 programmes to 21-60 students each, primarily at Mishelundu High School with their newly-created Conservation Club. We introduced students to an array of local and global conservation issues while engaging them in the work and activities ranging from debate, to quizzes and informative presentations on the Liuwa ecosystems and careers in conservation. For two outstanding Conservation Club volunteers—Muyenga Muyenga and Hellen Pelekelo—we provided an exclusive visit to ZCP to have volunteers help conduct our work for five days. Muyenga and Helen were taught about carnivore and herbivore research and monitoring methods such as radio tracking, den observations, individual identification and research ethics and also enjoyed a night out camping with the teams in the park. We hope to broaden these programmes in 2019 and continue to mentor outstanding students for careers in conservation. ZCP Ecologist Shadrach Mwaba, together with three graduates of ZCP Conservation Club Programmes who now work for ZCP as part of the research team (Dean Banda, Peter Musenge, and Kings Chimungu) organized all activities and presentations for the club.

In the Kafue we conducted 16 programmes to 312 students visiting our partner Treetops School, while continuing to develop programmes with Chunga School in Central Kafue for more intensive work similar to the other sites. Students learned the value of carnivore conservation, ecology, and the impacts of humans on ecosystems, as well as the benefits of wildlife-based economies. In addition students also learned about conservation biology methods such as radio-tracking, counting and identifying animals, and got to search for carnivores as part of the ZCP study work.

Citizen Science

Individuals of all large carnivore species we study are easily identifiable by their markings, and given that they are often very wide-ranging and not always easily observed, collaborations with safari guides to collect sightings data are extremely valuable. We continued our long-term Citizen Science programmes in the Luangwa and Kafue in 2018, working with safari guides as part of the Luangwa Valley Carnivore Monitoring Programme (LVCMP) and the Kafue Carnivore Coalition (KCC) respectively. In the Luangwa all lodges had guides participating in the programme and submitting photos and sightings data on a regular basis to field teams, in addition to reporting any sightings of snared animals. Similarly in the Kafue, KCC guides from all camps regularly submitted their data to ZCP or Panthera, as they jointly coordinated the efforts and managed the data. Award ceremonies for outstanding contributers were again held at both sites following the season, with continued and expanded work in both ecosystems planned for 2019.

Community-Based Education

As part of our community conservation initiatives in 2018, we conducted a variety of community engagement, outreach programs and events that were targeted at district, provincial, national and international audiences.

ZCP Field Researcher Benny Mwila (top left) poses with the Mimulu Boys football team. Benny now manages the team's activities while founder Henry Mwape is in graduate school.

ZCP Carnivore Conservation Cup and CSL Community Fun Run

Together with our partner Conservation South Luangwa (CSL) we held our Third Annual Carnivore Conservation Cup Football Tournament in concert with the long-standing CSL Community Fun Run. The Tournament was multiple weeks long beginning at the chiefdom level and culminating with the championship and Fun Run.

Organised in partnership with Community Resource Boards (CRBs) from the Mnkhanya, Nsefu, Jumbe and Kakumbi chiefdoms, we reached over 5000 people through the chiefdom level matches and the cup final.

Concurrently with the tournament we worked with the local theatre group SEKA (Sensitisation and Education with the Kunda Arts) to develop and present plays highlighting ZCP-DNPW-CSL collaborative conservation work, as well as various issues regarding carnivore conservation. These plays were performed throughout the events at the chiefdom level and during the championship.

ZCP Ecologists Henry Mwape and Thandiwe Mweetwa conduct their monthly hour-long conservation radio show on Breeze FM, reaching all of Eastern Province on an array of issues and discussions.

General Outreach

In 2018, our engagement and outreach programs and events targeted both domestic and international audiences. Locally, we held meetings with community resource boards in Jumbe, Nsefu, Kakumbi and Mnkanya chiefdoms to discuss how to collaboratively address issues such as wire snaring and the growing human-lion conflict (see Conservation Action). We also met with Chief Kakumbi and over 40 traditional leaders in the chiefdom on the impact of wire snaring on wild dogs and other carnivores. With support from Dazzle Africa, Mimbulu Footbal Club—initiated by ZCP's Henry Mwape and continued by ZCP's Benny Mwila—participated in the local league and other conservation-themed tournaments. The team used these opportunities to raise awareness about carnivore conservation and general environmental protection throughout the district.

Regionally ZCP, in partnership with CSL, participated in the annual district and provincial Agricultural and Commercial Shows in Mambwe and Chipata respectively. From April to December, we conducted radio programs focused on carnivore conservation through Breeze FM radio station in Chipata. The monthly live phone-in program covered topics such as the role of research in conservation, threats to top predators, citizen science, human-wildlife conflict and community-based conservation. The program, which was broadcast throughout Eastern Province to tens of thousands of listeners, was very well received.

On a national level ZCP was invited to attend the inaugural conservation careers fair in Lusaka and we reached over 500 students from universities and colleges across Zambia. We also shared our work through presentations and talks to diverse audiences which included primary school pupils, the general public, tourists, safari guides, government officials, traditional leaders, journalists and international conservation organizations. ZCP was included in the final video shown to the UN as part of the The People's Seat campaign on climate change, and we participated in an array of international media (see Media and Special Events).

ZCP Conservation Club programme graduate and Conservation Biologist Trainee Lameck Sakala monitors an immobilized wild dog

Women in Wildlife Conservation Programme

We made significant progress in 2018 training and assisting women interested in pursuing field-based conservation careers through our Women in Wildlife Conservation programme. Under the mentoring of ZCP Education Manager and Ecologist Thandiwe Mweetwa, we rapidly expanded the programme, attaching five women to our Luangwa Project, where they received intensive training in all aspects of field research and monitoring and educational and community outreach. With multiple female researchers at all sites, we will be expanding the programme in 2019 to include Liuwa and Kafue and will continue to seek support for secondary school level programmes across all sites to provide additional mentoring and training to aspiring female conservation biologists.

Conservation Biologist Training Programme

The unique long-term field-based conservation programmes continued to provide a wealth of training opportunities for aspiring local conservationists recently graduated from secondary school and aspiring toward advanced education or recent university graduates looking to supplement their education with field-experience.

Consequently ZCP expanded its ongoing Conservation Biologist Training Programme

Former ZCP Conservation Club Graduate (top) and Wildlife Vet Programme Trainee Kings Chimungu working in Liuwa (bottom) and as an attachment to the local vet clinic at the University of Zambia as part of his vet nurse degree (right).

aimed at equipping incoming students with the theory and practice behind research as well as with practical field skills. Students underwent intensive training in the theory and practice of ecological research, as well as hands-on training in Land Rover and motorbike servicing, repair, recovery and 4x4 driving skills. In 2019 we will be upscaling our efforts to signifcantly increase our trainee attachments at across all sites.

Wildlife Vet Training Programme

Training continued for aspiring Zambian wildlife veterinarians and vet nurses on all sites, with two vet students and one vet nurse student receiving intensive instruction from ZCP, CSL, and DNPW's wildlife vets and field staff on wildlife immobilization techniques as well as fundamental information on each species' ecology, physiology and behavior. Trainees attached to the programme during their term breaks in school and will continue to do so in 2019 with additional trainee attachments planned.

Professional Training and Advanced Education

In addition to working closely with DNPW in on all aspects of our work we also continued to support professional training and advanced educational opportunities for DNPW Research staff and Wildlife Police Officers. We continued supporting Kafue Wildlife Police Officer Charles Kalambata's extended studies in wildlife and natural resources managment through Livingstone International University. We supported DNPW Kafue wildlife veterinarian Dr. Libakeng Nibewa to attend a course in wildlife capture and chemical immobilization in Zimbabwe. We continued to have attached or seconded at least one scout on each project who worked as a full time field team member.

DNPW's Charles Kalambata radio-tracks for carnivores in the Kafue in between university breaks.

We also continued to support local Mfuwe student George Phiri in his education at Southern Africa Wildlife College, where he completed an Advanced Certificate in Transfrontier Conservation Area Management. George was also elected Class President and again graduated with honors while garnering Best Student in Financial Management and being elected Graduation Speaker.

In late 2018 ZCP Liuwa Ecologist Shadrach Mwaba was one of 12 students selected worldwide for the Postgraduate Diploma in International Wildlife Conservation Practice at Oxford University's Wildlife Conservation Research Unit (WildCRU). Shadrach will attend the 10 month course in 2019 to supplement his substantial field experience and schooling. Shadrach follows fellow Liuwa Ecologist Teddy Mukula who was selected and completed the course in 2017 (see Graduate Students).

Graduate Students

Given the diversity and abundance of both large carnivore populations and threats facing them, highly-skilled conservation biologists with a wealth of field experience and education are extremely important to help guide science-based conservation in Zambia and the region. Consequently we invest heavily in graduate education.

ZCP Liuwa Ecologist Shadrach Mwaba in the field studying hyena before heading to Oxford University in 2019.

In 2018 Fulbright Scholar Henry Mwape began his Master's research with ZCP at the University of Arizona (UA). Under the mentoring of ZCP Researcher and UA professor Dr. David Christianson, Henry is evaluating long-term Luangwa lion spatial dynamics from 2008-present, across gradients of protection.

We also began working with DNPW Ecologist Clive Chifunte to evaluate leopard and lion dynamics in Zambia. With long-term projects and a wealth of genetic samples, Clive will be working with Dr. Goran Spong and Dr. Scott Creel at the Swedish Agricultural University. Returning from his Oxford course he completed in 2018 (see preceding section), ZCP Liuwa Ecologist Teddy Mukula is also slated to begin his Master's research on Liuwa cheetah with Dr. Creel at Montana State University within the year.

ZCP Luangwa Ecologist and Education Coordinator Henry Mwape (R) helps de-snare a wild dog. A Fulbright Scholar and WCN Scholar, Henry is currently conducting his Master's research on lions with ZCP at the University of Arizona.

DNPW Ecologist Clive Chifunte will be working with ZCP on leopard and lion genetics as part of his Master's research at the Swedish Agricultural University in Umea.

National Geographic photographer Shannon Wild photographs Kafue lions with ZCP Kafue Project Manager Ben Goodheart.

Shannon Wild and National Geographic photograph ZCP and DNPW teams as part of the NGS-Gemfields shoot.

ZCP Ecologists Henry Mwape and Thandiwe Mweetwa on National Geographic's Expedition Raw.

ZCP-DNPW-AP Liuwa team conduct hyena work with Dutch television.

Media and Special Events

We increased our media and outreach production in 2018, beginning with the launch of our new website.

We collaborated on a number of feature films on our collective work: in the Luangwa we worked with the National Geographic Explorer Series to feature NGS Explorer and ZCP Ecologist Thandiwe Mweetwa's collaborative conservation and education work; in Kafue we worked with National Geographic photographer Shannon Wild and Gemfields to produce a short film on our collaborative work, and we saw the release of a feature film on our DNPW-ZCP Kafue work entitled Guardians of the Wild: Carnivore Rescue, in the USA and UK.

In Liuwa we worked with Dutch television to feature ZCP Liuwa Manager Daan Smit and our collaborative work with African Parks and DNPW in the "Heroes of the Wild" series viewed by over 11 million people.

Thandiwe Mweetwa continued to garner awards for her work and leadership: she was selected for the Obama Foundation Leaders Africa Program, as one of 200 people out of over 10,000 applicants. She also attended the Wings WorldQuest Women of Discovery Awards in April 2018 to accept her award in recognition for her contributions for world knowledge and science through exploration. Thandiwe also was a guest speaker at the Wildlife Conservation Network Expo in 2018 and attended with fellow ZCP Ecologist and graduate student Henry Mwape.

The Science of Conservation

ZCP Scientific Publications for Policy and Management

Given that the strongest measure of the validity of science-based management and conservation recommendations is publication in peer-reviewed scientific journals, ZCP endeavors to ensure that findings and recommendations undergo this process as much as possible. We work with a variety of collaborating agencies, organizations, and institutions to accomplish this, and to ensure that these findings and recommendations are provided to managers and policy makers to help drive science-based conservation outcomes. To date ZCP has contributed to an array of scientific papers to provide science-based guidance on topics ranging from poaching, demography, and predator-prey dynamics, to large landscape conservation, genetics, disease, trophy hunting, fencing, community conservancies, land-use planning and human encroachment.

Rosenblatt, E., S.Creel, P.A. Schuette, M.S.Becker, D.Christianson, E.Droge, T.Mweetwa, H.Mwape, J. Merkle, J.M'soka, J. Masonde, and T.Simpamba. In Review. **Do protection gradients alone explain changes in herbivore densities? An example with four ungulate species in Zambia's Luangwa Valley.** Biodiversity and Conservation

Creel, S., M.S.Becker, E.Droge, J. M'soka, W. Matandiko, E. Rosenblatt, T. Mweetwa, H. Mwape, M. Vinks, B.Goodheart, J.Merkle, T.Mukula, D.Smit, C. Sanguinetti, C.Dart, D. Christianson, and P. Schuette. 2019. **What explains variation in the strength of behavioral responses to predation risk? A standardized test with large carnivore and ungulate guilds in three ecosystems.** Biological Conservation. https://www.sciencedirect.com/science/article/abs/pii/S0006320718315118

Droge, E., S.Creel, M.S. Becker, D. Christianson, and J. M'soka. 2019. **Response of wildebeests (*Connochaetes taurinus*) movements to spatial variation in long term risks from a complete predator guild.** Biological Conservation. https://www.sciencedirect.com/science/article/abs/pii/S000632071830226X

Christianson, D., M.S.Becker, S. Creel, A.Brennan, E.Droge, J.M'soka, T.Mukula, P.Schuette, D.Smit, and F.Watson. 2018. **Foraging investment in a long-lived herbivore and vulnerability to coursing and stalking predators.** Ecology and Evolution. https://onlinelibrary.wiley.com/doi/full/10.1002/ece3.4489

Creel, S. **The Control of Risk Hypothesis: Reactive vs. proactive anti-predator responses and stress-mediated vs. food-mediated costs of response.** 2018. Ecology Letters. https://onlinelibrary.wiley.com/doi/abs/10.1111/ele.12975

Creel, S., W. Matandiko, P.Schuette, E.Rosenblatt, C. Sanguinetti, K.Banda, M.Vinks and M.S.Becker. 2018. **Changes in large carnivore diets over the past half-century reveal depletion of large prey.** Journal of Applied Ecology https://besjournals.onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.13227

Mweetwa, T., D.Christianson, M.S. Becker, S.Creel, E.Rosenblatt, J. Merkle, E.Droge, H.Mwape, J. Masonde, and T. Simpamba. 2018. **Quantifying lion demographic responses during a three-year moratorium on trophy hunting.** PLOS1. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0197030

Schuette, P., N. Namukonde, M.S.Becker, F.Watson, S.Creel, C. Chifunte, W. Matandiko, P. Millhouser, E.Rosenblatt, and C. Sanguinetti. 2018. **Boots on the ground: In defense of low-tech, inexpensive, and robust survey methods for Africa's under-funded protected areas.** Biodiversity and Conservation. https://link.springer.com/article/10.1007/s10531-018-1529-7

Becker, M.S., S.M. Durant, F.G.R. Watson, M. Parker, D. Gottelli, J. M'soka, E.Droge, M. Nyirenda, P. Schuette, S.Dunkley and R. Brummer. 2017. **Using dogs to find cats: detection dogs as a survey method for wide-ranging cheetah.** Journal of Zoology http://onlinelibrary.wiley.com/doi/10.1111/jzo.12445/full

Creel, S., E.Droge, J.M'soka, D.Smit, M.S.Becker, D.Christianson, and P.Schuette. 2017. **The relationship between direct predation and antipredator responses: a test with multiple predators and multiple prey.** Ecology. http://onlinelibrary.wiley.com/doi/10.1002/ecy.1885/full

Droge, E., S. Creel, M.S. Becker, and J. M'soka. 2017. **Measuring the 'landscape of fear': risky times and risky places interact to affect response of prey.** Nature Ecology and Evolution. https://www.nature.com/articles/s41559-017-0220-9

Droge, E., S. Creel, M.S. Becker, and J. M'soka. 2017. **Spatial and temporal avoidance of risk within a large carnivore guild.** Ecology and Evolution: 7: 189–199. doi: 10.1002/ece3.2616 http://onlinelibrary.wiley.com/doi/10.1002/ece3.2616/full

M'soka, J., S.Creel, M.S. Becker, and J.Murdoch. 2017. **Ecological and anthropogenic effects on the distribution and abundance of migratory and resident ungulates in a human-inhabited protected area.** African Journal of Ecology. http://onlinelibrary.wiley.com/doi/10.1111/aje.12398/full

Creel, S., J. M'soka, E.Droge, E.G. Rosenblatt, M.S.Becker, W. Matandiko, and T. Simpamba. 2016. **Assessing the sustainability of African lion trophy hunting, with recommendations for policy.** Ecological Applications 26:2347-2357 http://onlinelibrary.wiley.com/doi/10.1002/eap.1377/full

Durant, S.M., Mitchell, N., Groom, R., Pettorelli, N., Ipavec, A., Jacobson, A., Woodroffe, R., Bohm, M., Hunter, L., Bashir, S., Broekuis, F., Becker, M., Andresen, L., Aschenborn, O., Beddiaf, M., Belbachir, F., Belbachir-Bazi, A., Berbash, A. Brandao de Matos Machado, I., Breitenmoser, C., Chege, M., Cilliers, D., Davies-Mostert, H., Dickman, A., Fabiano, E., Farhadinia, M., Funston, P., Henschel, P., Horgan, J., de Iongh, H., Jowkar, H., Klein, R., Lindsey, P., Marker, L., Marnewick, K., Melzheimer, J., Merkle, J., Msoka, J., Msuha, M., O'Neill, H., Parker, M., Purchase, G., Saidu, Y., Samaila, S., Samna, A., Schmidt-Kuentzel, A., Selebatso, E., Sogbohossou , E., Soultan, A., Stone, E., van der Meer, E., van Vuuren, R., Wykstra, M., and Young-Overton, K. 2016. **Disappearing spots: the global decline of cheetah and what it means for conservation.** Proceedings of the National Academy of Sciences 114: 528-533. http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12415/full

Miller, J.R.B., G. Balme, P.A.Lindsey, A. Loveridge, M.S. Becker, C. Begg, H. Brink, S. Dolrenry, J.E. Hunt, I. Jansson, D.W. Macdonald, R.L. Mandisodza-Chikerema, A. Oriol Cotterill, C.Packer, D. Rosengren, M. Trinkel, P.A. White, C. Winterbach, H.E.K.,Winterbach, K.Stratford and P.Funston. 2016. **Aging traits and sustainable trophy hunting of African lions.** Biological Conservation. 201:160-168. https://www.sciencedirect.com/science/article/pii/S0006320716302671

M'soka, J., S.Creel, M.S. Becker and E.Droge. 2016. **Spotted hyaena survival and density in a lion depleted ecosystem: The effects of prey availability, humans and competition between large carnivores in African savannahs.** Journal of Applied Ecology. 201:348-355. https://www.sciencedirect.com/science/article/pii/S0006320716302750

Rosenblatt, E., S.Creel, M.Becker, J. Merkle, H. Mwape, P. Schuette, and T. Simpamba. 2016. **Effects of a protection gradient on carnivore density and survival: an example with leopards in the Luangwa valley, Zambia.** Ecology and Evolution. 6:3772-3785. http://onlinelibrary.wiley.com/doi/10.1002/ece3.2155/full

Creel, S., Becker, M.S., D. Christianson, E. Droge, N. Hammerschlag, M.W. Hayward, U. Karanth, A. Loveridge, D.W. Macdonald, W.Matandiko, J. M'soka, D.Murray, E.Rosenblatt, P.Schuette. 2015. **Questionable policy for large carnivore hunting.** Science 350: 1473-1475. http://science.sciencemag.org/content/350/6267/1473?ijkey=MyytU6s3AMMAw&keytype=ref&siteid=sci

Durant, S.M., Becker, M.S., Bashir, S., Creel, S., Dickman, A.J., Beudels-Jamar, R.C., Lichtenfeld, L., Hilborn, R., Wall, J., Wittemyer, G., Badamjav L., Blake, S., Boitani, L., Breitenmoser, C., Broekhuis, F., Christianson, D., Cozzi, G., Davenport, T.R.B., Deutsch, J., Devillers, P., Dollar, L., Dolrenry, S.,

Douglas-Hamilton, I., Dröge, E., FitzHerbert, E., Foley, C., Hazzah, L., Hopcraft, J.G.C., Ikanda, D., Jacobson, A., Joubert, D., Kelly, M.J., Milanzi, J., Mitchell, N., M'Soka, J., Msuha, M., Mweetwa, T., Nyahongo, J., Rosenblatt, E., Schuette, P., Sillero-Zubiri, C., Sinclair, A.R.E., Stanley-Price, M. R., Zimmermann, A., Pettorelli, N. 2015. **Developing fencing policies for dryland ecosystems.** Journal of Applied Ecology. 52:544-551. http://onlinelibrary.wiley.com/doi/10.1111/1365-2664.12415/full

Lindsey, P.; Nyirenda, V. ; Barnes, J.; Becker, M.S.; McRobb, R.; Tambling, C.; Taylor, A.; Watson, F, T'Sas-Rolfes, M. 2014. **Underperformance of African protected area networks and the case for new conservation models: Insights from Zambia.** PLOS. 9:1-14. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0094109

Rosenblatt E., Becker M., Creel S., Dröge E., Mweetwa T., Schuette P., Watson F., Merkle J, and Mwape H. 2014. **Detecting declines of apex carnivores and evaluating their causes: an example with Zambian lions.** Biological Conservation 180: 176-186. https://www.sciencedirect.com/science/article/pii/S0006320714003875

Watson, F., M.S. Becker, J. Milanzi, and M. Nyirenda. 2014. **Assessing Human Encroachment Trends in Protected Area Networks Using Land Use Change Data: Implications for Large Carnivore Conservation.** Regional Environmental Change 15:415-429. https://link.springer.com/article/10.1007/s10113-014-0629-5

Williams, B.M., A. Berentsen, B. C. Shock, M. Teixeira M. R. Dunbar, M. S. Becker, and M. J. Yabsley. 2014. **Prevalence and diversity of Babesia, Hepatozoon, Ehrlichia, and Bartonella in wild and domestic carnivores from Zambia, Africa.** Parasitology Research 113: 911-918. https://link.springer.com/article/10.1007/s00436-013-3722-7

Becker, M.S., R. McRobb, F. Watson, E.Droge, B. Kanyembo, J. Murdoch, and C. Kakumbi, 2013. **Evaluating wire-snare poaching trends and the impacts of by-catch on elephants and large carnivores.** Biological Conservation 158:26-36. https://www.sciencedirect.com/science/article/pii/S0006320712003722

Becker, M.S., F. Watson, E.Droge, K. Leigh, R.Carlson and A.A. Carlson. 2013. **Estimating Past and Future Male Loss in Three Zambian Lion Populations.** Journal of Wildlife Management 77:128-142. http://onlinelibrary.wiley.com/doi/10.1002/jwmg.446/full

Berentsen, A.R., M.R. Dunbar, M.S.Becker, J. M'soka, E. Droge, N. Sakuya, W. Matandiko, R. McRobb, and C.A. Hanlon. 2013. **Rabies, canine distemper and canine parvovirus exposure in large carnivore communities from two Zambian ecosystems.** Vector-Borne and Zoonotic Diseases 13:643-649. http://online.liebertpub.com/doi/abs/10.1089/vbz.2012.1233

Creel, S., Becker, M.S., Durant, S.M., M'Soka, J., Matandiko, W., Dickman, A.J., Christianson, D., Dröge, E., Mweetwa, T., Pettorelli, N., Rosenblatt, E., Schuette, P., Woodroffe, R., Bashir, S., Beudels-Jamar, R.C., Blake, S., Borner, M., Breitenmoser, Broekhuis, F., C., Cozzi, G., Davenport, T.R.B., Deutsch, J., Dollar, L., Dolrenry, S., Douglas-Hamilton, I., Fitzherbert, E. Foley, C., Hazzah, L., Henschel, P., Hilborn, R., Hopcraft, J.G.C., Ikanda, D., Jacobson, A., Joubert, B., Joubert, D., Kelly, M.S., Lichtenfeld, L., Mace, G.M., Milanzi, J., Mitchell, N., Msuha, M., Muir, R., Nyahongo, J., Pimm, S., Purchase, G., Schenck, C., Sillero-Zubiri, C., Sinclair, A.R.E., Songorwa, A.N., Stanley-Price, M., Tehou, J., A., Trout, C., Wall, J., Wittemyer, G., Zimmermann, A. 2013. **Conserving large populations of lions – the argument for fences has holes.** Ecology Letters 16: 1413-e3. http://onlinelibrary.wiley.com/doi/10.1111/ele.12145/full

Creel, S. and Rosenblatt, E. 2013. **Using pedigree reconstruction to estimate population size: genotypes are more than individually unique marks.** Ecology and Evolution 3: 1294-1304. http://onlinelibrary.wiley.com/doi/10.1002/ece3.538/full

Creel, S., J. A. Winnie Jr., and D. Christianson. 2013. **Underestimating the frequency, strength and cost of antipredator responses with data from GPS collars: an example with wolves and elk.** Ecology and Evolution 2013; 3(16): 5189–5200. http://onlinelibrary.wiley.com/doi/10.1002/ece3.896/full

Halloran, K., J.D. Murdoch, and M.S. Becker. 2013. **Applying computer-aided photo-identification to messy datasets: a case study of Thornicroft's giraffe (*Giraffa camelopardalis thornicrofti*).** African Journal of Ecology. 11:1-8 http://onlinelibrary.wiley.com/doi/10.1111/aje.12145/full

Lindsey, P., Balme, G., Becker, M., Begg, C., Bento, C., Bocchino, C., Dickman, A., Diggle, R., Eves, H., Fearnhead, P., Henschel, P., Lewis, D., Marnewick, K., Mattheus, J., McNutt, J.W., McRobb, R., Midlane, N., Milanzi, J., Morley, R., Murphree, M., Nyoni, P., Opyene, V., Phadima, J., Purchase, N., Rentsch, D., Roche, C., Shaw, J., van der Westhuizen, H., Van Vliet, N., Zisadza, P. 2013. **Illegal hunting and the bush-meat trade in African savannas: drivers, impacts and possible solutions.** Biological Conservation 160:80-96. https://www.sciencedirect.com/science/article/pii/S0006320712005186

Watson, F., M.S. Becker, R. McRobb, and B. Kanyembo. 2013. **Spatial Patterns of Wire-Snare Poaching: Implications for Community Conservation in National Park Buffer Zones.** Biological Conservation. 168:1-9. https://www.sciencedirect.com/science/article/pii/S0006320713003121

Berentsen, A.R., M. S. Becker, H.Stockdale-Walden, W. Matandiko, R. McRobb, M.Dunbar. 2012. **Survey of gastrointestinal parasite infection in African lion (Panthera leo), African wild dog (*Lycaon pictus*) and spotted hyaena (*Crocuta crocuta*) in the Luangwa Valley, Zambia.** African Zoology 47:363-368. http://www.bioone.org/doi/abs/10.3377/004.047.0204

Riggio, J., A. Jacobson, L.Dollar, H. Bauer, M. Becker, A. Dickman, P. Funston, R. Groom, P. Henschel, H. de Iongh, L. Lichtenfeld, and S. Pimm. 2012. **The size of savannah Africa: a lion's (*Panthera leo*) view.** Biodiversity and Conservation 22:17-35. https://link.springer.com/article/10.1007/s10531-012-0381-4?hc_location=ufi

2018 Supporters

The Bennink Foundation

Individuals:

Rob and Kayte Simpson, Anna Kalynych, Nina Siemiatkowski, April and Mark Johnston, Dr. Anne Roney Fitzpatrick, Rachelle Crupi, Alec and Kate Lindsay, Adam Lewenhaupt, Rocky and Kat Hawkins, Jen and Bill Johnson, Orlando Griffith, Reuben Rich, Peter Archdale, Carol and Mark Roe, Rosalind Morrill, Susan Creveling, Justin Mason, Dr. Kathleen Curtis, Kim Pham, Meg and Dick Scanlon, Adriana Reyes, Gregor Schuurman, Cristiano Nicolini, Cory Elder, Jeffery Riecke, Teresa Yepes, Sebastiaan Kamphuis, Fitness Elephants

Back cover: A young male lion in the Greater Kafue Ecosystem. As the northern frontier of the Kavango-Zambezi Transfrontier Conservation Area, the Kafue holds great promise for lions and other carnivores. *Photo: Marcus Westburg*

Zambian

CARNIVORE PROGRAMME