Zambian

CARNIVORE PROGRAMME

DEPARTMENT OF NATIONAL PARKS & WILDLIFE

DNPW

"CONSERVE WILDLIFE"

Annual Report 2020

A lone hyena at dusk in Western Zambia's Liuwa Plain. Liuwa is the site of the country's longest-running hyena conservation project.

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Zambian
CARNIVORE PROGRAMME

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DEPARTMENT OF NATIONAL PARKS & WILDLIFE
DNPW
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Cover: A young male lion from the Kafue's Kasonso Pride. Ranging throughout one of the area's highest snaring risk areas, the pride has been de-snared four times. Read his story in the Conservation Action Section.
Photo by Anna Kusler

Zambian
CARNIVORE PROGRAMME

OUR **IMPACT** IN 2020

5 ecosystems

7 National Parks

7 Game Management Areas

34,500 km² Covered

3,566 Person Days in the Field

930 large carnivores intensively monitored

10 large carnivores de-snared

No snared lions detected in the Luangwa for first time in 20 Years

119 Community Game Drives Hired for 813 Community Members

351 Livestock owners worked with across 5 chiefdoms to mitigate carnivore conflict

6 Zambian students supported for university degrees in wildlife conservation

14 Zambian trainees in Women in Wildlife Conservation, Conservation Biologist Training Programme and Wildlife Vet Training Programme

10 peer-reviewed scientific studies published/in review for policy and management

3 Zambian students supported for graduate degrees

11 Conservation Club Programmes to **390** students

300+ Community Cleans Sweeps Employing over 700 People

Worked with **17** Conservation Partners

3 Cutting-Edge Genetic Tools Developed to Combat Illegal Carnivore Trafficking

The Year in Review

As for everyone, the year of 2020 started very different than it finished for our work conserving large carnivores and ecosystems. With the continued growth of our organization, we had a wealth of exciting plans to roll out once the rainy season subsided in March. And then the world turned upside down.

As news of the emerging COVID-19 pandemic reached us, tourism stopped, borders closed, key supply lines (such as Land Rover parts!) ceased, and lockdowns were implemented. We anxiously monitored the spread of the virus across Africa and the world, and discussed the array of concerning scenarios we would soon be dealing with. In addition to the immediate threat to everyone's health that the virus posed, with unemployment and food insecurity heightened, it also looked like a worst-case scenario might be likely. The pandemic could drive spikes in poaching and conflict and undo the conservation gains that had been made. Furthermore, the pandemic brought a significant loss of funding to ZCP and most conservation organizations, hindering our collective ability to respond to the crisis at a time when it was most needed.

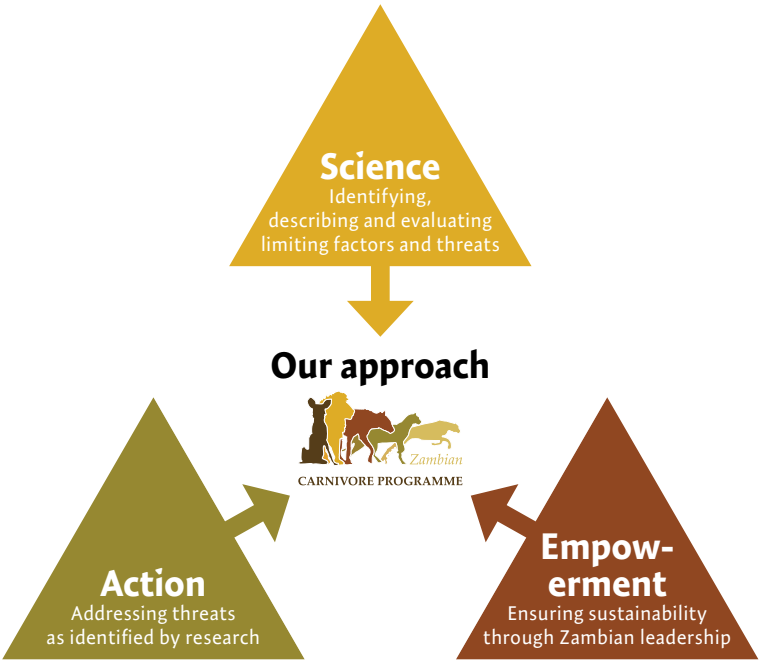
But while it will always be remembered as the pandemic year, 2020 was also ultimately a testament to resilience and teamwork in the face of adversity. As critical workers, our teams and partners decided to keep working; we dug in and distilled our focus down to two main objectives: 1) Keep everyone employed and safe, and 2) Minimize the loss of carnivores from increases in poaching and conflict. To keep safe, we closed our camps to non-team members, and implemented strict hygiene, travel, quarantine, and social distance practices to ensure that we minimized the chance of exposure and transmission. Together with our partners, we worked to mitigate losses from poaching and conflict, while many of our key donor organizations rescued the work with vital financial assistance to make up for the funding shortfall.

And though 2020 was replete with challenges and setbacks, ultimately as the year came to a close, and promising news of vaccines and progress in combatting the virus spread emerged, the year was a success. We kept everyone employed and supporting their families. Despite working across the country with a 45-person team and over a dozen partner organizations, we had only one mild case of COVID-19 at the end of December, which was effectively contained. We reached new records in field effort, and intensively monitored carnivores, and despite increases in poaching the losses were nowhere near as bad as they could have been. In the Luangwa we did not record a snared lion for the first time in our history. We greatly expanded our human-carnivore conflict work and began to see positive impacts from our investments. And we continued to run our training programmes for aspiring Zambian conservationists across the country. To address the loss of safari tourism, we worked with partners to develop novel new programmes for guides and communities hit hard by the losses. Certainly, a number of initiatives and programmes suffered or did not occur, but ultimately the work carried on and had positive impacts. This was a testament to the strength of our organizational partners, donors, and teams, and to our shared commitment, vision, and resilience.

Now in 2021 we are far from being finished with the pandemic impacts. The financial impacts continue to be felt and it is likely to be a hard year. Nevertheless, we go forward with strength and positivity, knowing that together we can address whatever challenges the year brings to keep this important work going. From everyone on our team, thank you again for your support and collaboration. Stay safe.

Dr. Matthew Becker
Chief Executive Officer

Our Approach



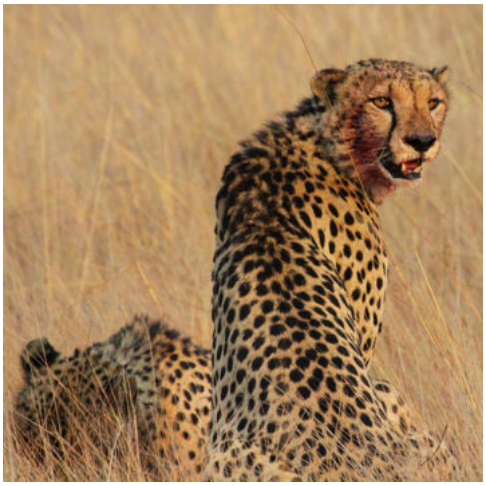
The Zambian Carnivore Programme (ZCP) follows a three-tiered interdisciplinary approach of Conservation Science, Conservation Action and Conservation Empowerment to fulfill its goal of conserving large carnivores and ecosystems.

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 Empowerment

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.

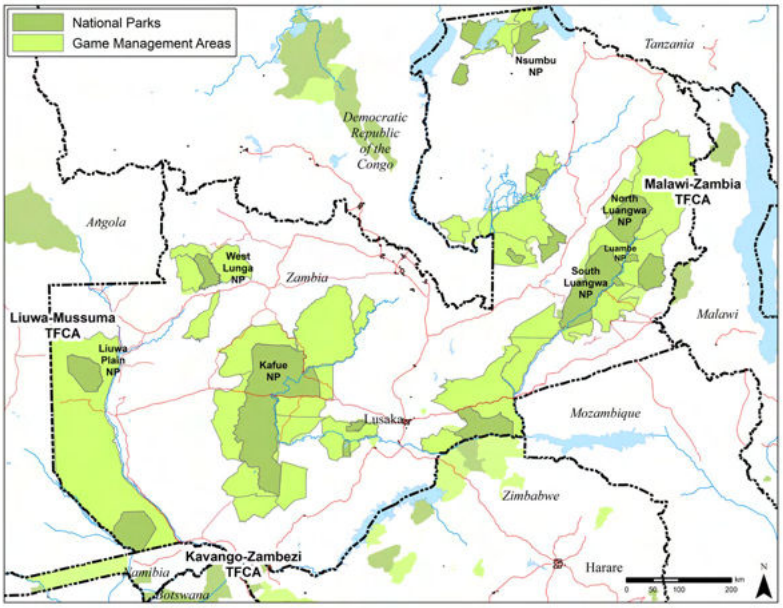
Where we work

Zambia – the crossroads of connectivity

Connects eastern and southern African wildlife populations

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

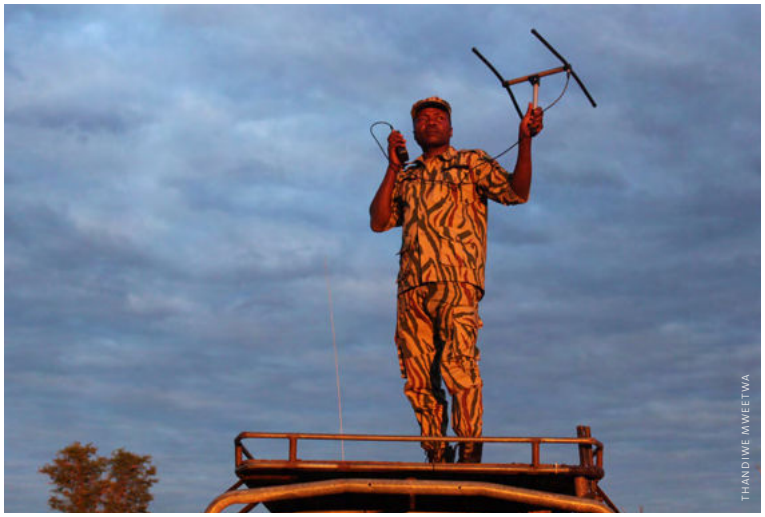
Large-scale ecological processes (migration, dispersal, flooding, etc.) still occur



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



DNPW Wildlife Police Officer Gibson Banda tracks wild dogs in the Luangwa Valley.

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). We also work with partners in the recovering Kabompo and Nsumbu Ecosystems. 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.

Conservation Science: Field Reports

Key outputs 2020

- 375 lions in 63 groups intensively monitored across 3 ecosystems
- 279 wild dogs in 22 groups intensively monitored across 2 ecosystems
- 239 hyenas in 13 clans clans intensively monitored in one ecosystem, photographic monitoring in three
- 37 cheetah intensively monitored across 2 ecosystems
- 2 leopard camera trap studies across 2 ecosystems
- 10 studies completed on wild dog connectivity, bushmeat poaching impacts on lion, leopard and wild dog demography and herbivore density and distribution, Luangwa lion spatial dynamics, conservation genetics and carnivore population monitoring techniques
- Ten surveys of herbivore density and distribution across 5 ecosystems

Luangwa Valley

African Wild Dogs

We continued the country's longest-running wild dog conservation project in 2020, on the country's largest population. The year further highlighted the importance of large landscape connectivity, as 195 individuals were recorded across 18 packs and dispersal groups ranging from North Luangwa National Park down to Lower Zambezi National Park.

DNPW-ZCP teams intensively monitored 15 packs across over 12,000 km^2, utilizing ground-based field teams, satellite-GPS collars and aerial tracking and logging over 1220 person days in the field. Work spanned three national parks (South Luangwa, North Luangwa, and Luambe), as well as three Game Management Areas. Given that wild dogs typically disperse from their natal pack between 1-3 years of age, we continued to document large-scale dispersal events across the Valley, and particularly with the smaller packs we recorded frequent changes in composition with multiple dispersals and takeovers. With collaborative work ongoing with the DNPW, Conservation South Luangwa, and Frankfurt Zoological Society's anti-poaching efforts, Luangwa wild dogs continued to be at high numbers in 2020.

We continued to evaluate wild dog demography across gradients of protection, as well as the dynamics between predation risk effects on wild dogs from lions, and the impacts of prey depletion

Litters from subordinate females are rare in wild dogs, but one female (from a subordinate litter herself) has managed to beat the odds.

Like Mother, Like Daughter

Along the Muphamadzi river that forms the northern boundary of South Luangwa National Park, resides a large wild dog pack bearing the same name as the river. The Muphamadzi pack was formed by a dispersal group of Manzi females in 2018. The Manzi dispersal females consisted of 5 sisters born to the alpha female, and 1 cousin (sole survivor) born to the subordinate female.

For African wild dogs it is primarily the alpha pair that has pups in a pack, though it is not uncommon to have a subordinate pair to breed and attempt to have their own litter. Depending on the pack dynamics, the alpha females pups typically receive priority for packs attention and thus are more likely to survive. In the case of Manzi pack, the subordinate had attempted rearing her own pups for three years in a row but it was only with her last litter that successfully raised a pup to adulthood. The sole surviving daughter is now a subordinate female in Muphamadzi pack. While she is significantly smaller than her pack-mates, she followed in the footsteps of her mother when she gave birth to a litter of her own. The subordinate female's pups were born later than the alpha female's pups and are noticeably smaller in size. In addition they bear the same tawny coat as their mother. The subordinate litter, consisting of only two pups compared to the alpha's eight pups, will have an uphill struggle to survive as they become more mobile over the rainy season.

While the pups' fate remains unknown, ZCP's continued monitoring effort will reveal how their story and that of their pack unfolds.

A new dynasty: the Manzi pack

Another legacy long in formation is that of Manzi pack, one of the largest and most productive packs in the main game.

Unfortunately, end of 2018 the pack lost its alpha male and therefore did not den in 2019. The pack never found a replacement alpha male and later in the year a second tragedy befell the pack with the loss of the alpha female to conflict with an overlapping lion pride. Manzi pack's legacy continues as both male and female dispersers from the pack have already successfully positioned themselves as alphas in packs of their own. In fact, previous dispersers from Manzi pack are known to have formed at least 3 additional packs ranging from North Luangwa National Park down to Lower Lupande Game Management Area.

Formed in 2013, the Manzi pack is becoming another of Luangwa's wild dog dynasties.

In 2020, Manzi descendants were responsible for more than 50% of the recorded pup production in the intensive study area of Luangwa Valley. The Manzi males inherited the home range of their natal pack and together with the new alpha female, they reared their first success litter of 8 pups (with 6 pups surviving into the early rains). After a brief foray to the western boundary of South Luangwa National Park, the Manzi males returned with a new female and inherited the core of their natal range in 2020.

from bushmeat poaching and snaring by-catch on wild dogs. Comparisons of these dynamics across ecosystems are ongoing (see Kafue Wild Dogs) and preliminary findings expected in 2021.

As space for large carnivores continues to decrease, the importance of connectivity and the ability to move across human-altered landscapes increases. We published our first evaluation of wild dog spatial dynamics in 2020 entitled "Hidden Markov Models reveal a clear human footprint on the movements of highly mobile African wild dogs," published in Nature Scientific Reports. Using data from GPS-collared wild dog packs in the Luangwa Valley, together with the DNPW we evaluated how the Human Footprint affected wild dog movements within and outside of South Luangwa National Park, finding a clear impact of humans on wild dogs which has strong implications for connectivity conservation planning (see Large Landscape Conservation).

While wild dog numbers naturally fluctuate, we were able to minimize the impact of snaring by-catch deaths on wild dogs through collaborative anti-snaring work with DNPW and CSL patrols and only detected a single snared dog in 2020, which was successfully de-snared (see Anti-Snaring). The mitigation of perhaps the most immediate threat facing wild dogs has contributed substantially to the high numbers of wild dogs currently in the population but snaring remains an ever-present threat, particularly during the pandemic.

Lions

In 2020, DNPW-ZCP field teams monitored 209 individual lions across 22 prides and 12 coalitions, ranging from north of Luambe National Park to south of SLNP's Luamfwa area and across three Game Management Areas (GMAs). As in prior years, the vast majority of prides and coalitions frequented both the strictly protected parks as well as the GMAs. The gradient of protection between these areas regularly subjected lions to diversity of human impacts, including conflict with livestock and people (see Human-Carnivore Conflict), bushmeat poaching impacts in the form wire-snare poaching and prey depletion (See Anti-Snaring), as well as legal trophy hunting.

Given the concentration of human impacts on lions along the park boundaries and GMAs we continued to focus our monitoring efforts on these areas using a combination of GPS/Satellite collar technology, and ground and aerial support. Despite the negative impacts of the pandemic, collaborative work between the DNPW, Conservation South Luangwa and ZCP resulted in the first year this century where no snared lions were detected.

We also completed the first analysis of lion spatial dynamics as part of Luangwa Assistant Project Manager Henry Mwape's graduate research (see Graduate Students). Utilizing over a decade of lion spatial data, home ranges and

ZCP-DNPW Luangwa field teams collect data from some of the over 200 lions from 34 prides and coalitions that form the country's longest-running lion conservation project.

The Luangwa is one of 10 remaining lion strongholds on the continent. We completed the first analysis of lion spatial dynamics across protection gradients in 2020 and further developed new methods of monitoring low-density, wide-ranging carnivores.

We continued work on the Luangwa leopard stronghold in 2020, continuing to evaluate demography and prey abundance using camera trap methods.

movement patterns of Luangwa lions were evaluated in relation to an array of ecological and anthropogenic factors likely to be influential. The study is expected to be submitted for publication in the coming year to help provide continued insights into lion dynamics.

In concert with our work combatting trafficking of big cat skins and parts (see Anti-Trafficking) we made significant progress in 2020 with the development of a genetic tool for lions known as a SNP Chip. This tool enables the acquisition of high-quality genetics data from low quality samples from trafficked skins and parts (enabling identification of source populations for law enforcement intelligence) but also from scat. Given our recent work on population monitoring methods has highlighted the need for effective methodology (Droge et al. 2020, see Scientific Publications), the SNP Chip will enable new population monitoring methods using Pedigree Reconstruction techniques (Creel and Rosenblatt 2013) and enable unprecedented evaluations of genetic connectivity within and across ecosystems (see Large Landscape Conservation).

Leopard

We completed our ninth year of camera-trap based studies of the Luangwa leopard stronghold in the South Luangwa area, while completing our second year of identical work in Luambe National Park. We continued to collect data on leopard survival and density, while also evaluating the dynamics of their prey and competitors.

While our prior studies demonstrated a strong impact of prey depletion from bushmeat poaching in the GMA areas (see Scientific Publications), the methods used to estimate prey density and distribution do not always effectively evaluate some of the smaller, lower density and more elusive prey species for leopard. Consequently, in 2020 we began evaluations of ungulates such as bushbuck, as well as the mid-sized carnivore guild (known as mesocarnivores) from camera trap data. The studies were particularly challenging in the areas of high human impacts, given that cameras were frequently stolen, making assessments of heavily-human impacted areas difficult. Nevertheless, we will be adapting our work to address these challenges in 2021.

Similar to our lion work, we made significant strides assisting in combatting the illegal trafficking of leopard skins in Zambia (see Anti-Trafficking), including the development of a genetic SNP Chip specifically for leopards. This tool enables high quality genetics data to be

Wild dog yearlings harass a herd of zebra. Surveys of herbivore density and distribution across protection gradients are conducted twice annually to evaluate the changing impacts of human and ecological factors on these species.

obtained from low quality samples such as trafficked parts (whereupon the animal can be traced to its population of origin for law enforcement intelligence) and scat.

Given the extreme difficulties in monitoring leopards due to their elusiveness, utilizing the SNP Chip with scat samples shows great promise in enabling population monitoring through Pedigree Reconstruction (see Scientific Publications), as well as in evaluating connectivity within and across ecosystems (see Large Landscape Conservation).

Herbivores

Prey depletion is one of the most pervasive impacts on top carnivores, owing largely to the fact that large herbivores are globally declining due to human impacts, and these declines have a variety of direct and indirect impacts on ecosystems. We completed our ninth year of bi-annual, ground-based herbivore surveys across South Luangwa National Park and adjacent Game Management Areas (GMAs), as well as our third year of surveys in Luambe National Park, continuing to evaluate the ever-changing dynamics of herbivores and human-modified landscapes.

With our large herbivore methods well-established through ground transects for most species, in 2020 we began focusing on evaluations of the more elusive ungulates such as bushbuck using camera trap data from our ongoing leopard studies (see Leopard). While these species are difficult to survey due to both their elusiveness and preference for densely-vegetated habitats, they play important ecological roles as both herbivores, and as prey for top carnivores.

We also continued our long-term demographic studies of the Luangwa's geographically-isolated giraffe population, using photographic monitoring and mark-recapture techniques to collect data on over 400 individuals across most of the population range in the Valley. While analyses were delayed with the pandemic, we continued to make progress on comprehensive demographic evaluations of this small population, and expanded collaborations with Giraffe Conservation Foundation on this work in the coming year.

The Greater Kafue Ecosystem is Zambia's largest cheetah population, though like other carnivores in the Kafue cheetah are threatened by a diversity of human impacts.

Greater Kafue

Cheetah

We completed our 10th year of long-term conservation work on Zambia's largest cheetah population in the Greater Kafue. In 2020 we monitored 25 individual cheetah through a combination of intensive fieldwork and collaborative citizen science with Panthera and the Kafue Carnivore Coalition (KCC, see Citizen Science). We also intensively monitored eight animals with GPS/Satellite collars across approximately 16,000 km2 of national park and Game Management Areas.

As a subordinate competitor to the larger lions and spotted hyena, cheetah have evolved to mitigate competition with these dominant species, and these adaptations can be reflected in their diet, space use, and behavior. However, in heavily human-impacted ecosystems the effectiveness of these strategies can be altered significantly. Our prior work on the impacts of prey depletion demonstrated that large carnivore diets in Kafue had significantly changed over the last 50 years, with large prey such as buffalo dropping out of lion diets (see Scientific Publications). One of the many conservation implications of the changing preybase is that lions are increasingly focusing on the small to mid-size ungulate prey more typical of cheetah and wild dog. This dynamic increases the risk of lion predation on cheetah and weakens the effectiveness of dietary niche partitioning (i.e. focusing on different prey species to mitigate competition). Preliminary findings show differences in cheetah prey selection between sexes and also spatially. In contrast to males, breeding females frequented areas away from high prey density and focused on smaller-bodied, water-independent species such as duiker and grysbok. While this may be a strategy to avoid lion predation, these areas can also on park boundaries, and in GMAs, where snaring risk is typically higher.

Luckily, we detected no snared cheetahs in 2020, and the young male we de-snared in 2019 made a full recovery. There was, however, a report of a cheetah with a healed snare-wound on his leg in the Lunga-Luswishi GMA, which suggests that

snaring does still pose a significant threat to cheetahs in the GKE. Preliminary demographic evaluations also indicate that while adult cheetah survival appears to be reasonably high, cub recruitment overall may be low. While cheetah demographic analyses are ongoing, if this is accurate it would be comparable to our findings on lion demography (see Kafue Lions), and is in line with ecological theory predictions for a prey-depleted system. In a system where food is scarce, cheetahs and lions would prioritize survival over reproduction. For cheetahs, low recruitment may also be further exacerbated by bush fires, which are pervasive across the park and adjacent GMAs. Cheetah cubs are small and helpless for the first two months of their life, and during this time cubs are kept in a lair by their mother. Our long-term cheetah data across sites indicates that these lairs are typically in tall grass areas. Frequent and extensive burning is therefore a serious threat to cheetah cub survival and in years past we have documented loss of litters suspected to be from fire.

Thankfully, however, we did continue to regularly document successful recruitment of cubs to dispersal age. For example, this year we documented two young sisters in the Fig Tree area reaching dispersal age, leaving their mother, and successfully hunting and dispersing on their own. Similarly, we also documented an impressive dispersal of a young male cheetah, whereby he left his sibling group in the Musekese area, swam the formidable Kafue River, and was re-sighted by safari operators 40km away.

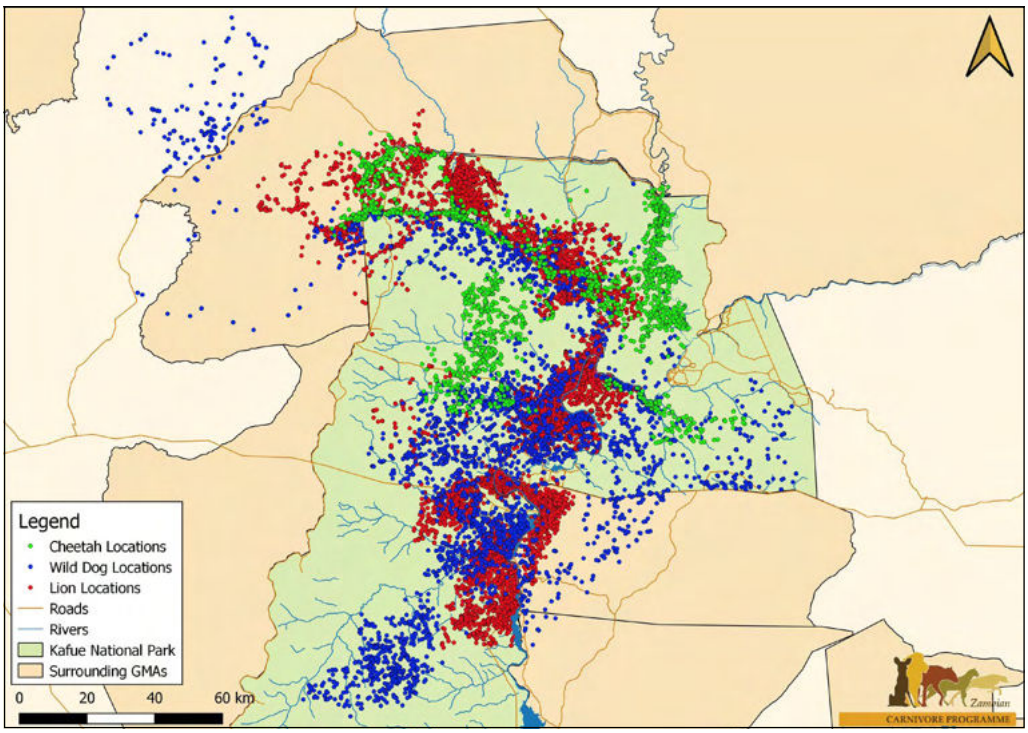
In addition to our citizen science program, data from GPS/Satellite collars continued to provide crucial insight to the dispersal movements, spatial dynamics, and connectivity of cheetah across not just the GKE, but the entire KAZA Transfrontier Conservation Area. Evaluations of cheetah spatial movements across natural and human-modified landscapes are ongoing to help guide and evaluate connectivity conservation efforts. Similarly, analyses of genetic connectivity for cheetah and other carnivores continued throughout 2020 as part of our African Carnivore Connectivity Project (see Large Landscape Conservation).

As a naturally rare species that is at even lower densities due to human impacts across their range, the majority of remaining cheetah populations number fewer than 100 individuals. Monitoring of these populations is critical; however, it is also extremely difficult. Traditional survey techniques used for large carnivores can be especially difficult for cheetah, and therefore new methods are urgently needed. Spatial capture-recapture (SCR) using camera traps is widely viewed as an effective alternative to traditional population monitoring methods, but its utility with cheetah is not well-understood. Utilizing data from GPS-collared Kafue cheetah, in 2020 we completed an evaluation of SCR methodology for cheetah and submitted it for review and publication. The study, entitled "Simulation-based assessment of spatial capture-recapture models for a low density, elusive carnivore (see Scientific Publications)," found that SCR did not provide accurate estimates of cheetah population size or trends across a range of densities, and in cases where attractants were used it could significantly overestimate the true population size. Thus, while the methodology is sound and practical for many carnivores, cheetah and other low density/naturally rare species are unlikely to provide enough data to make SCR an effective monitoring method. Consequently, emerging genetic techniques such as pedigree reconstruction (see Scientific Publications) continue to be an area of focus for the critical task of monitoring imperiled carnivore populations.

Wild Dog

In 2020, we completed our 10th year of intensive wild dog conservation work. We monitored 94 dogs in seven packs throughout our intensive study area in Northern and Central Kafue, and a total of 132 individuals in 13 packs throughout the Greater Kafue as part of a collaborative citizen science programme (see Citizen Science) with DNPW, Panthera and Musekese Conservation, and safari operators and guides. We added two new packs to the intensive monitoring programme: Mayukuyuku Pack and Lumbeya Pack. Lumbeya Pack was formed through successful dispersal events from other known packs, which again demonstrates the importance of large landscape connectivity (see Large Landscape Conservation). These two groups are greatly enhancing our knowledge of wild dog dynamics in the Mumbwa GMA and Musekese-Lumbeya regions of the GKE, which are areas heavily impacted by human activities.

In 2020 we completed the first analysis of Kafue wild dog demography and dynamics and the human and ecological factors affecting them. Across their range, wild dogs are naturally negatively impacted by lions and have evolved strategies to avoid lion predation, including often avoiding areas of high lion density. Given prior work on herbivores demonstrated significant prey depletion (see Kafue herbivores), which has resulted in low densities of lions (see Kafue Lions), it is possible that Kafue wild dog populations could benefit from low lion populations.



Locations from over 40 groups of lion, wild dog and cheetah intensively monitored across ~16,500 km2 in 2020. These data provide critical information on demography, spatial dynamics and connectivity, as well as a host of other information fundamental to conservation.

Using long-term data from 425 individual wild dogs from 2012-2019, we evaluated demography and dynamics for the Kafue population. Kafue wild dog densities were some of the lowest recorded, while home ranges were some of the largest, and pack sizes were small.

Similar to our past studies on other carnivore species (see Kafue lions, Scientific Publications), survival in the core population was comparable to other populations not as significantly affected by bushmeat poaching. Core populations are therefore likely persisting at very low densities due to limited prey availability, while subjected to an array of negative human impacts concentrated on the boundaries of the protected area networks. Consequently, it is clear that the benefits of low lion density for wild dogs are negated if prey depletion drives low lion populations. This has clear conservation implications in that recommendations for wild dog restoration have targeted areas with low lion numbers; however, these efforts are unlikely to succeed if an area is heavily impacted by prey depletion, and an emphasis on restoration of a diverse and abundant preybase should be emphasized. The study, entitled "Low apex carnivore density does not release a subordinate competitor when driven by prey depletion," was accepted for publication in the scientific journal Biological Conservation.

The first demographic study on wild dogs in the Greater Kafue was completed in 2020. While lions are naturally a strong limiting factor on wild dogs, the benefits of low lion density in the Kafue were negated by prey depletion from poaching. Kafue's dog population was characterized by low densities, large home ranges and small pack sizes.

Lions and Hyenas

We completed 9 years of long-term lion conservation work in the Greater Kafue, continuing the work begun by the Kafue Lion Project in 2010. We intensively monitored 146 lions in 16 prides and 9 coalitions across northern and central Kafue, and we continued to expand monitoring work in the Game Management Areas (GMAs) surrounding the park. With the dramatic economic impacts from COVID-19 significantly limiting tourism and increasing the risk of poaching, our lion monitoring capacity was substantially increased with additional lion monitoring teams through a collaboration between Panthera and the Lion Recovery Fund. These teams were able to focus on continued monitoring of prides and coalitions as part of our collaborative anti-snaring work (see Anti-Snaring section).

A lioness from Kafue's Mwawimbi pride rests with her young cubs. Using data from these prides we completed and published the first demographic study of Kafue lions and the impacts of prey depletion from poaching on survival and reproduction. While survival was comparable to other ecosystems, lion density, pride size and cub production were all very low, likely as a result of prey depletion.

Prey depletion from bushmeat poaching is widely recognized as one of the biggest threats to lions and other carnivores rangewide, but specific impacts are poorly understood, and not rigorously analysed. As part of our comprehensive evaluations of the impacts of bushmeat trade on large African carnivore communities we published the first scientific study of lions and prey depletion in 2020. The study, entitled "Response of lion demography and dynamics to the loss of preferred larger prey," appeared in the scientific journal Ecological Applications. We analysed demographic data from 170 individuals in 16 prides and 16 coalitions from 2013-2019 and found that lion density was significantly lower than similar ecosystems less affected by prey depletion, but that survival across sex and age classes was comparable.

However, cub recruitment into subadult age classes was low, and pride sizes were small. This suggests that low cub recruitment might be a better signal of low prey density than overall lion survival. Thus, describing a lion population's age structure and average pride size may be a simple and effective method of initially evaluating whether a lion population is affected by prey depletion.

We continued to amass spotted hyena data from opportunistic photographic monitoring, and in 2020 we monitored over 20 hyenas in at least six clans across our study area. In contrast to our other sites, hyenas are relatively low density and likely in smaller clans. Prey depletion from bushmeat poaching and other human impacts are undoubtedly contributing to these low densities but the actual dynamics of GKE hyenas are unclear. Resident clans appear to have expansive home ranges, with some individuals traversing at least 60km between sightings. Road collisions along the M9 highway seem to be one of the greatest threats to this species (see Road Impacts section), and hyenas with snare injuries are not uncommon, suggesting that hyenas are being impacted by multiple anthropogenic threats.

We currently have 93 individual hyenas in our databases, and we continue to expand this long-term monitoring work in 2021 with partners such as Musekese Conservation and Panthera.

Hyenas are a key component of the large carnivore guild in Kafue yet appear to be at densities much lower than expected.

The first study of Kafue leopards was completed and published in 2020. The camera-trap based study evaluated leopard density and survival in a core area of Kafue National Park. Leopard density and survival in this area was comparable to other ecosystems, likely because prey depletion has weaker effects on the smaller prey of leopards, and because the density of dominant competitors such as lions was low.

Leopard

The GKE is likely to be the country's second-largest stronghold behind the Luangwa Valley, with considerable potential to increase with expansion of resource protection efforts in the ecosystem. Like other carnivores, leopards are threatened by the bushmeat trade's two-pronged impacts of prey depletion and snaring by-catch, but the impacts of bushmeat poaching on leopards are poorly understood. In 2020 we continued our long-term population monitoring, with 108 individual leopards in our database, and we continued to expand this work in partnership with Panthera and Musekese Conservation.

We also completed and published our first analysis of leopard density, survival, and the impacts of prey depletion and lion competition in the Kafue. Prey depletion is a major cause of global carnivore declines, but the response of leopard survival and density to this threat is unclear. By reducing the density of more dominant lion competitors (see Kafue Lions), prey depletion likely creates both costs and benefits for subordinate competitors such as leopards. Because the densities of large herbivores preferred by lions have declined more than the densities of smaller herbivores preferred by leopards (see Kafue Herbivores), lion density is consequently relatively low. Our study, entitled "Leopard Panthera pardus density and survival in an ecosystem with depressed abundance of prey and dominant competitors" used capture-re-capture models fit to data from a 7-year camera trapping study in Northern Kafue National Park. Estimates of our study suggest that leopard densities in northern KNP are comparable to ecosystems with more intensive protection and favorable prey densities.

However, it is important to note that the study was conducted in one of the core areas of northern KNP, with good ecological conditions and high levels of protection (relative to other portions of the ecosystem). Consequently, extrapolating these estimates across the park or into the adjacent GMAs would be unlikely to be valid. However, leopard density and survival within north-central Kafue remain good despite prey depletion, perhaps because (1) prey depletion has had weaker effects on preferred leopard prey, when compared to larger prey preferred by lions, and (2) the density of dominant competitors (lions), is consequently low. Combined with studies of herbivore prey and competitors, our ongoing work continues to provide insights into the impacts of bushmeat poaching and competition on large carnivore communities.

Herbivores

In concert with our large carnivore work, we continued ground-based biannual surveys of all herbivore species across Northern and Central Kafue in 2020. The diversity of herbivores in the GKE is one of the highest in Africa, yet most species, particularly the larger ones, are

A breeding herd of impala in the Greater Kafue. In 2020 we completed and published an additional study on herbivore density and distribution across the Northern Kafue National Park. The density of herbivores, particularly large species such as buffalo, were extremely low relative to smaller species, indicating the need for increased resources to combat prey depletion from poaching.

threatened by depletion from poaching and the illegal bushmeat trade. This has a wide array of impacts on ecosystems, as well as negative impacts on wildlife-based economies in and around Kafue.

With nine years of survey data in the GKE we continued to evaluate the impacts of the bushmeat trade and other human impacts, as well as the ecological factors, driving the density and distribution of herbivores. Building upon prior ZCP analyses of the most abundant herbivore species and of GKE carnivore diets (See Science of Conservation section), we published an extensive study in 2020 on the GKE herbivore community entitled "Testing the effects of anthropogenic pressures on a diverse African herbivore community." Published in the scientific journal Ecosphere, one of the underlying goals of the study was to rigorously determine if herbivore densities were indeed as low as has been previously suggested for this system. Our findings did suggest that this is indeed the case, and more importantly they suggest that the densities of larger-bodied herbivores are greatly depressed relative to smaller species. Preliminary findings from our 2020 surveys continued to support this pattern, which could have direct and indirect effects on large carnivore populations, with broader implications for the ecotourism and trophy hunting industries. These findings continue to highlight that the GKE requires continued increases in resource protection to facilitate the recovery of an economically and ecologically important large herbivore guild.

Greater Liuwa

Spotted Hyena

The 2020 season marked the 11th year of our work on the Greater Liuwa Ecosystem's (GLE) apex predator, the spotted hyena. We intensively monitored 243 hyenas across 12 clans throughout approximately 6,000 km^2 of Liuwa Plain National Park and the adjacent Upper West Zambezi Game Management Area.

An abundant preybase, minimal livestock conflict, and a small lion population continued to enable what is likely to be one of the region's stronghold populations to thrive, though wire-snare poaching by-catch (see Anti-Snaring section) continues to pose a serious threat to many clans.

Preliminary demographic assessments for 2020 indicate that adult survival continues to be high overall, and juvenile (cub) survival was higher than the prior year. While more analyses are needed, a main factor enhancing survival rates appears to be the substantial rainy season relative to the extremely dry 2019. The drought year resulted in increased cub mortality as a result of water pans in the southern portion of the ecosystem drying up completely and driving territorial bull wildebeest north. These wildebeest are normally in the south year-round and form a key prey item for the high-density southern hyena clans in the dry season. Without this readily available source of food, hyena females were forced to long-distance commute in search of prey. The substantial rains in 2020 provided relief with an abundant and year-round preybase for southern GLE hyenas. These dynamics emphasized the myriad ecological influences of flooding and precipitation, as well as the potentially damaging impacts of climate change and flow alterations from human activities in the region (see Large Landscape Conservation).

Our focus on hyena work in 2020 continued to be in the northern GLE that forms the dry season range of the migratory wildebeest population, and extends to the Angolan border as part of the proposed Liuwa-Mussuma Transfrontier Conservation area. Since 2018 we have been intensively monitoring four clans situated in the northern GLE, which are subject to significantly different dynamics than those of the southern park clans.

Hyena cubs rest at a communal den in Liuwa Plain. With 13 clans and nearly 250 animals under study, the Liuwa hyena project is one of the longest-running conservation projects in the region for this important but much-maligned species.

The northern clans range widely outside the park across more human-impacted landscapes, and appear to have substantially smaller clan sizes. This lower density of top predators likely is an important factor in the migration of wildebeest to their dry season ranges in north (see Liuwa Wildebeest).

We conducted most of this work from our seasonal base at Salwela Scout Camp, and in 2020 also were able to fit VHF collars to two northern clans, Luola and Maifupa. The data provided by and collected through these collars is already proving to be invaluable for the understanding of the complex ecological dynamics of large mammals and human-impacted landscapes in the GLE.

Snaring continued to be a serious issue for carnivores, particularly for the North Clan of hyenas. Our ability to mitigate this threat and respond to snared carnivores was greatly improved with the addition of a full-time, field-based Zambian vet (see Anti-Snaring and Wildlife Vet Training Programme) in 2020.

Cheetah

Greater Liuwa's cheetah population is Zambia's second largest, and also transboundary with Angola's Mussuma Ecosystem as part of the proposed Liuwa-Mussuma Transfrontier Conservation Area. Cheetah are, however, experiencing unprecedented and ever-increasing rates of human impact throughout their range.

In this 11th year of cheetah conservation work in Greater Liuwa, we intensively monitored 12 animals, throughout their range inside the national park as well as in the Upper Western Zambezi Game Management Area (GMA), which provides a corridor between Liuwa Plain NP and Angola. We continued to collect survival, reproduction and spatial data to understand the dynamics of Liuwa's cheetah population. This work was greatly facilitated by GPS/Satellite collar technology and a year-round field effort, logging 1297 person days in the field in 2020.

The proposed Liuwa-Mussuma Transfrontier Conservation Area is thought to encompass the historic migratory range of wildebeest, and carnivore populations are likely to have been transboundary as well. However, this had not been confirmed for cheetah until 2020. Thus, this year's highlight was the recording of the first Zambian cheetah crossing over into Angola. Monitored by GPS/Satellite collar technology, we documented a dispersal-aged female briefly crossing from the GMA into Angola during the dry season. While she did not remain in Angola, this was very promising, particularly in light of ongoing collaborations with carnivore monitoring teams on the Mussuma side that continue to document cheetah.

While the wildebeest population's range is well-studied (see Herbivores), populations of oribi and duiker are much wider distributed throughout the GLE, which is likely to enable cheetah to persist throughout much of the GMA and mitigate competition with large competitors

South Clan: Starring in BBC's Dynasties II in 2022

At the start of the Liuwa Project in 2010 we only studied 4 hyena clans, South Clan is one of them. South Clan's territory is situated in the Southern section of the park, south from the famous palm tree in the plains better known as 'Lone Palm'. With more than 40 individuals South Clan used the be one of the strongest clans at that time. But dynamics changed and rival clans around South Clan increased in clan size, territory size and some of them split up. The competition for the favourable part of the landscape in the south, which south Clan called their home, increased over time. It holds high prey densities in both dry and wet season. After a couple years, South Clan got 'pushed' southwards by Miumi Clan and Lone Palm Clan and South Clan's reproductive success decreased. Miumi even took over their den location. At the moment South Clan remains a strong and vital clan and consists of roughly 30 individuals. Some of the key individuals such as: Hyena Suma (287), Sid (182), Sia (625), Sara (411) and Sitale (264) are still alive and reproducing and form an important part of South Clan's current existence.

Lone survivor: Cheetah 784 feeds on her oribi kill. Orphaned at the age of 13 months when her mother and sister were caught in wire snares, 784 miraculously survived to adulthood. As a young breeding female she will play a critical role in the recovery of Liuwa's transboundary cheetah population.

Cheetah 180 (Kali) stars in BBC's Dynasties II

In June 2011, a shy female cheetah with number 170 gave birth to four cubs, a female cheetah with number 180, was one of them. She had 2 sisters and 1 brother. They all dispersed successfully from their mom two years later, in 2013. The 3 sisters stayed together for 6 months, but eventually, as expected, split up. Both of her sisters had cubs a year later and raised them to dispersal age successfully, but cheetah 180 didn't. Now, 10 years later, cheetah 180 turns 10 years old and has in total had 5 different litters and raised 5 cheetahs successfully. Her sisters have passed away and cheetah 180 is now the oldest known female cheetah in the ecosystem and with reproductive success she plays a fundamental role in the recovery of the cheetah population in the GLE. At the moment, at the age of 10 years, cheetah 180 has one male cub whom is about the disperse and go his own way as well. And because of that, in Liuwa, Cheetah 180 is now called 'the queen'. When the famous lioness Lady Liuwa died in 2016, cheetah 180 inherited the symbolic position that Lady had in the Liuwa ecosystem. Cheetah 180 is now Liuwa's new icon, and a symbol of survival and resilience.

such as spotted hyena through dietary niche partitioning (i.e. different prey). We documented over 186 hunts and over 74 kills by cheetahs in 2020. Small-sized antelope such as oribi and common duiker continued to be the primary prey items, as well as reedbuck and wildebeest calves.

The season was tumultuous in that we lost another female to snaring for the fourth straight year. Given the wide-ranging nature of the species and that Liuwa cheetah range far into the GMA and corridor area and across human-impacted landscapes, the risk of snaring is quite high (see Anti-Snaring section), particularly for dispersing animals.

While collars are critical for monitoring, they also play a key role for protecting cheetah, and this year one of our main focuses was to create a presence in risky areas close to human settlements. Because cheetah frequented areas close to human settlements and high snare risk, we created a presence in these areas through monitoring of cheetah, which allowed for detection of snares and deterrence of illegal activities near animals.

In the coming year we will continue this work in addition to surveying for additional cheetah in the far northern and western portions of the GLE.

Lion

Once down to a single female--the renowned late Lady Liuwa--the GLE continued to have a breeding pride of lions in 2020, now 12 strong with multiple generations of cubs. Three cubs were born from the pride female, and three coalitions of males were present.

Two subadult males dispersed from the pride early in the year, and like a similar coalition of males that left the pride in 2019, continued to roam in and around the park. The Liuwa pride male continued to spend most of his time with the females and cubs and protected them from multiple visits from the male coalitions.

As with prior years the pride spent most of their time in the scattered woodlands of the park's northeast sector, versus following the migratory wildebeest herds out on the shortgrass plains, where ambush cover and subsequent hunting success was likely to be low. The pride continued their patterns of residing throughout the wet season in the center of the park where the wildebeest spent the majority of the rains.

As the pride continues to grow there are numerous challenges with lion management, ranging from conflict with livestock to genetic considerations with inbreeding. To address these concerns, Liuwa's first Predator Management Plan (PMP) was finalized in 2020, providing the vision, goals, objectives and activities for lions and all large carnivore species in the GLE for the next 5 years. Given people and livestock reside throughout Liuwa, mitigating human-lion conflict was one of the highest priorities (see Human-Carnivore Conflict Mitigation), and multitude of initiatives are ongoing to address this and help ensure that the lion population remains a viable and important component of the Liuwa ecosystem.

Wild Dogs

Similar to prior years, wild dogs continued to be absent from the southern portion of the GLE. As part of the Liuwa Predator Management Plan (PMP) an assessment of the status of wild dogs in the northern portion of the GLE was planned in 2020 using detection dog surveys, but was delayed due to COVID-19 concerns. The survey is expected to be conducted in 2021 and is in collaboration with ongoing surveys in the adjacent Mussuma area of Angola, where wild dogs continue to be detected.

Given the strong dispersal abilities of wild dogs, recent ZCP analyses of their ability to move through human-impacted landscapes, and high genetic connectivity between Greater Kafue and Luangwa populations (see Large Landscape Conservation) the potential for natural recolonization of southern Liuwa remains high. However, an urgent need remains to address the continued threat of rabies posed by an estimated 7,500 unvaccinated domestic dogs in and around Liuwa Plain National Park.

A comprehensive vaccination plan will be launched in 2021 to encourage the recovery of wild dogs in Liuwa as part of the PMP.

Lions from the Liuwa Pride cavort on the plains before hunting. Once a single lioness, Lady Liuwa, the lion population has grown to over a dozen animals, necessitating a comprehensive lion management plan to guide future growth of the population.

Liuwa is the largest population of migratory blue wildebeest in the region, a keystone species for the ecosystem. It is also the focus of the longest-running, individually-based study of wildebeest and this work is done in concert with carnivore studies to help inform, guide and evaluate conservation efforts.

Herbivores

Large herbivores play critical roles in ecosystems through their impact on vegetation structure, diversity, nutrient cycling and as prey for carnivores. However, these species are also imperiled globally due to an array of human impacts, and migratory African herbivores are some of the most threatened.

We completed our 9th year of work in 2020 on the GLE's keystone herbivore, the wildebeest, intensively monitoring 35 adult cows, their calves, and their accompanying herds throughout the year to collect survival, reproduction, habitat selection and migration data for this recovering population. The GLE experienced above average rainfall for the 2019-2020 season, dispersing the wildebeest population and conforming to more typical migration routes and timings relative to the drought year of 2019.

Similarly, more solitary bulls and other large herbivores such as zebra remained in the southern portion of the park during the dry season, while the majority of the wildebeest population migrated to the northern parts of the park and the Upper West Zambezi GMA.

Together with the DNPW and African Parks we completed our first analysis of Liuwa wildebeest demography in 2020 and submitted it for publication. The study, entitled "Predation drives demography of a keystone migratory herbivore in a recovering transboundary ecosystem," evaluated survival and reproduction of wildebeest from 2012-2019 across 107 collared cows and their calves, and over 7,500 herd observations and compared this to findings from 12 aerial surveys. Adult survival was strongly age-dependent, with older animals being much more susceptible to predation, primarily by spotted hyena.

Predation was the primary cause of death and there was a significant increase in mortality risk during the wet season (27%) as well as in the southern portion of the wildebeest migratory range (45%). From essentially zero knowledge of the GLE wildebeest dynamics, this work now provides estimates of survival and reproduction, a plausible mechanism for the migratory tendency, and a robust foundation to evaluate potential restrictions in migratory range, climate change, predator-prey dynamics, and poaching.

Synthesizing our long-term wildebeest, flooding, vegetation, and fire work, we continued to work on a climate change barometer to effectively evaluate long-term changes in the climate of the GLE and the Upper Zambezi watershed and help predict changes for ecosystems and communities (see Large Landscape Conservation). This work continued to be facilitated through intensive monitoring of the wildebeest population using both fine-scale GPS collar data and more than 1100 ground-based sightings and 1062 herd composition counts over approximately 6000 km^2. Concurrent and similar work on large carnivores, as well as on human encroachment, environmental and biological variables continues to provide key insights into the GLE dynamics and help direct the actions needed to conserve this unique ecosystem.

Concurrent with our intensive wildebeest work, we also continued to conduct our tri-annual surveys of all large herbivores in southern Liuwa to evaluate changes in densities and distributions due to ecological and human factors. While wildebeest are a clear keystone species for GLE, numerous other resident and migratory species have important dynamics that both drive and are driven by other factors. With the expansion and intensification of our field effort in the north, similar surveys will be undertaken in the northern section of the park and GMA that comprises the wildebeest winter range.

Long-term demographic studies of wildebeest coupled with studies of carnivores, human impacts, and ecological change help guide science-based management of this transfrontier ecosystem.

Greater Kabompo and Greater Nsumbu

In addition to our three long-term study sites, we continued to work with partners in 2020 to upscale conservation work across Zambia's current and potential carnivore strongholds, as well as on the connectivity between them. The Greater Kabompo and Nsumbu Ecosystems are two former wildlife strongholds that have been heavily depleted due to human impacts, with carnivore species extirpated or severely reduced. However, they have great potential for wildlife and wildlife-based economies, and are now the focus of intensive restoration efforts.

In the Kabompo we continued to develop a long-term research and monitoring programme in concert with restoration efforts by the West Lunga Conservation Project, WWF-Zambia, and the DNPW. Our work formed part of WWF Zambia's integrated programme in the Upper Zambezi Landscape that seeks to provide key information towards ensuring sustainable natural resource use and biodiversity conservation management within the broader landscapes of Greater Liuwa and North-Western Zambia's Greater Kabompo Ecosystem (GKBE). The GKBE includes a well-developed protected area network consisting of West Lunga National Park, and adjacent Game Management Areas and Forest Reserves. Historically rich in the diversity and abundance of wildlife, the ecosystem has long been severely depleted by poaching and persecution as a result of human wildlife conflicts, and the impacts on wildlife and the extent of connectivity remaining between these areas and other ecosystems in Zambia, Angola and the Democratic Republic of Congo (DRC) is unknown.

The survey teams from DNPW, WWF-Zambia, West Lunga Conservation Project and ZCP.

West Lunga's first recording of spotted hyenas. Large carnivores have been absent for a long time and the discovery of a hyena latrine was a ground breaking first sign of the recovery of West Lunga NP.

In 2020 we completed a third year of ground-based wildlife surveys conducted bi-annually within and around West Lunga. The most exciting development was the detection of spotted hyena during the transects—the first evidence of large carnivores in West Lunga. The survey work and concurrent camera trapping work formed the graduate thesis of Copperbelt University student Esther Boomba (see Graduate Students). In a large landscape context we also completed an encroachment analysis of the surrounding landscapes potentially connecting to Greater Kabompo within Zambia, Angola and the DRC. The large corridor between Kabompo and the Greater Kafue Ecosystem forms one of the last intact and unrecognized areas of large landscape connectivity left in Zambia (see Large Landscape Conservation). We also made significant progress in the construction of a Climate Change Barometer for the GKBE and Greater Liuwa Ecosystem to assist in climate change predictions and adaptions for communities and wildlife. In 2021 we will continue to upscale work with a continuation of surveys and an expansion of camera trap work across West Lunga, in addition to assisting in developing science-based reintroduction plans, corridor protection, and climate change adaptation tools.

In the Greater Nsumbu Ecosystem we continued working with our partners Frankfurt Zoological

ZCP's Salia Phiri and Emmanuel Chibusa conduct ground transects for herbivores as part of the Kambompo surveys.

Society (FZS) and DNPW to assist in developing a research and monitoring programme to document and evaluate the impacts of the FZS-DNPW restoration efforts focused on Nsumbu National Park and the surrounding GMAs. This work built on prior surveys from 2017, and training and collecting camera trapping and herbivore data commenced in 2019.

In 2020 Dr. Egil Droge of Oxford University's WildCRU and ZCP worked with FZS Ecological Monitoring and SMART teams along with DNPW and community scout teams. As the ecosystem recovers with the substantial investments from FZS, DNPW and partners, these monitoring programmes will increasingly inform, evaluate and guide conservation efforts in this ecosystem. In 2019 three 100 km^2 grids were surveyed with a pair of camera traps in each of 25 four km^2 grid cells (5x5). Cameras were deployed for approximately 6 weeks, for a total of 5,020 nights. In total 38 species were recorded, of which 33 were mammal species. Hyaenas, servals and side-striped jackals were recorded, but not leopards or lions. Good populations of a diverse prey community were also present.

To increase the possibility of detecting large carnivores, grids sizes will be increased and additional cameras used to be deployed at opportunistic strategic locations, such as crossroads and big game trails.

Camera trap-based studies in the Nsumbu Ecosystem indicate a recovering preybase but few large carnivores save for spotted hyena. Continued conservation efforts by Frankfurt Zoological Society and the DNPW will further improve the conditions for restoration of big cats and other species.

Conservation Action

Key outputs 2020

- Conducted anti-snaring work across 3 ecosystems to help protect 930 large carnivores in 134 groups
- De-snared 10 large carnivores
- Conducted Human-Carnivore Conflict Mitigation Across 5 chiefdoms with 351 livestock owners
- Developed cutting-edge genetic tools to combat trafficking of big cats
- Developed climate change barometer to predict and adapt to changes for communities and wildlife
- Completed an analysis of trends and patterns of human encroachment across all of Zambia and parts of eight neighboring nations
- Continued connectivity and corridor protection work across three ecosystems

Anti-Snaring

The illegal bushmeat trade is one of the most pervasive impacts on large carnivores throughout their range in Africa. Wire-snare poaching is one of the most widespread methods of obtaining bushmeat, and this has diverse and severe impacts on carnivore prey populations, competitive interactions between species, and on individual survival due to snaring by-catch injuries and death. Consequently, combatting the impacts of snaring on carnivores is a fundamental objective of our conservation actions.

The economic impacts of the COVID-19 pandemic dramatically reduced tourism revenue and food security, and strained law enforcement resources, and there were spikes in bushmeat poaching across much of our study areas. We thus expected to have extremely severe snaring impacts on carnivores in 2020. However, owing to effective collaborations and support amongst partners and donors we were able to substantially mitigate snaring impacts across all sites. We detected 7 lions, 1 wild dog, 1 cheetah, and 11 hyena and successfully treated 2, 1, 0, and 6 respectively. This work consisted of intensive monitoring of carnivore groups utilizing radio collars, GPS/Satellite technology, and ground and aerial monitoring. Locational data from this work was provided to anti-snaring patrols in the Luangwa (DNPW-Conservation South Luangwa), Kafue (DNPW-Panthera, Musekese Conservation, Ntengu Safaris), and Liuwa (DNPW-African Parks) to direct efforts toward areas of high risk and high use for carnivores. In addition, full-time, field-based Zambian wildlife vets were a key part of each ZCP team and enabled us to effectively rescue snared carnivores and keep them on the landscape.

In the Luangwa we detected no snared lions for the first time in our history, and the lowest incidences of snaring of carnivores overall, with one de-snared. Given that bushmeat poaching and snaring were still serious threats in South Luangwa and increased during the pandemic, this success is likely due to significantly increased law enforcement presence by our partners Conservation South Luangwa and the DNPW, providing substantially more patrols, coverage, and deterrence across both the park and the GMAs. In addition, our novel COVID-19 community relief work with Clean Sweeps (see Empowerment) contributed substantially to reduce snaring impacts in and around the Mfuwe and Lower Lupande GMA. While this is good news, the impacts of the pandemic continue in 2021 and will require an increased effort and resources to maintain these trends.

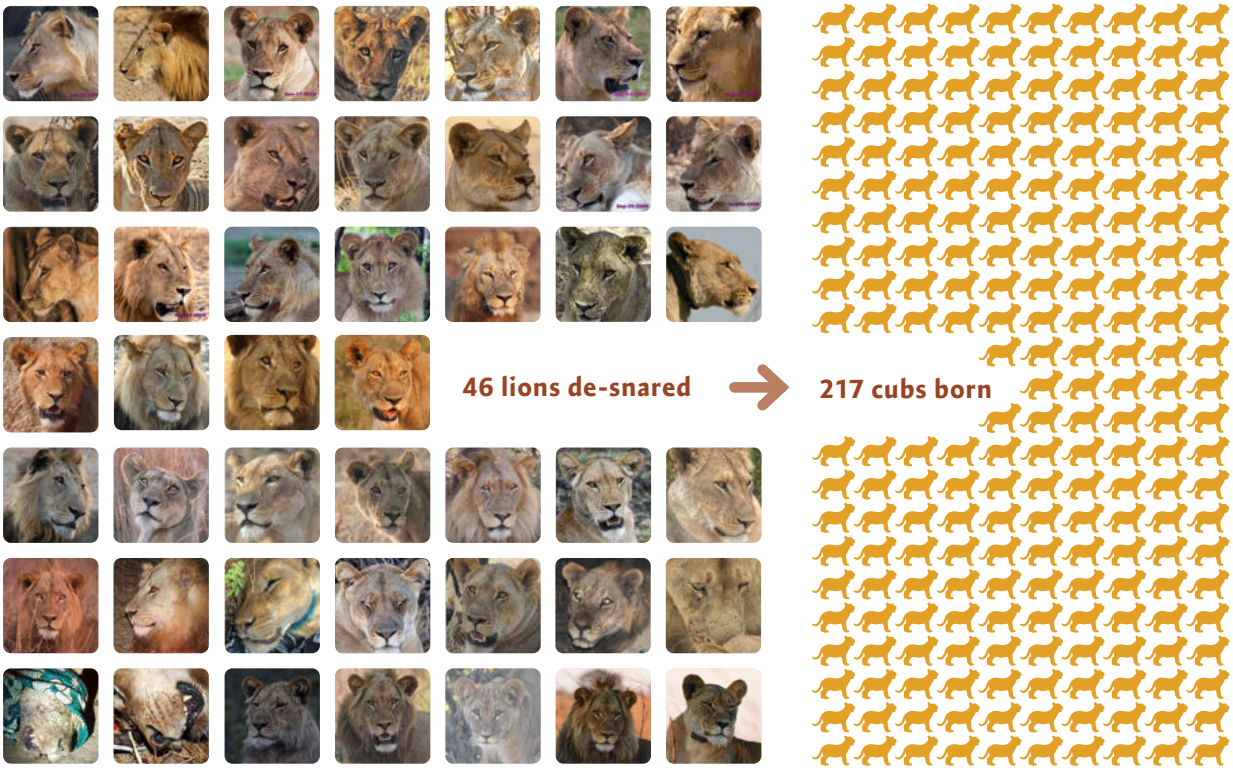
In the Kafue we de-snared two lions, both from the embattled Kasonso Pride (see Feature) that frequented the high-risk Kasonso-Busanga GMA and northern part of the park. An additional three lions and 1 hyena were reported snared in remote portions of the park not in our immediate study area. We also lost two study lions to poaching in the central area of the park early on in dry season. This alarming incident led to the formation of a Lion Monitoring Team in collaboration with Panthera and the DNPW that specifically focused on the 11 lion prides intensively monitored in the Northern and Central Kafue. This greatly increased the ability to regularly check lions for snares and provided a deterring presence in these areas. We continued our collaborative anti-snaring work across all species with the DNPW, Panthera, Musekese Conservation, and Ntengu Safaris. In

collaboration with ZCP, Panthera's Kafue Law Enforcement and Wildlife Support Program (KLAWS) supports DNPW to adaptively deploy its anti-poaching efforts in the 'Halo Approach' program. This approach integrates law enforcement efforts led by DNPW-Panthera teams with long-term, intensive monitoring of lion prides by ZCP-DNPW teams. Collectively, data from ZCP's intensive monitoring provided valuable information to KLAWS patrol planning to re-direct anti-poaching efforts on the ground to where it is most necessary, based on carnivore movements. This year, in 2020, the Halo Approach provided targeted anti-snaring protection to two cheetah dens, four wild dog dens, two lion dens, and 11 core lion pride areas.

Unfortunately, we continued to document an increase in wire-snare poaching across that GLE in 2020, though it is unknown whether this was related to the COVID-19 pandemic. Spotted hyena were hit particularly hard with snaring, and it is unknown whether this snaring was by-catch or targeted at the animals themselves. We detected 10 hyenas with snares or snare injuries and together with African Parks and the DNPW we successfully de-snared six.

A successfully de-snared hyena from Liuwa's North Clan recovers next to the removed snare. Hyena were heavily impacted by snaring in 2020, with six animals successfully rescued.

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 de-snaring.

Kasonso Pride enjoying the late afternoon sun. Three of the four lions in this photo have been de-snared by the ZCP-DNPW team. Though fierce and resilient, even the strongest of creatures need a little help sometimes...

The Kasonso Pride: A tale of strength, determination and a little bit of help!

A single female lioness fending for herself and her offspring on the fringes of the Kafue National Park, in the rugged Kasonso-Busanga Game Management Area (GMA). Though a beautiful landscape, it is fraught with peril. The region has battled a long history of heavy poaching, and it is a difficult place to survive as a lone lioness, let alone one trying to raise cubs on her own. A single poacher's snare could mean the end of her life and the life of her offspring…

We first found the matriarch of the Kasonso pride when conducting "call-ins" in the in the Kasonso GMA as part of our work expansion into this area. By using large speakers to play the recordings of lion roars and the sounds of dying prey, these "call-ins" help us find un-collared lion groups, who are attracted by the curious sounds. There were not many lions in the GMA and after many unsuccessful nights some appeared. When the matriarch first approached the call-in, she was accompanied by two big male cubs. After successfully collaring her, our conservation work with this pride began… and so to, did our respect for this truly special lioness.

Kafue Lion 992, as she is called in our database, has the largest home-range of any monitored lion in the Greater Kafue Ecosystem. Her home-range is so massive that is spans the National Park, the Kasonso-Busanga Game management area, and a nearby neighboring small community reserve. But unfortunately, all of her ~2000 km2 range is under heavy threat of bushmeat poaching and snaring. To date, our partners Ntengu Safaris and the DNPW have already removed over 1000 snares from the area. Navigating this literal minefield is no small task, but not only does 992 manage to keep herself alive and unharmed, but she also manages to provide for and protect her offspring.

Lion 992 is a ferocious mother. At the end of 2018, she gave birth to three new cubs, bringing the pride total to six. During the rainy season, heavy flooding across the region prevents us from monitoring the pride on the ground. During that time, we could only monitor the GPS locations sent from her satellite tracking collar. She was making massive movements outside the protected areas, which worried us greatly. Unfortunately, such wide-ranging movements like this usually indicate that she lost her cubs – a sad but common reality for lions, especially single mothers. But when we could finally access the GMA in June of 2019, we were shocked to find not just a healthy matriarch and one of her older male sons, but that all three cubs were still by her side!

Yet delight immediately turned to horror when we discovered that one of her cubs was actively caught in a poacher's whipsnare! The tiny lion was still attached to the snare pole, which was buried deep in the ground, pinning him to that location. Being a small cub, he was too weak to break free. Thankfully the ZCP-DNPW team was able to remove the snare, and the young male cub has since made a full recovery.

Sadly, two months later during another routine monitoring check, we found that the older subadult male (Lion 994) had also picked up a snare. Because he was already adult-sized, he had been able to break free from the snare pole, but the wire was still wrapped tightly around his foot and cutting deep into the muscle, thereby cutting off critical circulation. Though the snare wound was likely only one week old, our veterinarian Dr. Kambwiri Banda estimates that without rescue, he would have lost his paw within another week's time. Luckily, our team jumped into action and were able to immobilize Lion 994 and successfully remove the snare. We are happy to report that he made a full recovery.

At the beginning of 2020, the Kasonso matriarch made it through yet another perilous rainy season with all four of her offspring. She is probably the most incredible, fierce, protective, and cunning lioness that we know of. But despite all of her tenacity and strength, the pride has still found trouble… and will unfortunately continue to do so, given the sheer amount of poaching that continues to plague the area.

In late July 2020, the subadult Lion 994 was again entrapped in a snare, this time along the southwestern extents of the Busanga Plains. This time the snare was wrapped around his other front leg and had cut significantly deeper. Luckily ZCP-DNPW teams were able to remove the snare that same day, and he made a full recovery. Twice snared, twice de-snared.

And sadly, not two weeks later, the matriarch herself finally became victim to these dangerous devices. When we found her resting on a large anthill, a snare wire was biting deep into her front paw. But luckily, the ZCP-DNPW again came to the rescue, and we managed to successfully remove the deadly snare. By the next morning she had already moved 5km, and as a testament to her strength… she wasn't even limping.

By the end of 2020, the Kasonso Pride was five members strong and all were in excellent health.

And on November 20th 2020, Lion 994 – the matriarch's twice de-snared son – began the next chapter of his life. He left his mother and siblings in search of a new pride to call

home, to father his own offspring and begin his own legacy. To date, his dispersal movements have now exceeded 300km, and we look forward to seeing where his journey takes him!

The Kasonso pride is a prime example of why we conduct our intensive monitoring work. Even though Lion 992 is perhaps the most capable lioness we know of, in this day and age – with human pressures around every corner – even the toughest lions need a small bit help. And that is precisely why her monitoring collar is so valuable. Without a tracking collar, it would be impossible to find 992 and regularly monitor her and the pride to check for snares and collect valuable data that will aid in the long-term conservation of the species. And without the collar, there is no doubt that she would have lost both her male offspring in the span of two months, and that she herself would have eventually died from infection or starvation. And the collars even help further: not only has this collar saved her life and the lives of her sons, but it has also aided in the planning of anti-poaching scout patrols, that are helping to remove snares from the landscape. With the use of the location data sent to us by the collars, we are working with patrol teams to set up a halo of protection around the core areas that the Kasonso pride uses. This will help ensure that this resilient and strong family stays safe for years to come.

How Much Is One Dog's Life Worth?

WILD DOG 73

Rescued from a lethal snare in 2014

At Least 16 Additional Packs formed from Dispersing Offspring

At least 208 pups, grand-pups and great-grand pups

Packs have populated throughout the Luangwa Valley

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.

A wild dog pack hunts down Kafue's highspeed M-9 highway. Road kills of dogs and other carnivores are a signficant source of mortality in the Kafue and elsewhere in Zambia.

Working with partners road signs were designed and placed along the M-9 in areas of high risk for carnivores.

The majority of snared hyena were in clans that resided in close proximity to the communities living in and around the national park. The North Clan in particular was severely impacted, and we have documented a decline in numbers from 33 animals in 2018 to 20 animals in 2020. This is likely due to intensive snaring impacts. Hyenas are extremely prone to snaring impacts, can be targeted directly with snares by livestock owners, and are very slow to recover demographically from elevated levels of mortality.

While cheetah generally fared well in 2020, human impacts on this small transboundary population continued to have severe consequences. For the fourth-straight year we lost a female cheetah to poaching. This year a sub-adult dispersal female monitored since birth died, likely due to getting caught indisriminately in a wire-snare. Her sister managed to survive on her own and has made it to adulthood. However, snaring remains a serious and increasing threat to cheetah and Liuwa's recovering carnivore populations in general.

A bright spot for anti-snaring work in Liuwa was the hiring of a full-time field-based vet. Dr. Brian Musalo joined the team in June 2020 and rapidly acquired experience in carnivore work (see Wildlife Vet Training Programme). Dr. Musalo's presence on the teams enabled us to rapidly respond to snared animals upon detection, greatly improving prospects for mitigating snaring impacts on Liuwa's carnivores. In addition, Dr. Musalo oversaw disease mitigation programmes, assisted in human-wildlife conflict mitigation work, and served as a veterinary extension specialist for local communities as part of the Liuwa Predator Management Plan (see Human-Carnivore Conflict Mitigation).

Road Impacts

Our ongoing work on human encroachment trends and patterns (see Large Landscape Conservation section) highlights the impacts of roads and road improvements as key drivers of habitat loss, but roads can also have a strong direct impact on carnivores through roadkills. Particularly in Kafue, where the high-speed M-9 Highway and other tarmac roads bisect and border the national park, roadkill impacts can be significant.

In 2020 we documented one wild dog, one lion cub, two hyenas, and at least two leopards killed by road collisions along the nearly 200 km of highspeed M9 highway. In 2020, ZCP joined the new "M9 Working Group" in the GKE community. As part of this endeavor, we helped design new road signs that were placed along

core wildlife movement corridors along the M9, in an effort to help reduce the number of animals hit and killed by speeding cars. While signage is important, much more work remains to be done to reduce wildlife mortalities from vehicle strikes, and ZCP continues to be an active member of this working group, and is currently supporting an initiative by DNPW to secure autonomy in enforcing speeding regulations within the park.

Wildlife Crime and Trafficking in Big Cat Skins and Parts

Illegal wildlife trade in the form of trafficked big cat skins and parts is becoming more widespread throughout Africa. Given Zambia borders eight countries and is situated between Eastern and Southern African carnivore strongholds--in addition to being a stronghold itself--the potential for illegal trafficking is high.

We continued to make progress in 2020 on collaborative anti-trafficking work with the DNPW, Wildlife Crime Prevention, TRACE, the University of Zambia, and several dozen rangewide partner organizations and projects across all the stronghold countries for big cats. Our work centered on three main objectives:

1) Continuing to develop genetic tools to identify source populations of big cats for law enforcement intelligence
2) Continuing to build in-country capacity for forensics and prosecution of wildlife crimes with genetic tools, and

3) Utilizing and providing these tools to partners to protect at-risk populations.

Following the successful development of a cutting-edge genetic tool for lions, the SNP Chip, we successfully developed a SNP Chip for leopard in 2020 as well. These tools enabled the extraction of high-quality genetics data from low quality samples, such as is common in trafficked skins and parts. It also enabled a significant expansion of baseline genetics information for tracing seizures to big cat populations, given that scat can now be used to generate high quality genetics data.

In 2021 we will be finalizing the SNP Chip for cheetah and thereby creating the best possible genetics tools for law enforcement intelligence for the three most-trafficked species.

In addition to this work we continued our collaboration with TRACE and the University of Zambia to develop forensics capacity for trafficking prosecutions. With our long-term work on big cats ongoing, we were able to provide genetics samples with which forensics methods and databases could be built upon.

We also assisted in the sequencing of the leopard genome across the entire range of variation (see Scientific Publications), allowing substantial advancements in the utility of our intelligence and forensics-related genetic tools for combatting trafficking.

Trafficking of big cat skins and parts has increased across Africa. In 2020 we developed tools to trace trafficked skins and parts back to their populations of origins as part of a collaborative effort with the DNPW, Wildlife Crime Prevention, TRACE and the University of Zambia to combat trafficking of big cats.

Large Landscape Conservation

Zambia – and most of Southern and Eastern Africa – is characterized as a dryland ecosystem. These are extremely seasonal areas with dramatic fluctuations in rainfall, water and resource availability. Consequently, wildlife and people are dependent on mobility, both to adapt to these seasonal fluctuations, and to adapt to ever-increasing human impacts, particularly climate change.

Gathering clouds over the Liuwa Ecosystem. Integrated work on large mammals, human encroachment, connectivity and climate change help conserve the large landscapes in Zambia and the region.

The Importance of Connected Landscapes

Having been absent for the past 14 years, elephants briefly returned to Liuwa Plain National Park in 2020! While reintroductions and restockings of wildlife are popular and supported throughout Africa's ecosystems, the importance of natural recovery and recolonization should be prioritized through maintaining connectivity and large landscapes through which animals can move and disperse in the manner that populations likely behaved historically. While we don't know what the future holds for elephants in Liuwa, the fact that Zambia still retains large tracts of connected, relatively intact land makes it of critical importance for conservation planning!

Through a public-private partnership with Zambia's Department of National Parks and Wildlife, African Parks Network and the Barotse Royal Establishment, the greater Liuwa area has received considerable resource protection and still remains connected to broader landscapes in the region.

Large landscapes are becoming increasingly fragmented worldwide, making connectivity of critical importance. In addition to supporting numerous large carnivore strongholds, Zambia lies between Eastern and Southern Africa, borders 8 countries, has large tracts of connected and unfenced protected area networks, and is the source of some of the region's major watersheds such as the Zambezi and Luangwa. Utilizing a diverse and integrated array of methodologies and collaborations we made significant progress on our large landscape conservation work in 2020.

Climate Change

Climate change is expected to significantly alter ecosystems throughout Southern Africa, and there has been considerable interest and investment in developing strategies for communities and wildlife to adapt. In the Upper Zambezi Watershed strong seasonality makes mobility critical for adaptation. We continued to make progress on the construction of a Climate Change Barometer in 2020. This tool identifies and standardizes data inputs and sources for precipitation, temperature, flow, flooding, and fire in both the Liuwa and Kabompo Ecosystems. The Barometer will then allow for forecasting and evaluations of climate change impacts while improving preparedness for communities and managers.

Human Encroachment, Land Use Change, and Corridor Protection

In the age of rapid, human-induced ecological change, habitat fragmentation is rapidly dimin-

ishing the available habitat for large carnivores and their prey, and severing connectivity vital for the sustainability of populations. Human encroachment and land-use change trends and patterns are vital to understand for large landscape conservation, but difficult to quantify. In 2020 we completed an analysis of human encroachment for all of Zambia, as well as the connectivity between the Upper Zambezi watershed and neighboring Angola and Democratic Republic of Congo. This work quantified trends and patterns of encroachment over the last several decades, and identified key corridors remaining between protected area networks. One of the most important corridors remaining in Zambia that has received little attention is the Kafue-Kabompo corridor between the Greater Kafue Ecosystem and the Greater Kabompo Ecosystem. This corridor will be the focus of increased conservation efforts in the future to protect this important connectivity.

Large Carnivore Connectivity and Dispersal

We continued to make significant progess in evaluating large carnivore dispersal and connectivity across the range of large carnivores in 2020. We conducted genetic work through the African Carnivore Connectivity Project, a collaboration between institutions, departments and carnivore conservation projects and organizations across Southern and Eastern Africa. The project has three main objectives, namely 1) Developing genetic tools to combat wildlife trafficking (see Wildlife Crime), 2) Evaluating and conserving genetic connectivity between carnivore populations, and 3) Improving the means of population monitoring through genetic tools. We continued to evaluate genetic connectivity across all large carnivore species in Zambia and developed SNP Chips for lions, leopard, wild dogs and spotted hyena, with cheetah in development. These SNP Chips enable high quality genetic data from low quality samples such as scat. The ability to get high-quality genetic data from scat for the large carnivore guild now provides a simple and cutting-edge tool for evaluating connectivity across large landscapes, which is the ongoing focus of this work.

Concurrent with the genetic connectivity work, we continued to make progress evaluating spatial connectivity and dispersal of large carnivores from GPS/Satellite collared animals in our three long-term study sites. In 2020 we completed a study on wild dog movements in the Luangwa Valley in relation to the human impacts. The study was published in Nature Scientific Reports and entitled "Hidden Markov Models reveal a clear human footprint on the movements of highly-mobile African wild dogs." Using GPS

Kafue wild dog pups on the alert. Most wild dogs leave their natal pack between 1-3 years old, dispersing widely, sometimes over several hundred kilometers.

Long-Distance Dispersals of Dogs and Lions in the Greater Kafue and Beyond

We continued to document large-scale dispersals and movements of wild dogs in the Greater Kafue Ecosystem, with the most dramatic being a group of males from Twin Palm pack. We were able to track their wide-ranging movements thanks to the GPS/Satellite collar fitted on the group. Upon leaving their natal group, the dispersers first struck west, out of the famous Busanga Plains into the Kasonso-Busanga GMA. Within four days they had already traveled more than 85 km, at which point they began encountering human settlements from the regional community Kaoma. The males then began moving north, covering another 70+km before entering the Shinganda Conservancy. Somewhere along this journey, the males met up with an unknown young female, thereby creating a new pack! This new group spent the next few weeks exploring the region, going 60+km north of the conservancy base before returning. At their northern-most point they were approximately 60km northwest of Kafue National Park, which put them only 80km south of West Lunga National Park! Unfortunately, at this point the collared dog and potentially others were killed in a poacher snare set in the conservancy. Such movements demonstrate the incredible dispersal capabilities of this species, the threats facing dispersers, and the importance of large landscape conservation and connectivity.

But dogs were not the only wide-ranging Kafue carnivores in 2020. This year we also documented the successful dispersal of an impressive young male lion, known as Lion 994 (see Kasono Feature). This young male is no stranger to ZCP; a member of the Kasonso Pride from the Kasonso-Busanga GMA and western Busanga Plains, ZCP had already de-snared KLI-994 twice the past two years. After finally leaving his mother in early December 2020, he dispersed a minimum of 175+km before being seen again along the M9 highway in central Kafue! Even more surprising than his journey was his company; upon leaving his mother, this young male was thought to be traveling alone. But when he was sighted on the M9, he was in the company of Lion 909, a much older male from the Red Rocks coalition in northern Kafue – an 8+ year old male that had not been seen since 2017! Lion 994's dispersal event has now exceeded 200km, highlighting the importance of large-landscape conservation work, demonstrating the incredible mobility of this iconic species, and suggesting there remains strong connectivity within the GKE's core lion population.

data from resident and dispersing wild dogs it was found that there was a clear impact of human activities and impacts (collectively known as the human footprint) on the movements of wild dogs. Such findings have significant implications on both protecting connectivity and understanding dispersal across different species within the large carnivore guild. Similar studies are ongoing with wild dogs in the Greater Kafue, as well as additional carnivore species. Together with genetic, human encroachment, and corridor evaluations we continue to better evaluate, understand, and protect connectivity critical to wildlife and communities in a rapidly changing world.

Human-Carnivore Conflict Mitigation

Behind bushmeat poaching, human-lion conflict is estimated to be one of the biggest threats rangewide. While conflict in our study systems was historically minimal due to the prevalence of tsetse-fly borne livestock disease, rapid changes in human demographics and tsetse control have resulted in dramatic increases in livestock in many areas. Consequently, we continued to upscale and strengthen our human-carnivore conflict (HCC) mitigation work in 2020, particularly as the pandemic's economic impacts strained food security for many communities.

We successfully continued our Human-Lion Conflict Mitigation Programme in South Luangwa—an integrated collaboration between the Department of National Parks and Wildlife (DNPW), Conservation South Luangwa (CSL), the Zambian Carnivore Programme (ZCP), and local communities, traditional leaders and Community Resource Boards (CRBs). As a new programme addressing a rapidly growing problem, we encountered numerous challenges and setbacks but built a strong foundation of mitigation work.

This work included improved and incentive-based husbandry techniques, designing and implementing early warning and aversive conditioning work for at-risk prides, community outreach and education across 5 chiefdoms and utilizing SMART-based monitoring and evaluation methods. Together with partners we conducted 21 sensitization programmes to nearly 8,600 people and held 27 different meetings with tribal leaders and CRBs. We also worked with 351 livestock owners to develop a livestock register, enabling us to better evaluate the distribution of stock and the dynamics of conflict.

With changing human and livestock demographics this work will continue to increase both in importance and in the myriad challenges to mitigate lion conflict with communities, further emphasizing the importance of having a programme in place upon which to build.

Inadequate livestock husbandry such as poorly-constructed bomas encourage lion predation. Working with Conservation South Luangwa, the DNPW and community leaders we significantly improved the bomas used to house livestock, leading to a decrease in lion predation. Additional boma models are being designed and trialled for 2021.

ZCP Human-Wildlife Conflict Mitigation Officer Dennis Zimba works with livestock owners to explain the use of noise-makers and solar lights in deterring lion predation.

Community members receive benefits from a performance payment pilot project conducted by Conservation South Luangwa, ZCP and DNPW using track beds to detect wildlife. Modeled after our colleagues in the Ruaha Carnivore Project, the initiative rewards communities based on the abundance and diversity of wildlife detected by surveys in their area.

In Liuwa we continued our collaborative lion conflict mitigation work with African Parks, the DNPW, the Barotse Royal Establishment, and local communities. As the Liuwa lion pride grows (see Liuwa Lions section) dispersing male lions in particular have become problematic with cattle predation. In mid-2020 we supported the second workshop for the Liuwa Predator Management Plan (PMP), which was attended by 11 different stakeholder groups who collectively reviewed and finalized the proposed plan. A detailed Human-wildlife conflict mitigation strategy is a core aspect of this plan, with lion conflict mitigation the most important component. This work will be continued to be rolled out in 2021 to better mitigate the continued lion recovery.

Disease Control and Mitigation

Much of Zambia's protected area networks include human-impacted landscapes, particularly in Game Management Area (GMA) buffer zones surrounding and linking national parks. Consequently, these areas also are an interface for disease transmission, particularly with unvaccinated domestic dogs as a reservoir for highly contagious and dangerous diseases such as rabies, which threaten people and wildlife alike. Across all sites we have documented disease, with sometimes catastrophic consequences, and consequently disease control and mitigation plays an ever-increasing role in conservation.

In collaboration with Conservation South Luangwa, we continued our rabies vaccination campaigns in the Luangwa, vaccinating 257 domestic dogs and cats and spaying and neutering 84 dogs and 18 cats from the local communities. The long-term goal of the spaying and neutering programme is to limit the number of dogs and cats to only those owners can effectively care for, thereby reducing the risk of disease transmission in both animals and humans.

For 2021, we plan to intensify our domestic dog and cat vaccination programmes. Vet student Mercy Njobvu has been awarded a grant by the National Geographic Young Explorers programme (see Women in Wildlife Conservation section), and the grant funds will be used to vaccinate dogs in South Luangwa's Mambwe District.

In Kafue we fortunately did not detect additional rabies outbreaks, and the 2019 outbreak was traced to domestic dog populations in the GMAs. Consequently, in concert with partners we continue to seek support for large-scale rabies vaccination campaigns for domestic dog populations surrounding the national park.

In Liuwa we finalized the Predator Management Plan in 2020, which includes implementing a domestic dog vaccine programme to mitigate the risk of rabies to people and wild carnivores, and domestic dog vaccinations will be rolled out in 2021 as part of this plan. The GLE has had frequent incidences of rabies in domestic dogs over the last six years. Most domestic dogs are unvaccinated, and there is an estimated 5460-7560 dogs in and around the park alone.

Senior Ecologist and Education Coordinator Bridget Mayani (L) heads out into the field with Field Ecologist and Conservation Biologist Training Programme Graduate Peter Musenge. Despite the pandemic we were able to continue our field training programmes with increased restrictions to limit exposure and transmission of COVID-19.

Empowerment

Key outputs 2020

- 119 Community Game Drives hired for 813 community members
- Over 300 Community Clean Sweeps Employing over 700 People
- 11 Conservation Club Programmes to 390 students
- 14 Zambian trainees in Women in Wildlife Conservation, Conservation Biologist Training Programme and Wildlife Vet Training Programme
- 6 Zambian students supported for university degrees in wildlife conservation
- 3 Zambian students supported for graduate degrees

time. Together with our long-term partner Conservation South Luangwa, and with the support of the Lion Recovery Fund, we initiated two new community support initiatives to help mitigate the economic and ecological impacts of the pandemic. These initiatives—Community Game Drives and Community Clean Sweeps—helped provide badly-needed income to community members while increasing conservation impacts through outreach and education as well as reductions in snaring.

Community Support in the Time of the COVID-19 Pandemic

The pandemic brought wildlife tourism in Zambia, and throughout Africa's ecosystems, to an almost complete standstill. The economic impacts from the loss of tourism and from the pandemic in general led to widespread unemployment, food insecurity, and increases in bushmeat poaching. In the country's premiere wildlife tourism area, the South Luangwa Valley, an estimated 1,000 safari industry people were unemployed in 2020, or at home on reduced wages, with large numbers of dependent family members.

While tourism will recover, it was essential to provide support for communities during this

Community Game Drives

Over 20 lodges and several dozen bushcamps are typically operating in South Luangwa; thus the loss of safari tourism in 2020 hit the area's guides hard, with most unemployed or on reduced wages. In addition, there were few safari vehicles in the park, which provides an important presence and deterrence for poaching. At the same time, while communities live on the edge of the South Luangwa National Park, few have the opportunity to visit and enjoy the safari experience. Thus, the pandemic created a unique situation and potential opportunity to help mitigate the economic and environmental impacts that ensued. Together with Conservation South Luangwa, we worked with the Luangwa Safari Guides Association and lodge

operators to conduct Community Game Drives. Local safari guides were hired to take community members on a safari drive similar to what safari clients would experience, and also discuss the importance of conservation work and wildlife tourism. Community members ranged from traditional leaders and Community Board Members, to local business owners, students and women from the local markets. A total of 119 game drives for 813 community members were conducted in 2020. Participants were from five of the surrounding chiefdoms and ranged in age from five to 85 years old, with 58% female. For nearly 60% of the participants it was their first time in South Luangwa National Park on a game drive. The initiative was very successful and is now a core part of our community work going forward into 2021 and beyond.

Community Clean Sweeps

The loss of tourism in South Luangwa also resulted in the loss or reduction in employment of most staff that worked in lodges and bushcamps. Consequently, in addition to our Community Game Drive initiative, we partnered with Conservation South Luangwa to implement a Community Clean Sweeps Initiative aimed at providing community members employment while reducing the impacts of snaring and litter in the Lower Lupande Game Management Area. Accompanied by a DNPW wildlife police officer, community members were hired to conduct sweeps for litter, snares and other items in the areas in the natural areas outside of Mfuwe and around the GMA. Over 300 clean sweeps were conducted in 2020, which employed over 700

With the pandemic resulting in over 1,000 people unemployed or on reduced wages together with Conservation South Luangwa we implemented: A) Community Game Drives employing local safari guides to take 813 community members into the park on 119 game drives. For nearly 60% of the people it was their first time in the park. B) Community Clean Sweeps: Employing over 700 community members to conduct over 300 sweeps for litter and snares in the areas surrounding the park.

Developing Local Leadership in Conservation: How it all Fits Together

Thandiwe Mweetwa and Henry Mwape both grew up in the villages bordering South Luangwa National Park. They both became passionate about wildlife and conservation as secondary school students through Chipembele Wildlife Education Trust's Conservation Club programmes, and both pursued university degrees in wildlife-related fields. During their term breaks they began to work with ZCP as student interns, and both soon became seasoned researchers, working their way up to Ecologists and Educators. Both earned their Master's degree in the United States with ZCP, working on Luangwa lion dynamics.

Coming full circle in 2020, Thandi and Henry now manage the country's longest-running carnivore conservation project in the Luangwa—and one of the region's longest running projects—in the place where they grew up. Utilizing their stories and experience they continue to upscale ZCP's conservation impact and serve as inspirations and role models to aspiring young local conservationists.

Henry Mwape (L) and Thandiwe Mweetwa grew up outside South Luangwa National Park, and now manage the country's longest-running large carnivore conservation project.

Secondary school Conservation Club students take part in ZCP-Chipembele's science programme. Due to school closures and COVID restrictions programmes were limited in 2020.

ZCP Liuwa Senior Ecologist and Education Coordinator Bridget Mayani runs the Conservation Club activities with students from Mishulundu School.

people from the surrounding communities. In addition over 450 snares were recovered, playing a key role in reducing snaring impacts on carnivores and other wildlife (see Anti-Snaring), while providing important employment at a challenging time. The success of this initiative has also ensured it will be continued through 2021.

Primary and Secondary School Programmes

The COVID-19 pandemic severely affected our primary and secondary school programmes in 2020. Students in our programmes across Zambia's carnivore strongholds started the year meeting on a regular basis, learning core skills necessary for advanced education and employment opportunities following graduation. These programmes ground to a halt in early 2020 as the pandemic spread through the region. Schools were shut for much of the year beginning in April, and when they re-opened students and teachers were often unavailable due to the need to recover lost classroom time and pandemic restrictions.

Despite the challenges and limitations, we were able to continue with our programmes in a limited capacity, conducting 11 programmes to 390 students across all three sites.

In the Luangwa we continued the Field Ecology Club Project in collaboration with Chipembele Wildlife Education Trust. This programme worked with secondary school Conservation Clubs at Mfuwe and Yosefe Day Secondary Schools, and is designed to give students the opportunity to learn concepts about protected area management and reserve design, connectivity, the importance of land use planning and safe coexistence with wildlife. The project was also going to allow them to further develop their field research, spoor/track identification, computer and public speaking skills. However, this programme did not run smoothly due to the pandemic, and was put on hold following school closures. We are hopeful that the programmes will resume in 2021.

Similar to the Luangwa, Kafue Conservation Club programmes remained primarily closed in the throughout 2020. Our longstanding partnership with Treetops Schools was on temporary hiatus, as schools did not elect to send their students to the remote camp. But ZCP's new Education Coordinator, Kachama Banda, continued actively developing curriculum for the new Conservation Club that we plan to launch at the Mukambi School in 2021. And in late 2020, ZCP partnered with Green Safaris and By Life Connected (BLC) to prepare curriculum for a new Conservation Club that was launched at the Lukanga school in the Nalusanga community. This community is located in the Mumbwa GMA at the eastern gate of Kafue National Park, and in its first few sessions, the club has already attracted over thirty grade seven students, and has been tremendously popular with the community. In collaboration with BLC and Green Safaris, we hope to support the continued expansion and growth of additional conservation clubs in the neighboring GMA in the coming year as school schedules normalize.

In Liuwa in 2020, we continued to build upon prior years' work. Despite the challenges such as floods and the COVID-19 pandemic, which prevented us from reaching the schools as planned, we managed to work closely with Mishilundu School inside the park and to expand the Liuwa Conservation Club Programme that was initiated in 2016. This year, we established Conservation Clubs at Sibemi Primary School, which is situated in the middle of the park and Nalionwa Secondary School in the Kalabo district. At Sibemi Primary, Nalionwa Secondary and Mishulundu Schools we conducted several lessons and activities with approximately 100

DNPW-AP Wildlife Police Officer Chisola Sibemi takes students from schools in and around Liuwa out in the field to study carnivores as part of the Introduction to Conservation internship programme initiated in 2020.

students. Conservation Club days ranged from outdoor activities to conservation quizzes to wildlife related discussions and presentations. With COVID-19 regulations in place all activities were facilitated according to proper safety standards to minimize exposure and transmission.

Our biggest success this year in Liuwa was the start of the "Introduction to Conservation Internship Programme" for secondary school graduates, most of which were part of the conservation clubs in their respective schools. The program's aim is to expose young people to wildlife and conservation research. Conservation careers are not well known to most young people in Zambia despite them having a passion for it. With the help of African Parks (AP), eight students were selected based on conservation interest, academic performance, motivation and fluency in English. We introduced the interns to both field work and other field related aspects of our work. We covered a broad spectrum of various subjects to provide skills training that can be used both personally and professionally. Liuwa continued to have Copperbelt University graduate Bridget Mayani on the team, who was busy in her roles of both Ecologist and Education Coordinator. As an alternative to normal Conservation Club days in the village school, Bridget coordinated a Conservation Intern programme in which three girls took part. During this period, they learned all about the work ZCP does, conservation and wildlife. Furthermore, the interns did daily activities and assignments and wrote an exam at the end of their programme.

Citizen Science

With the severe downturn in tourism resulting from the pandemic, safari-guide led citizen initiatives were not as expansive compared to past years. Nevertheless, we still had substantial contributions from members of the Luangwa Valley Carnivore Monitoring Programme (LVCMP), and Kafue Carnivore Coalition (KCC) and the Liuwa Carnivore Monitoring Programme. The LVCMP, in partnership with the South Luangwa Professional Guides Association, did not run its usual capacity in 2020. However, we continued to receive reports from operators throughout the Luangwa Valley mainly from camp managers and staff that remained in lodges. In addition, we partnered with Conservation South Luangwa and were able to continue receiving reports through the Community Game Drives initiative (see COVID Community Support section).

Despite the hit of COVID-19, we continued our longstanding partnership with Panthera to run the Kafue Carnivore Coalition (KCC), compiling and identifying citizen science data, and receiving strong engagement from the few guides and lodge owners still operating through the pandemic.

We also designed three new posters for participating lodges to display that highlighted three core topics of the KCC initiative: the concept and purpose of the KCC initiative, how to take a good carnivore ID photo for conservation

ZCP-DNPW team members staff an informational booth as part of Youth Day in Zambia, recognizing the pivotal role of young people in conservation.

ZCP Luangwa Assistant Manager Henry Mwape (R) speaks with a livestock owner on human-lion conflict issues.

The local theatre group SEKA performs a skit on human-wildlife conflict mitigation for community members. In collaboration with Conservation South Luangwa and the DNPW plays were conducted on a variety of conservation topics.

purposes, and the importance and utility of tracking collars for conservation work.

Citizen science work in Liuwa was significantly curtailed through much of the year with limited tourism but we still continued to work with operators and tourists to collect sightings data.

Community-Based Education

Throughout the year ZCP participated in a number of community-based education activities with the goal of sharing knowledge and information on carnivore conservation, including the threats they face and what can be done to help protect them and their natural habitats.

Because most of our programs rely on close interaction with community members, COVID-19 safety regulations restricted the type of work we could do in 2020. Therefore, we had to cancel a number of our annual events and modify others. Earlier in the year, before gathering restrictions were put in place, ZCP attended the district celebrations of International Women's and Youth Day. We had a stand where we shared information about the organisation's conservation work and the various capacity building programs that we run. We also had a drama performance highlighting the impact of wire snares on carnivores. We postponed our March monthly radio show to April as we figured out transmission amidst the COVID-19 outbreak. However, follow up shows were recorded as normal.

The majority of our education and outreach work was done mostly through radio for the rest of the year. We began co-hosting the Conservation Hour radio program at Mnkhanya FM with CSL, CWET and DNPW. During our segments of the show we covered a wide range of topics including the role of young people in conservation, conservation status of Zambia's large carnivores, the significance of the Luangwa Valley for carnivore conservation in Zambia as well as the challenges and opportunities that come with living with carnivores. Human-Carnivore Conflict (HCC) emerged as one of the major topics of our radio program and we shared information on personal safety around predators and carnivore conflict mitigation methods (see HCC section). We also partnered with CSL to start a radio program recorded in the field aimed at bringing out community perspectives on HCC and facilitating knowledge sharing among subsistence crop and livestock farmers in different chiefdoms on effective conflict mitigation methods.

Soccer activities were suspended most of the year due to the pandemic. Because of this we were not able to host our annual Carnivore Conservation Cup (CCC). However, we were able to do a few activities with the Mimbulu Soccer Academy when COVID-19 restrictions were relaxed towards the end of the year. Mimbulu saw a high number of kids wanting to participate in this year's Mimbulu Soccer conservation activities, but we could not do a lot of activities as we were following the health guidelines announced by the ministry of health.

The conservation ambassadors of Mimbulu Academy attend a series of football games in Chipata as part of their community outreach work.

Hence, we were only able to do five sensitizations through songs as Mimbulu participated in Independence and Christmas tournaments. This reached out to almost 1000 people within the Valley. They used the sound system to deliver the message through songs and speeches.

We also had banners to display highlighting the threat of snaring among others to wildlife including carnivores. In addition, we continued carrying out our anti-litter campaigns and sensitizing the community about how detrimental plastics are to wildlife. The team did this when they traveled to Chipata for the first time to play with soccer teams in Chipata and talk about conservation.

Conservation Biologist Training Programme

With three long-term, field-based conservation projects ongoing across the country we continued to provide some of the premiere opportunities for aspiring local conservationists recently graduated from secondary school or university.

The goal of our program is to impart practical skills to motivated local young people because we believe they are vital to the future of conservation in Zambia and the world at large. To help trainees to become well-rounded conservationists, we immersed them fully in all of ZCP's programs and activities, thereby developing a variety of research, communication and basic mechanics, vehicle and equipment maintenance skills. In 2020, we had initially planned to expand this program to colleges and universities across Zambia offering natural resource-related courses; however COVID-19 restrictions required us to scale back on these plans. Nevertheless, we had 4 trainees across the three sites, each receiving intensive instruction and ranging from gap year students, to recent university and secondary school graduates. The interns worked as members of our field teams and were trained in all aspects of the work. Trainees were also given opportunities to develop soft skills essential for conservation practice such as communication and interpersonal skills.

In the coming year we will continue to expand the programme's breadth and depth.

ZCP Human Wildlife Conflict Officer Dennis Zimba speaks to students about Luangwa lions. Public speaking and community outreach are core components of all training programmes.

ZCP Kafue Ecologist and Educational Coordinator Kachama Banda radio-tracks cheetah in the Greater Kafue. A graduate of the Women in Wildlife Conservation Training Programme, Kachama now trains and mentors new programme participants.

Women in Wildlife Conservation Programme

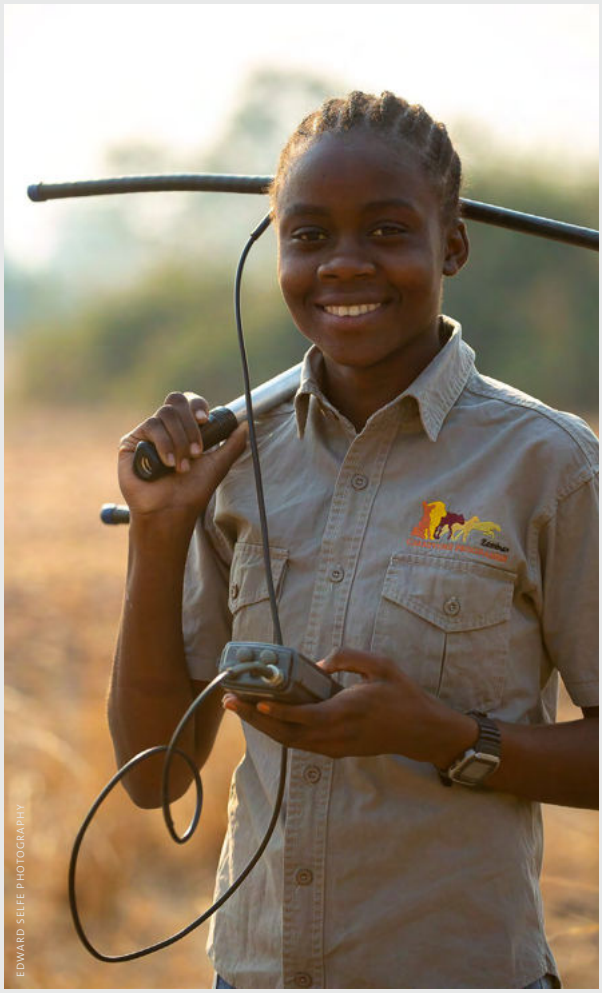
Similar to many of our programmes, our Women in Wildlife Conservation training programme (WIWC) was affected by the pandemic restrictions that limited our ambitious plans for 2020. Nevertheless, we managed to have six trainees across three sites for the year. The programme, aimed to increase the participation of women in field-based conservation, partners trainees with a female ZCP Ecologist in order to receive intensive training and mentoring on all aspects of the work.

In the Luangwa our programme continued to be led by Project Manager and Ecologist Thandiwe Mweetwa, mentoring trainees Margret Mwale and Nomsa Kamanga. In addition to being involved in all of ZCP's operations, they had an opportunity to develop further skills by being given specific projects to run. Margret was very engaged in data management and Nomsa helped run the community camera trapping project that was started in partnership with Conservation South Luangwa (see Community section). Both women excelled in the programme and are transitioning into four-year university degree programmes in conservation through ZCP and partners (see Advanced Education section).

Women in Wildlife Conservation Graduate Mercy Njobvu received a National Geographic Young Explorer Award in 2020 to work on disease mitigation in the Luangwa Valley with ZCP and partners.

In Liuwa 2019 trainee Bridget Mayani continued to work with mentor Ecologist Sandra Martens, and transitioned to a full-time role as an Ecologist and Education Coordinator. Bridget was instrumental in developing and conducting Liuwa's new Introduction to Conservation Internship Programme (see Secondary Education).

Kafue's WIWC initiative continued to expand in 2020. Kachama Banda, a 2019 trainee, continued to work with her mentor, Site Co-Manager and Ecologist Anna Kusler, and transitioned into a full-time Ecologist and Education Coordinator for Kafue. Kachama also provided mentoring of her own to new Kafue



Following in her Father's Footsteps, the Sky is The Limit for Margret Mwale

Margret Mwale was born and raised in Mfuwe, a small town in the Eastern province of Zambia, located right next to South Luangwa National Park. Raised by her single mother, after her father (an employee of Zambia's Department of National Parks and Wildlife (DNPW)) passed away when she was in grade 4.

She grew up with and around wildlife and always loved learning about the different interactions in the ecosystem. As a member of Chipembele Wildlife Education Trust's (CWET) Chongololo Club, she learned about the importance of conservation and was inspired and motivated to pursue a career in ecology.

Once she finished her secondary education, she was selected as a trainee in our Women In Wildlife Conservation (WIWC) programme. During her tenure with the WIWC programme, Margret was trained as a Field Ecologist honing her skills in scientific data collection, animal identification and community outreach and education. With the assistance of Dazzle Africa, Margret is taking the next big step in her career a degree by pursuing a BSc. in Wildlife Management at Copperbelt University. Margret is determined to follow in her father's footsteps in helping to protect Zambia's important carnivore populations and making a commitment to continue protecting this rich natural heritage.

trainee Ruth Kabwe in 2020. Ruth was selected for a collaborative internship opportunity in partnership with Musekese Conservation, further strengthening ties between the two organizations in the important Musekese-Lumbeya area of the GKE. Anna and Kachama also assisted in the mentorship and skills development of Lion Monitoring Team intern Patricia Kayula, as part of a collaborative initiative with Panthera (see Anti-Snaring section).

Lastly, we were thrilled to have former WIWC trainee Mercy Njobvu receive a National Geographic Society Fall 2020 Young Explorer Award. Mercy, currently a vet student at the University of Zambia following her ZCP work, developed a grant in collaboration with ZCP and Conservation South Luangwa to help mitigate the threat of rabies in domestic dogs and wild carnivores in the Luangwa Valley.

Assisted by ZCP-DNPW-APN teams, Dr. Kambwiri Banda (R) trains Liuwa Vet Dr. Brian Musalo (2nd from R) on cheetah immobilization work in the Greater Liuwa Ecosystem.

Wildlife Vet Training Programme

While interest in wildlife veterinary work in Zambia is growing, opportunities for gaining critical experience in wildlife work are rare. With our intensive monitoring and anti-snaring work across three systems, our work continued to provide unprecedented training opportunities for aspiring and current wildlife vets.

Under the tutelage of CSL-ZCP Veterinarian Dr Mwamba Sichande and DNPW Veterinarian Dr. Lengwe Bwalya, we assisted in the training of 6 veterinary and animal science students in the Luangwa. In Liuwa we were excited to add our first full-time field-based vet in Dr. Brian Musalo. Dr. Musalo, under the mentoring of veteran ZCP wildlife vet and ecologist Dr. Kambwiri Banda, was extensively trained in all aspects of ZCP wildlife vet work and conservation biology in 2020, rapidly gaining experience and providing a key presence in the system to combat snaring of carnivores

A Bright Light is Gone from This World: In Memory of Fitzgerald Mukumbi

Fitzgerald Mukumbi—our beloved friend and teammate—passed away unexpectedly in November 2020. We are devastated--for him, for his family, for his friends, for our family, and for the world at large, by this incalculable loss.

Raised in the Luangwa Valley, Fitzgerald had a love of conservation, for both people and animals. In 2014 Fitzgerald entered vet school at UNZA and--sponsored by Dazzle Africa and Conservation South Luangwa - he excelled in this work. During term breaks he spent months getting mentored in the CSL clinic and out in the field by CSL-ZCP Vet Dr. Mwamba Sichande. During the school shutdown he worked with Dr. Kambwiri Banda and our team in the Kafue. He was already an experienced wildlife vet, domestic animal vet, and conservation biologist before he even graduated. Fitzgerald had a way with animals and people such that both gravitated toward him and his kind, gentle, and competent yet humble demeanor. He was slated to graduate in December, and already had a full-time job lined up with ZCP upon finishing. Few people had more promise and potential, and no one was more destined to do more great things for conservation than Fitzgerald.

We still cannot comprehend this loss. But in an age of relentless conflict and ugliness perhaps let us all take an example from how Fitzgerald lived his life: one full of kindness, humility, grace, selflessness, service, and love for people and nature. We love and miss you Fitzgerald.

ZCP Luangwa Manager Thandiwe Mweetwa (4th from R) and members of the DNPW Research Team pose at a workshop on carnivore monitoring techniques led by Thandiwe, and sponsored by the Rangewide Conservation Programme for Wild Dog and Cheetah Conservation.

(see Anti-snaring section). In addition to this work, Dr. Musalo also serves as an extension specialist for local communities and their livestock as part of the Liuwa Predator Management Plan (see Human-Wildlife Conflict Mitigation section).

In the Kafue we welcomed vet student Fitzgerald Makumbi, who both worked with our team and continued his vet school coursework remotely from our camp. Fitzgerald had been a long-time trainee attachment in the Luangwa and was incredibly experienced in both wildlife vet work and conservation biology. Tragically, Fitzgerald passed away in November 2020 unexpectedly. He was weeks away from graduation and a full-time wildlife vet job with ZCP (see inset).

Professional Training and Advanced Education

Our long-term DNPW-ZCP partnership in support of professional training and advancement of DNPW personnel continued to make significant strides in 2020 through an array of programmes and educational opportunities. As part of Zambia's National Conservation Action Plan for Wild Dog and Cheetah, developed by the DNPW, Rangewide Conservation Strategy and partners, ZCP Luangwa Manager Thandiwe Mweetwa led a workshop on research and monitoring methods with DNPW Ecologists from across the country in 2020.

Celebrating Our Newest University Graduate – Kings Chimungu

ZCP Field Ecologist Kings Chimungu has essentially participated in almost every one of our conservation programmes on offer. As a young boy from the Luangwa Valley, Kings became actively involved in the Chipembele Wildlife Education Trust - CWET/ZCP Student Conservation Club and upon graduation he was selected for our Conservation Biologist Training Programme and our Wildlife Vet Training Programme. This year Kings successfully earned his university diploma in animal science and rejoined ZCP full-time at our Liuwa Project. Collectively, his work has been an integral part of our ability to ensure large carnivore conservation continues with strong local leadership. We are very proud of Kings and the achievements he has made. His dedication, motivation and heart to protect wildlife will help him climb the ladder as a young wildlife conservationist in Zambia.

Next Steps in Trainees' Careers

Lameck Sakala, ZCP Kafue Field Ecologist and Education Coordinator, exemplifies the impact that our school and training programmes can have on motivated student conservation leaders. Once a young farmer who just saw lions as killers of livestock, he quickly learned through his participation in Mfuwe Secondary School's Conservation Club and his career with ZCP to love and appreciate all animals.

Lameck began working with us as a Conservation Club student in Mfuwe before joining the team through the Conservation Biologist Training Programme. Through a scholarship sponsored by Project Luangwa he is currently working to advance his understanding of natural resources management by studying for a bachelor's degree at Mulungushi University. While he attended school remotely from our Kafue camp for a while he now has returned to campus for this exciting next stage of his career!

His hope is to use his education to help other Zambians to see the natural world as something to be protected and respected. His aim for the future is to apply his knowledge, skills and abilities to educate and inspire other Zambians to see our precious natural resources – such as wildlife, forests, and clean water – as integral resources to be protected and valued.

DNPW Wildlife Police Officer Charles Kalambata (C) attends to a snared lion with ZCP and DNPW vets Dr. Banda (L) and Dr. Phiri (R). Charles was one of three DNPW officers sponsored by ZCP to attend university in 2020.

In addition to intensive training in field-based conservation biology we sponsored the education of three DNPW Wildlife Police Officers (WPO) in 2020. In the Luangwa, Lackson Mbewe (DNPW WPO) obtained his Advanced Certificate in Transfrontier Conservation Area Management from Southern Africa Wildlife College. The knowledge and skills he learned during his certificate training programme has been applied in his everyday work supporting DNPW's large carnivore research projects. In the Kafue we continued to support project members and DNPW WPOs Charles Kalambata and Clement Mutanga in their continued studies in Wildlife and Natural Resource Management at Livingstone International University. Both Charles and Clement successfully graduated with their diplomas in December and returned to Kafue to utilize their new knowledge and skills.

We also were able to support multiple ZCP team members in their undergraduate education. ZCP Field Ecologist and former ZCP-CWET Conservation Club and Conservation Biologist Training Programme graduate Lameck Sakala began attending Mulungushi University's undergraduate programme in Natural Resource Management in 2020 with the assistance of our partner Project Luangwa.

In addition, Margret Mwale, one of our first Women in Wildlife Conservation (WIWC) trainees and a key member of the ZCP Luangwa Project, was able to begin her undergraduate degree at Copperbelt University with the support of our partner Dazzle Africa. Another WIWC trainee and core member of the Luangwa Project, Nomsa Kamanga, also received sponsorship in 2020 to begin her undergraduate work in 2021 with ZCP partners in the United States.

Graduate Students

In order to conduct science-based conservation it is vital to ensure that there is the capacity to effectively conduct the science. Opportunities for gaining experience on field-based conservation projects are very limited in Zambia and the region, and our long-term collaborative work provides unique opportunities and training grounds for early career conservation biologists. Consequently, we invest heavily in graduate opportunities for Zambian conservationists.

While the pandemic situation certainly provided a new array of challenges for this, we made considerable progress with graduate education initiatives. Long-time ZCP Luangwa Ecologist Henry Mwape completed his Master's

Dr. Kambwiri Banda in Yellowstone National Park. A long-term member of ZCP's Kafue Project, Kambwiri is now pursuing his Master's Degree at Montana State University with ZCP's Dr. Scott Creel, and his research will evaluate the demographic impacts of de-snaring efforts on wild dogs and lions.

degree in 2020 with ZCP's Dr. David Christianson at the University of Wyoming, evaluating the spatial dynamics of Luangwa lions and the human and ecological factors affecting them. Henry returned to the Luangwa following his successful defense, to serve as the Luangwa Project Assistant Manager and prepare his thesis for publication.

ZCP Kafue Vet and Ecologist Dr. Kambwiri Banda completed his final field season in 2020 before beginning graduate school with ZCP's Dr. Scott Creel at Montana State University in 2021, where he is evaluating the impacts of our collaborative de-snaring work on wild dogs and lions. While this work is likely to have significant positive impacts on carnivores (see Anti-Snaring section), the demographic impacts—both of the de-snaring work and of snaring by-catch—are not well-understood.

We also expanded our graduate research collaborations in 2020 with Copperbelt University's Dr. Vincent Nyirenda and WWF-Zambia. Together with Dr. Nyirenda we co-advised Master's student Esther Boomba in her work evaluating the dynamics and distribution of large carnivores and herbivores in the Kabompo Ecosystem's West Lunga National Park (see Kabompo Ecosystem). As the ecosystem changes with recovery efforts, implementation of a long-term research and monitoring programme to guide adaptive management will be very important.

While the pandemic delayed several plans, DNPW Ecologist Clive Chifunte continued to make preparations for his Master's research on lion and leopard genetics and anti-trafficking at Swedish Agricultural University, working with ZCP Research Scientist Dr. Goran Spong and we continued collaborations with the DNPW, Wildlife Crime Prevention and partners to assist in providing intelligence through this genetic work to combat trafficking (see Anti-Trafficking section).

Beginning as a volunteer with ZCP, Henry Mwape worked his way up to Ecologist and Educational Coordinator with the Luangwa Project, before pursuing his Master's Degree at the University of Wyoming studying Luangwa lion spatial dynamics across gradients of protection. Henry completed his degree in 2020 and returned as the Assistant Manager of the Luangwa Project.

ZCP Luangwa Manager Thandiwe Mweetwa (Center) attends the 2020 Leadership Training for Women at the Pathways Conference on Human-Wildlife Conflict in Kenya.

For the past two years ZCP has been working with the BBC to film two episodes of the 5-part series Dynasties II, featuring Liuwa's South Clan of hyenas and Liuwa Cheetah 180.

With three National Geographic Explorers and grantees on the team, ZCP's big cat conservation work was featured in 2020.

Right: The BBC's Dynasties II, set to air in March 2022, will feature Liuwa's South Clan of hyenas and Cheetah 180, each in one-hour episodes. Both dynasties are the focus of ZCP's long-term work dating back 12 years.

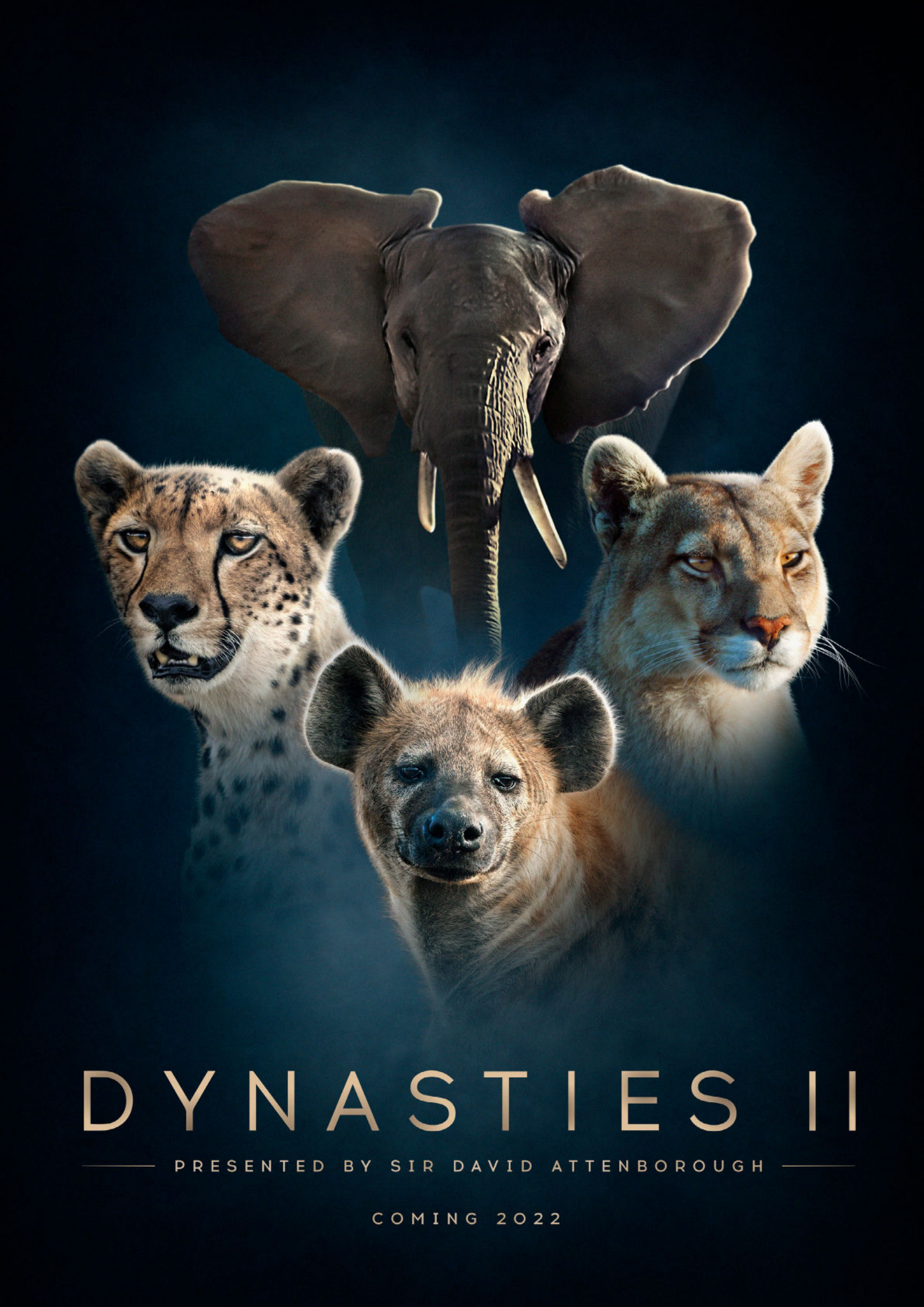
Media and Special Events

We conducted a diversity of media work and participated in a variety of special events in 2020. The pandemic restricted a lot of participation and travel after March, but nevertheless we were still able to engage in numerous media and special events nationally and internationally.

Thandiwe Mweetwa, Luangwa's Project Manager, was selected to attend the 2020 Pathways Conference on Human-Wildlife Conflict and leadership training for women working in conservation across Africa. While at the conference, she also worked with Kenya journalists to record promotional material for the event to be aired on Kenyan television. In September she was also a participant on a "Threatened Mammals" panel that focused on current and aspiring black mammalogists to form fruitful connections, in addition to illuminating historical and present-day black contributions to the field of Mammalogy.

The year saw a swell in online engagement and outreach in country and across the world. We took part in various panel discussions, university lectures, podcasts and articles, with one of the regular engagements being National Geographic's Explorer Classroom. We continued to collaborate on a number of natural history films in 2020, including a feature on Luangwa lions and our work for National Geographic and National Geographic's Big Cat Week. The biggest media news for 2020 was the long-awaited announcement of the BBC's blue-chip film, "Dynasties II." The five-part series intimately follows the lives and trials of a different animal group each episode, and we were fortunate enough to work with the BBC on two of the episodes for the last several years, featuring none other than Liuwa's South Clan of hyenas and Cheetah 180 (Kali). The series is set to air in March 2022, and we are extremely excited to showcase Liuwa's carnivores and the collaborative work to conserve them in what is sure to be an amazing film (see Liuwa Hyena and Cheetah section for more information on the stars).

As the pandemic's impacts on tourism hit communities and conservation organizations hard, we also participated in the Walk Luangwa fundraising initiative organized by Remote Africa Safaris. The walk raised funds for communities and conservation organizations in the Luangwa Valley, and covered 350km, 17 days, and 3 national parks to raise awareness and funds. Thandiwe and Assistant Manager Henry Mwape joined the walk at the halfway point.


DYNASTIES II
PRESENTED BY SIR DAVID ATTENBOROUGH
COMING 2022

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 a multitude 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.

Paterson, J. T., M. Vinks, M.S. Becker and S. Creel. In Review. **Simulation-based assessment of spatial capture-recapture models for a low density, elusive carnivore.** Ecological Applications.

Bertola, L.D., V. L. Williams, S. M. Miller, V. N. Naude, P. Coals, S. G. Dures, P. Henschel, M. Chege, E.A. Sogbohossou, A. Ndiaye, M. Kiki, A. Gaylard, D.K. Ikanda, M.S. Becker, P. Lindsey. **Assessment and genetic guidelines for translocations of lions (*Panthera leo*).** In Review. Evolutionary Applications.

Watson, F., M.S. Becker, D. Smit, E.Droge, T.Mukula, S.Martens, S.Mwaba, D.Christianson, S.Creel, A.Brennan, J.M'soka, A. Gaylard, C.Simukonda, M.Nyirenda, and B. Mayani. In Review. **Predation drives demography of a keystone migratory herbivore in a recovering transfrontier ecosystem.** Ecology and Evolution.

Goodheart, B., S.Creel, M.S. Becker, M.Vinks, K.Banda, C. Sanguinetti, P. Schuette, E. Rosenblatt, C.Dart, A. Kusler, K. Young-Overton, X. Stevens, A. Mwanza, and C. Simukonda. In Press. **Low apex carnivore density does not release a subordinate competitor when driven by prey depletion.** Biological Conservation.

Paijmans, J.L.A., A. Barlow, M.S. Becker, J. Cahill, J. Fickel, D.W.G. Foerster, K. Gries, S. Hartman, R.W. Havmoller, K.Henneberger, C. Kern, A. Kitchener, E. Lorenzen, M.Westbury, F.Mayer, S. O'Brien, J. von Seth, M.S. Sinding, G.Spong, O. Uphyrkina, B. Wachter, L. Dalen, J.Bhak, A. Manica, and M. Hofreiter. **African and Asian leopards are highly distinct at the genomic level.** 2021. Current Biology.

Vinks, M.A., S.Creel, E. Rosenblatt, M.S. Becker, P. Schuette, B. Goodheart, C. Sanguinetti, K.Banda, C. Chifunte, and C. Simukonda. 2021. **Leopard *Panthera pardus* density and survival in an ecosystem with depressed abundance of prey and dominant competitors.** Oryx.

Vinks, M.A., S. Creel, P. Schuette, M.S. Becker, E.Rosenblatt, C. Sanguinetti, K. Banda, B.Goodheart, K.Young-Overton, X. Stevens, C.Chifunte, Neil Midlane, and C. Simukonda. 2021. **Response of lion demography and dynamics to the loss of preferred larger prey.** Ecological Applications.

Creel, S., J. Merkle, T. Mweetwa, M.S. Becker, H.Mwape, T. Simpamba and C.Simukonda. 2020. **Hidden Markov Models reveal a clear human footprint on the movements of highly mobile African wild dogs.** Nature Scientific Reports.

Droge, E., S. Creel, M.S. Becker, A. Loveridge, L. Sousa, D. MacDonald. 2020. **Assessing the performance of rapid and inexpensive methods to monitor populations of imperiled apex carnivores.** Ecology and Evolution. https://onlinelibrary.wiley.com/doi/epdf/10.1002/ece3.6065

Vinks, M., Creel, S., P. Schuette, W. Matandiko, E. Rosenblatt, C. Sanguinetti, K. Banda, B.Goodheart, M.S. Becker, C.Chifunte, and C. Simukonda. 2020. **Evaluating the effects of anthropogenic pressures on a diverse African herbivore community.** Ecosphere. https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/ecs2.3067

Creel, S., G. Spong, M.S. Becker, A.Norman, C.Simukonda, and C. Chifunte. 2019. **Carnivores, competition and genetic connectivity in the Anthropocene.** Scientific Reports. https://www.nature.com/articles/s41598-019-52904-0

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. 2019. **Do protection gradients alone explain changes in herbivore densities? An example with four ungulate species in Zambia's Luangwa Valley.** PLOS-1. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0224438

O'Conner, D., J. Stacy-Dawes, A. Muneza, J. Fennessy, K. Gobush, M.J. Chase, M.B. Brown, C.Bracis, P. Elkan, A.R.M. Zaberirou, T. Rabeil, D. Rubenstein, M.S. Becker, S. Phillips, J.A. Stabach, P. Leimgruber, J.A. Glikman, K. Ruppert, T. Mueller. 2019. **An update of the geographical distribution of giraffe, Giraffa spp., throughout sub-Saharan Africa and its implications for conservation.** Mammal Review. https://onlinelibrary.wiley.com/doi/full/10.1111/mam.12165

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 underfunded 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

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Back cover: A wild dog in Zambia's Greater Kafue Ecosystem. This vast area is also the northern frontier of the Kavango-Zambezi Transfrontier Conservation Area (KAZA), and holds great potential for carnivores. *Photo: Anna Kusler*

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