PAINTED DOG CONSERVATION
RESEARCH ANNUAL REPORT
2017

Summary:

The painted dog (*lycaon pictus*), also commonly known as the African wild dog, has suffered a dramatic decline in the past decades, throughout its former range across Africa. The painted dog numbers have declined dramatically as a result of habitat loss, human persecution, and diseases (Fanshawe et al., 1991) and ecological factors that limit the species. Painted dogs requirements for large tracts of land to range and forage and their high mobility pose challenges for their monitoring, conservation and protection. Packs live at low densities relative to sympatric large carnivores and inhabit territories of 350-950 sq.km

Painted dogs are obligate cooperative breeders, thus making the species prone to anthropogenic impacts and worsened by ecological/environmental factors: effects of intraspecific and interspecific competition, diseases, hunting success and genetic diversity within dog populations. A pack in which membership drops below a critical size may be caught in feedback loop, characterized by poor reproduction and low survival of pups, further reducing pack size, culminating in failure of the whole pack and overall reduction in population numbers of dogs.

PDC values the importance of conservation management, through monitoring painted dogs as an indicator species and their presence, and density acts as an indicator of the conservation status of wildlife areas in Zimbabwe. Thus, successful painted dog conservation is beneficial to ecosystem conservation, as it results in the preservation of numerous species and natural processes in the wildlife areas, being protected.

Painted dogs in the country are listed as endangered and the population has been declining, however, HNP has recorded a slight recovery in painted dog population since 2016, brought about by more pups in breeding units, being linked to plenty rainfall. (Creel and Creel 1996; Mills and Gorman 1997) The Gwaai area in Hwange is still considered a sink habitat for dogs and herbivory, and other farmlands bordering HNP. The wide-ranging behavior of dogs means that some packs spend some time in human induced areas beyond the safe confines of protected areas. *See maps 1* &2. Here they encounter humans, snares, cyanide poison, speeding cars on tarred highways and domestic dog diseases. The Nyamandhlovu/Destiny pack, Broken Rifle pack, Gurangwenya pack, Mawuye mabena pack and Nkwizizi pack range beyond HNP and have resulted in mortality and injuries, during the reporting period, as a result of anthropogenic induced factors.

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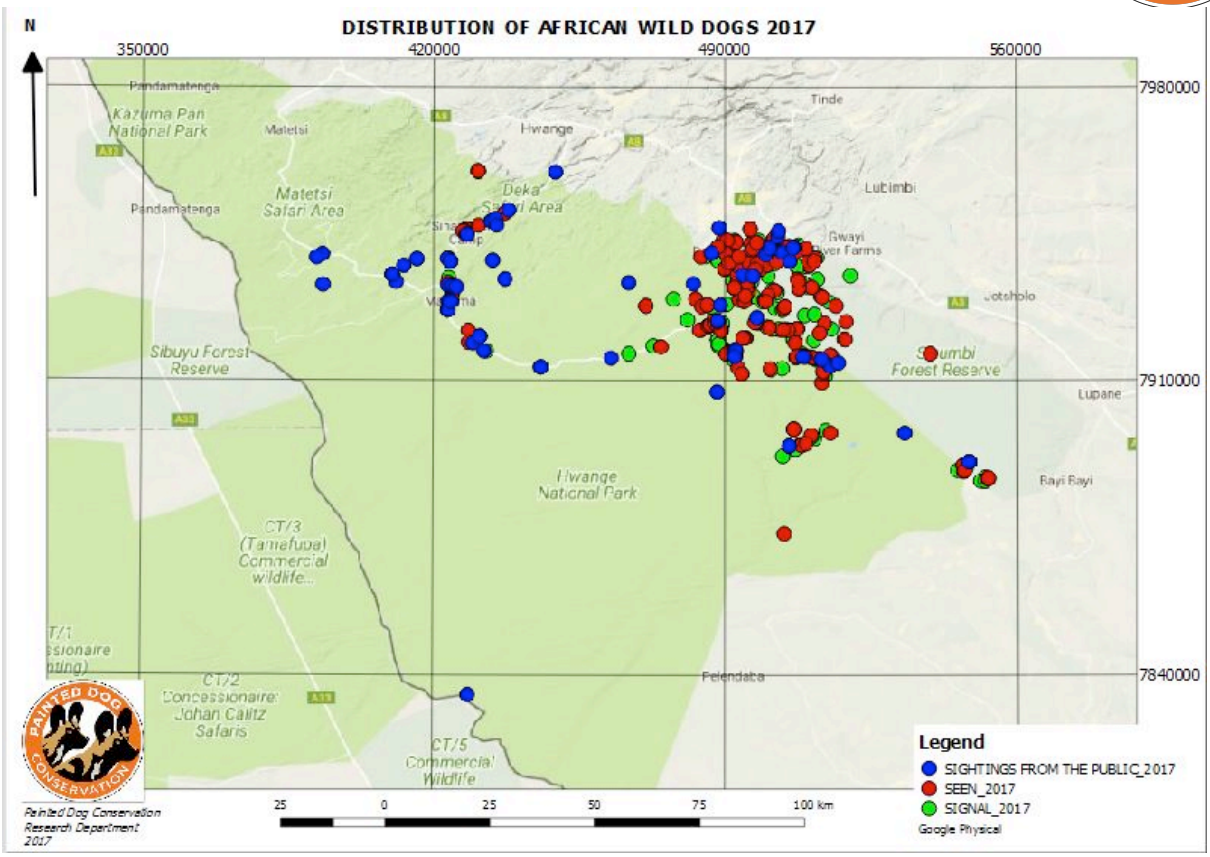

Map 1- DOG DISTRIBUTION AND RANGING FOR 2017

The painted dog population in the PDC Core research area of Hwange is 129 adult dogs for 2017, and 52 pups from eighteen known breeding units. One pack (Nyamandlovu) has already lost all pups, and less than half of the above (52) pups will reach twelve months. It is hypothesized that the unusual high pup numbers this year just like last season, is unusual, and indicates to good rainfall and plenty of prey.

Permission during the year was given by ZPWMA to collar six separate dogs in HNP and they are being monitored on their movements. Efforts are ongoing to collar two individual dogs from each pack foraging in snare infested areas of Gwaai and Forestry.

Sighting questionnaire forms were distributed throughout the HNP and all Safari camps/lodges, to broaden wild dog sighting data in all areas and photographs were requested from tourist whenever available to identify the individual dogs in the packs. These pictures significantly improve dog identification, as each dog has unique markings.

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Packs. Based on data available, a total count of all known packs in the HNP for the period January 2017 to November 2017, is 18, consisting of 129 adult/ yearling dogs and 52 pups.

An additional nine known packs, consisting of 51 adults were not recorded as seen in 2017.

It is estimated that an additional 5 packs consisting of approximately 30 adults/ yearlings exist in the unsurveyed areas of HNP.

Making the estimated population for HNP to be 210 adults in 32 packs at an average of 6.56 per pack

Mana Pools was monitored for two and half months only, total dog numbers can not be collated.

Based on photographs taken, through monitoring and received in 2017, it is known that significant dispersal from Gurangwenya, Nyamandhlovu and Mabuye mabena took place during the current year, resulting in the drop of adult dogs in the packs.

Feacal analysis. An analysis of dog scats from Mana Pools indicates to a high preference for baboons which has never been recorded or observed in Hwange and is being investigated through monitoring and research. An analysis of painted dog scats during the year from packs indicates to prey preference of dogs in HNP ecosystem for kudu and impala in larger packs (>five adults) and duiker in smaller packs (<five adults). **Thus lending support towards the argument for a moratorium on hunting Kudu and impala if the painted dog population is to thrive**.

Road counts. The road counts were conducted in collaboration with ZPWMA, CIRAD/CNRS and PDC to monitor and understand seasonal habitat preference and use in relation to spatial distribution for the herbivores, with emphasis on key dog prey species. The monitoring and analysis is aimed at assessing prey trends and abundance over a given period. Final results for road counts indicate a stable trend for all herbivores.

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PAINTED DOG POPULATION RESULTS FOR HWANGE NATIONAL PARK (HNP)

Data on the HNP population demographics is collated from direct sightings, photographs and sighting sheets. Each dog has a unique coat pattern and thus photographs or video footage are the most valuable tool in determining pack and pack structures (number of adult males/ females, yearlings and pups) and distinguishing one pack/ individual from another. Pup survivorship is a key element that is recorded as photo capture / recapture method of recording the individuals seen each time a pack is encountered and this is entered on data capture sheets. Painted dog monitoring was undertaken through ground based tracking of the VHF collared packs, combined with opportunistic observations of uncollared packs. Population parameters were derived from data collected during the course of the year. Pack size is estimated as the number of adults and yearlings in each pack, preceding breeding.

Data used in this report is based primarily on sightings recorded and received in the period January to November 2017. The Nyamandhlovu pack failed to raise any pups due to hyenas having raided the den last year and killing all pups and the alpha female, socks. The Nyamandhlovu has lost three entire litters of pups in dens to either lions or hyenas and this reinforces the threat to survivorship of dogs by large carnivores. *See table 3*.
Concern remains regarding the number of small packs consisting of 2 to 4 individuals and their apparent failure to produce pups. It is commonly believed that for packs to thrive and rear pups, there needs to be a pack of five or more adult dogs.

The average adults per pack for packs seen in 2017 is 7.2 as compared to 6.12 for 2016. *See table 1 below*.

Table 1: Demographic overview HNP dogs seen in 2017

Pack name	Total Number of Dogs	Total Ad	Ad M	AD F	Pups	Last seen
baNyayi	10	10	6	4	0	Nov-2017
Lukosi	9	9	5	4	0	Oct-2017
Manzichisa	7	4	2	2	3	Oct-

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						2017
Tshakabika	12	9	4	4	4	Nov-2017
Lukodet	17	9	5	4	8	Nov-2017
Brokenrifle	14	8	5	3	6	Oct-2017
New Robins	6	3	1	2	3	Sep-2017
Mabuye mabena	10	5	2	3	5	Nov-2017
Nyamandlovu/Destiny	7	7	6	1	0	Nov-2017
Gurangwenya	14	14	6	8	0	April-2017
Tshakagwenya	15	9	5	4	6	Oct-2017
Nyamandlovu Dispersals	5	5	0	5	0	Sept-2017
Ngwasha	13	8	5	3	5	Sept-2017
Mfagazaan	7	7	4	3	0	Oct-2017
Bathathu	4	4	2	2	0	Nov-2017
Mtoa	6	6	2	4	0	Nov-2017
Somalisa	20	8	4	4	12	Oct-2017
Robins	4	4	2	2	0	April-2017

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TOTAL	**182**	**129**	**66**	**63**	**52**	
Number of packs	**18**					
Average dogs per pack/pack size	**7.2**					

Fluctuations in population size at local scale HNP

Populations of painted dogs are prone to marked fluctuations at a variety of temporal and geographic scales. At local scale, a combination of high mortality, high fecundity, and dispersal by both sexes means that pack size fluctuates substantially over short periods. It is for these reasons that total dog numbers for each year differ. Because painted dogs are seasonal breeders, fluctuations may be synchronised across packs. These demographic characteristics lead to fluctuations at population scale. With painted dogs local extinctions are uncommon, under good conditions dog populations are able to grow quickly. It is a known fact that dogs have capacity for long-range dispersal, means sub-populations/packs reappear unexpectedly and grow rapidly. There are dispersers in HNP that have appeared from nowhere.

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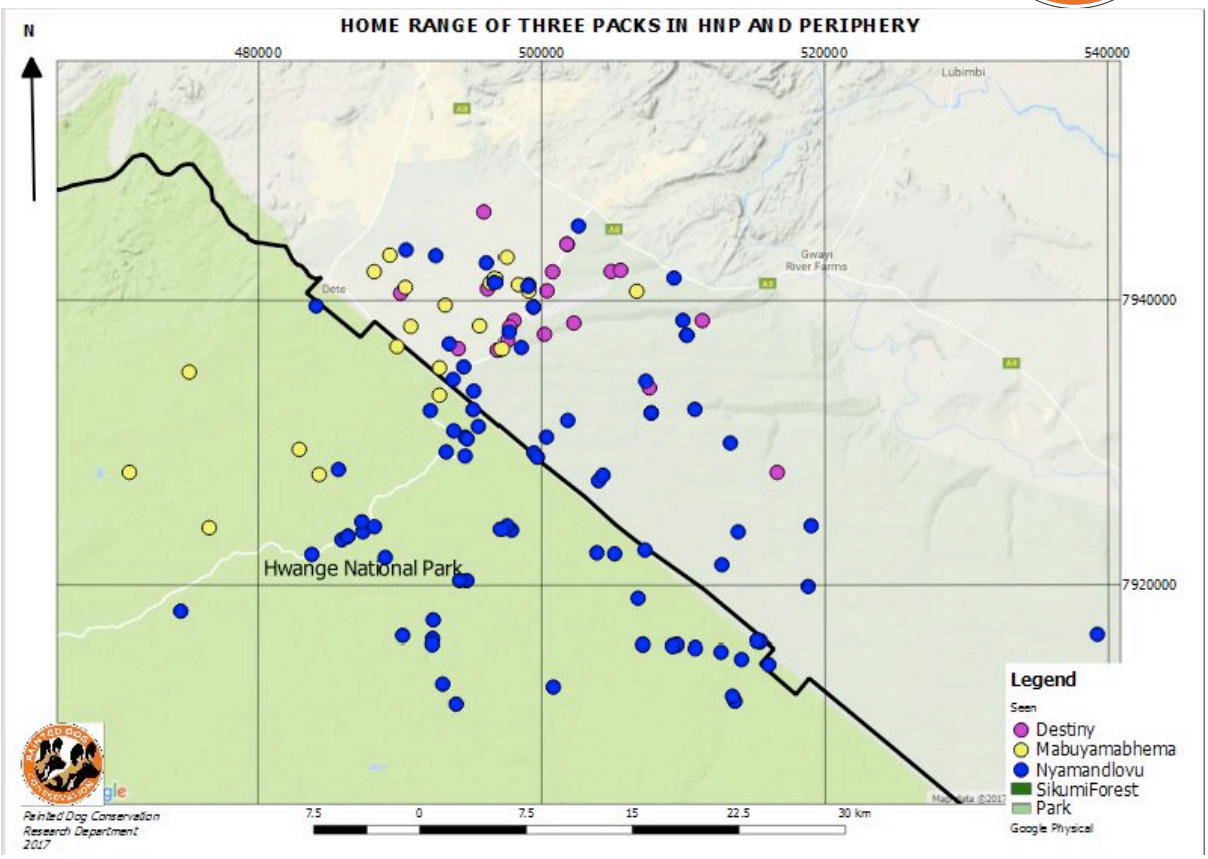

Map 2 –HOME RANGES OF THREE PACKS BEYOND HNP

Several large packs were no observed during the year, however dogs have surfaced several years without being seen, the HNP is big and challenging to monitor packs as only less than a third of the pack has roads. If Jozi, deteema, Nkwizizi and Kanondo pack had been visualized the total number of adult dogs would have been similar to last year's total adult population. *See table 2*.

Table 2: demographic overview for HNP dogs known but not seen in 2017

Pack name	Total Dogs	Total Ad	Ad M	AD F	Total YY	Pups	Last seen
Nkwizizi	5	5	3	2	0	0	Mar-2016
Sappers	3	3	1	2	0	0	Oct-15

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Kanondo	5	5	3	2	0	0	Sep-15
Jozi	15	15	10	5	0	0	Sep – 2015
Camp Hwange	2	2	1	1	0	0	Jul-15
New Guvalala	6	6	3	3	0	0	Dec - 15
Deteema	8	8	5	3	0	0	Sept-2016
Shakwanki	4	4	3	1	0	0	Aug-2015
Dopi	3	3	1	2	0	0	July-2016
TOTAL	**51**	**51**	**30**	**21**	**0**	**0**	
Number of packs	**13**						

Reference is also given to historical sightings and records, while whole packs/ individuals may not have been seen in 2017, it is unlikely that these dogs or packs no longer exist. The size of the area and the distribution of access roads makes it difficult to have full coverage of the park, a survey would partially indicate only occurrence of the dogs. Tendai of Makwa pack went missing with members of her pack for over one and half years, only for her to reappear at the Hide place looking healthy and well. Solero of Mawuye mabena was found by luck, at Robins after missing for nine months, he used to forage between Forestry and White hills area.

If an individual dog is not seen/recorded for a period of two years, the dog is marked as missing only and chances are the dog is still alive. The monitoring in HNP constitutes only about a third of the park, much of the park are inaccessible to vehicles, being largely roadless and covered with vegetation, hilly and rocky to the north, and the substrate being soft Kalahari sands. Hence painted dogs are difficult to observe and impossible to follow for any distance.

Table 3: Mortalities recorded in 2016 in HNP

NAME OF DOG	DATE OF BIRTH	NAME OF PACK	CAUSES OF DEATH
Kali	21 Feb 2017	Babili	Had an open Abdomen with

			intestines hanging, as a result of hyena attack died after treatment
Socks	09 August 2017	Nyamandlovu	Killed by hyena's found dead at Caterpillar
Unnamed pups	09 August 2017	Nyamandlovu	Suckling Alpha female-Socks killed –unknown number of pups died inside den
Thembile	02 August 2017	Nyamandlovu	Broke left foreleg. Vet put her down on humane reasons
John	15 September 2017	Resident PDC Rehabilitation Facility	Succumbed to old age (15)
Unnamed Pups x 2	26 November 2017	Broken Rifle	Suspected hyena
Phoeinix		Nyakasanga	lion
Unamed pups x 5	Aug - October	Nyakasanga	Leopard, Hyena and lion
Unamed pups x 4	Aug - October	Nyamatusi	hyena

Table 4. Dogs treated in 2017

NAME OF DOG	TYPE OF INJURY	PACK NAME	CURRENT STATUS	DATE OF INJURY
Browney	Snare wound on neck	Nyamandlovu	Fully recovered with pack	1 March 2017
Lemonie	Broken right foreleg	Nyamandlovu Dispersals	Fully recovered with pack	12 April 2017
Ntombi	Wound around neck from snare wire	Tshakagwenya	Treated, recovered with pack	22 April2017
Thembi-Faith	Broken right	Nyamandlovu	Treated,	15 May 2017

	foreleg	Dispersals	recovered with pack	
Buhle	Snare around neck	Brokenrifle	Treated, recovered with pack	15 July 2017
Notch	Wound around neck from wire snare and injury on left foreleg	Brokenrifle	Treated, recovered with pack	17 July 2017
Aubrey	snare around neck	Brokenrifle	Treated, recovered with pack	23/07/2017
Heather	snare around neck	Brokenrifle	Treated, recovered with pack	05/08/2017
Matthew	Wire snare wound on neck	Brokenrifle	Treated, recovered with pack	24 August 2017
Ring	Snare wound around neck	Nyamandlovu/Destiny	Treated, recovered with pack	August 2017

Until 2015, road kills, rail kill and snaring have been recorded as major causes of mortality, however a new emerging threat was recorded in the Protected areas, of cyanide poisoning at water points. **It is apparent that regular PDC daily patrols deter poachers and are effective in protecting wildlife and painted dogs**.

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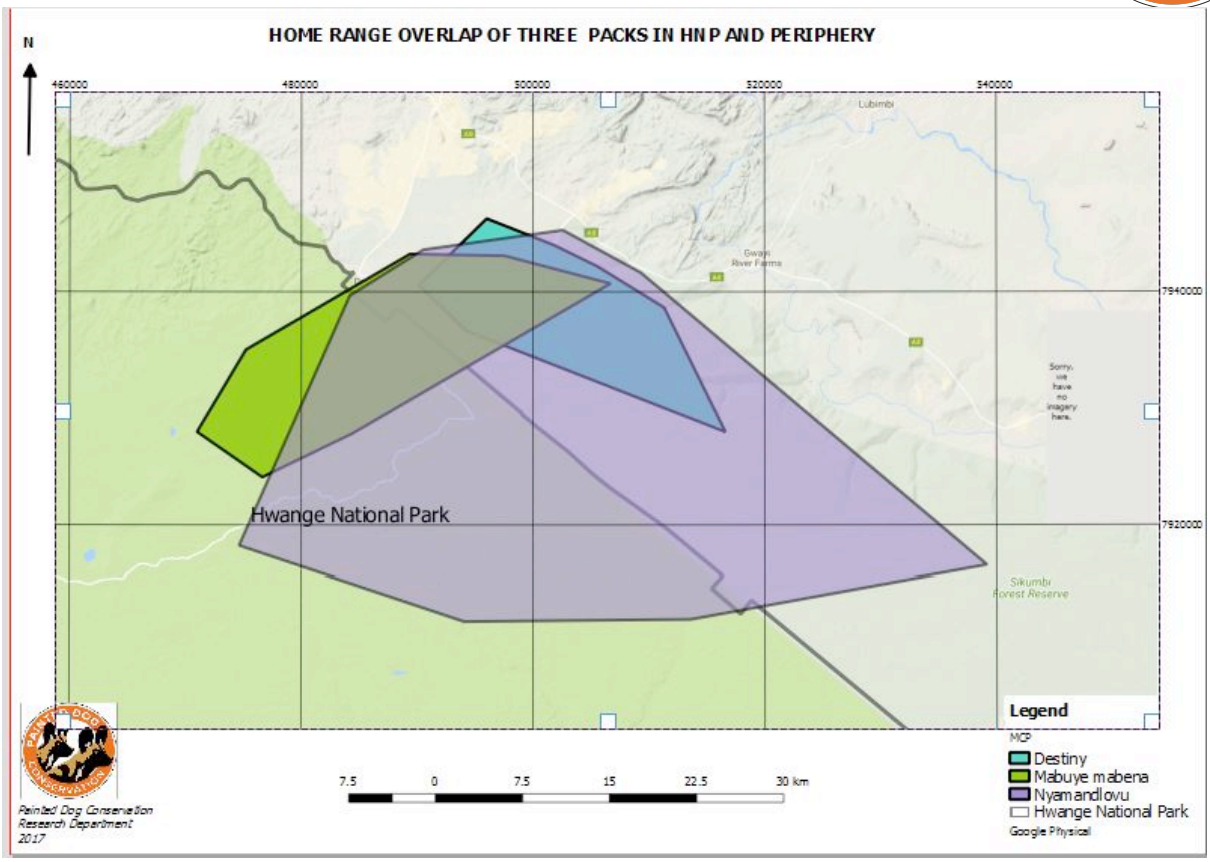

Map 3 - HOME RANGE OVERLAP OF THREE PACKS IN HNP AND PERIPHERY

Home range sizes are measured by the restrictive polygon method (Mills 1990), where the length of any side of the polygon enclosing the radio locations is restricted to the mean distance between fixes and the arithmetic mean center [i.e. the mean of the x and y coordinates] Habitat selection for dogs is measured at two levels, at landscape level, where habitat selection is measured for all known packs for HNP and individual habitat selection by each pack, the habitat preference for dogs and their prey is measured through compositional analysis and index of preference. Territory size of dogs highly differs and is mostly determined by the dispersion patterns of food patches, densities of lion and hyenas and other factors. *See map 3 above*.

Inadequate land management practices in the Gwaai and Forestry contribute enormously to loss of painted dogs and prey and the Gwaai has remained a critical source of sink for years. *See map 3*. Currently only three packs are ranging in the area as compared to seven packs that utilized the Conservancy at its peak.

Indications from the spoor transects undertaken in the Gwaai, suggest a massive decline in herbivore population especially kudu, impala, sable and eland and combined with the **PDC APU data, thus the need to urgently reduce the sport hunting quotas and the removal of prey**

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species (Kudu and Impala) for painted dogs from these areas or placing a moratorium on the hunting of some species.

Table 5: DOGS COLLARED IN 2017

PACK NAME	DOG NAME	TYPE OF COLLAR	DATE COLLARED
Nyamandlovu	Browney	VHF	1 / 01/2017
Nyamandlovu	Socks	VHF	17 / 02/2017
BaNyayi	Beetle	VHF	07/03/2017
Ganda	Fran	VHF	25/03/2017
Brokenrifle	Kisser	VHF	17/07/2017
Nyakasanga	Jiani	VHF	01/08/2017
Nyamandlovu Dispersals	Harry	VHF	22/08/2017
Mabuye mabhena	Moonbeam	VHF	16/09/2017
Brokenrifle	Cusp	VHF	26/11/2017

Hair Analysis of prey species in dog scat.

Diet and preference of painted dogs was also investigated through scat analysis and opportunistic observations of kills. Painted dog scats/faeces were collected opportunistically during the course of monitoring and were distinguished from those produced by other species on the basis of appearance and distinctive smell. Observers recorded the location of scats and named the packs where possible. Prey species were identified by comparing appearance of hairs, hooves, bones and even teeth found in faeces.

The prey hair analysis objective is to collect prey data to establish the extend of the predatory role of lycaon pictus and its impact on the ecology of the HNP ecosystem and provide **informed recommendations to Parks Management on sport hunting and ration usage.**

During the course of the year, 93 faecal samples were analysed, for hairs from prey species, the dogs, from different packs consumed in HNP. An additional 46 samples were analysed for the packs at Mana Pools.

The hair samples were taken from several parts of the body, specifically the neck area, tail, thigh, belly and shoulder. Plucking on different parts of the animal was done to see if the patterns were hair changed with location on the body and were compared with a hair reference data base compiled from the Bulawayo Museum.

Both the scale and cross pattern and cross section of the prey hairs was used to determine which species the different pack consumed within the Hwange Ecosystem and Mana Pools.

Results were analysed and compiled, the most preyed upon species as with the records, was kudu, for the HNP, followed by impala and bushbuck. At Mana Pools the packs preyed on impala and baboons mostly, the lack of kudu is baffling.

The importance of kudu and impala in the diet of dogs, re-enforces the argument and recommendations by PDC for the reductions or alternative species for management quotas for Parks and the Gwaai Area.

Table 6A: HNP Painted dog diet analysis results by species.

Species	**Totals**	**Percentages %**
Bushbuck	8	10.52
Kudu	37	48.68
Impala	22	28.94
Steenbok	3	3.94
Common Duiker	3	3.94
Bat eared fox	1	1.31
Scrub hare	1	1.31
TOTAL	**76**	**100%**

Table 6B: MANA POOLS Painted dog diet analysis results by species.

Species	**Totals**	**Percentages %**
Baboon	12	26.1
Impala	32	69.6
Buffalo	1	2.2
Warthog	1	1
TOTAL	**46**	**100%**

HNP and MANA Pools Faecal Hair analysis by pack.

Table 7A: NYAMANDLOVU/Destiny PACK Main Camp

Species	Totals
Impala	13
Kudu	18
Common Duiker	1
Bush buck	7
Water buck	1
Totals	**40**

Table 7B LUKODET PACK SINAMATELLA

Species	Totals
Kudu	6
Impala	2
Common Duiker	2
Totals	**10**

Table 7C TSHAKAGWENYA PACK Sinamatella Area

Species	Totals
Kudu	4
Impala	3
Totals	**7**

Table 7D GURANGWENYA PACK Sinamatella Area

Species	Totals
Kudu	2
Impala	2
Totals	**4**

Table 7E NKWIZIZI PACK Sinamatella Area

Species	Totals
Kudu	2
Impala	2
Totals	**4**

Table 7F NYAKASANGA PACK MANAPOOLS

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Species	Totals
Baboon	8
Impala	10
Buffalo	1
Totals	**19**

Table 7G NYAMATUSI PACK MANAPOOLS

Species	Totals
Baboon	4
Impala	22
Buffalo	1
Totals	**27**

HERBIVORE POPULATION TREND MONITORING

PDC participated and provided logistical support to the yearly PDC, ZPWMA, CNRS, CIRAD road counts in HNP. The objective of this monitoring and analysis was to find prey trends and abundance over given period.

Road counts

Road counts were carried out in May and October in the Main camp area, Sinamatella and Robin's camp. The most available roads were used as transects. Each transect was driven at least twice at different times of the day. The road count was followed by line transect method where perpendicular distances are calculated by using the angle and the direct distance between the animal and vehicle at first detection. Although the use of road transects has been under debate (Buckland *et al*….., 2001) it is often the only way to estimate densities over large areas and does allow for comparisons between sides and years. Data analysed for 2016 indicates a stable densities for most species and data for 2017 is yet to be analysed.

Additional Activities undertaken during the year:

- **Mana Pools**. The PDC had a vehicle based at Mana pools for two and half months and packs were fully tracked/monitored and ID done . Nyakasanga pack had 15 adult dogs and ten pups, currently there are 13 adults and 7 pups. Nyamatusi pack 11 adults and five pups, now there are 10 adults and 1 pup, confirming the rampant fluctuations of dogs at local scale. Rukomechi pack had 4 adults, now there are 5 adults in the

pack. Cheruwe pack has 9 adults only. Kanga pack has 14 adults and 5 pups.

- Five packs are monitored and population parameters taken as a data base is being collated for the valley.

- Genetic profiling is ongoing with Stanford University and PDC. (see appendix 1)

- PDC runs its own Anti-poaching Units that patrol the buffer zones around HNP.

- PDC provides material support and a hotline between Parks and the community in cases of poaching and human wildlife conflict.

- PDC conducted a series of community based meetings to tackle snaring and poaching.

- PDC meets the material needs of a Zero Tolerance to Wildlife Crime Campaign.

- **PDC provides learning experiences for Zimbabwean students and provided four internship opportunities listed below for this period:**

✓ **Deborah M Banda**: Geography and population studies, Lupane State University.

✓ **Mbongeni H Hadebe**: Geography and population studies, Lupane State University.

✓ **Sijabuliso Ndebele**: Journalism and Media studies, National University of Science technology.

✓ **Brightmore Ndlovu**: Wildlife Ecology and Conservation, Chinhoyi University of Technology.

PDC Support to ZPWMA:

- **PDC provided support to HNP Main Camp/Mana Pools in terms of fuel and vehicle use and man power for Anti-poaching operations.**
-
- **PDC donated 2221 litres of fuel to HNP Main Campduring the current reporting period for various purposes.**

- **PDC gave donated four tyres and six tubes for fire breaks and road maintenance.**

- **PDC donated over $4 600.00 for purposes ranging from tournaments, anti- poaching, operations, covert ops etc in this reporting period.**

- **PDC donors and supporters paid $7200.00 as park entry fees in eleven months only.**

- **PDC donors/visitors paid over $85000.00 as accommodation fees at Parks/ Lodges in Hwange during the period, contributing positively in growing the local economy plus the downstream benefits.**

- **PDC visitors paid over $7500.00 as aircraft charter fees.**

- **PDC has provided support to Sinamatella Camp/Mana Pools in terms of fuel and vehicle use for Anti-poaching operations**

- **PDC donated 250 pockets of cement ($2975) to Mana Pools for construction of roads / bridges.**

- **PDC donated six cameras and two GPS units ($1000) to Mana Pools for use by the scouts on patrol.**

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Publications:

"Entering the era of conservation genomics: Cost-effective assembly of the African wild dog genome using linked long reads." by Armstrong, Ellie; Taylor, Ryan; Prost, Stefan; Blinston, Peter; van der Meer, Esther; Madzikanda, Hillary; Mufute, Olivia; Madisodza-Chikerema, Roseline; Stuelpnagel, John; Sillero-Zubiri, Claudio; Petrov, Dmitri, Conservation Biology 17-616

Entering the era of conservation genomics: Cost-effective assembly of the African wild dog genome using linked reads. Ellie Armstrong; Ryan W Taylor; Stefan Prost; Peter Blinston; Esther van der Meer; Hillary Madzikanda; Olivia Mufute; Roseline Madisodza-Chikerema; John Stuelpnagel; Claudio Sillero-Zubiri; Dmitri Petrov. GIGA-D-17-00324

Entering the era of conservation genomics: Cost-effective assembly of the African wild dog genome using linked long reads Ellie E Armstrong, Ryan W. Taylor, Stefan Prost, Peter Blinston, Esther van der Meer, Hillary Madzikanda, Olivia Mufute, Roseline Mandisodza, John Steulpnagel, Claudio Sillero-Zubiri, View ORCID ProfileDmitri Petrov doi: https://doi.org/10.1101/195180

Stanford University and PDC Announce the *de novo* Assembly of the African Wild Dog Genome: *Cost-effective Assembly Represents an Important Conservation Milestone*

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Appendix 1:

FINAL REPORT
December 2017

Whole genome sequencing
and
genome assembly
for
Lycaon pictus.

Objectives:

The primary objective of this project was to focus the complimentary expertise of an international group of scientists to achieve a better appreciation of the ecological, demographic and molecular genetic mechanisms of resilience in a model apex species, the Painted Dog (Lycaon pictus). A crucial part in this was the generation of a high-quality reference genome for the Painted Dog, which then along with others can be used to better understand genetic diversity of Painted Dogs in the Hwange National Park, and obtain insights into fitness, inbreeding, and ecological adaptation.

Results:

1) Generation of a high-quality reference genome.

A major achievement of our collaboration was the generation of a high-quality genome assembly for the Painted Dog. More precisely, we generated genomes from three individuals, two from the Hwange National Park, Zimbabwe and one from the Endangered Wolf Center, Eureka, Missouri. A first pre-print of the resulting research paper can be found on bioRxiv (Armstrong et al. 2017; https://www.biorxiv.org/content/early/2017/09/27/195180 also attached). Interest in our findings within the research community was great with more than 100 downloads in the first three days.

Until recently, the generation of high-quality reference genomes has been very time consuming and costly, in many cases substantially delaying or hindering the establishment of effective genetic monitoring efforts. To address this issue, we evaluated a novel technology, 10x Genomics Chromium for use in the rapid and cost-effective

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assembly of genomes for species of conservation concern, such as the Painted Dog. The 10x Genomics Chromium technology was originally developed for use in human genetics and thus required some adjustments in order to work for our purposes. The first crucial step is to extract high molecular weight (HMW) DNA. Usual DNA extraction kits result in an

average DNA fragment length of 10-20kb, however, the 10x Genomics Chromium system requires an average length of 100kb. Furthermore, the extraction of HMW DNA requires high-quality blood samples which must be stored in liquid nitrogen during transport from Zimbabwe to the US. Because of the sensitivity of these materials and issues sending samples in liquid nitrogen to the US, we decided to focus on sequencing of two individuals. Next, we evaluated various DNA extraction kits for their ability to reliably yield sufficient amounts of HMW DNA from whole blood samples. Extraction using the QIAGEN MagAttract HMW DNA kit proved to be very reliable and efficient. Unfortunately, some blood clotting had occurred which can negatively impact the extraction of HMW DNA. However, we were able to obtain sufficiently long DNA from the two samples. In the next step, libraries were constructed using the 10x Genomics Chromium technology. In brief, this technology carries out individual fragment (~100kb DNA fragments) amplification in a highly-paralleled fashion. Beside gene regions, this allows for efficient assembly

of repetitive regions in the genome, which can be very difficult to resolve using standard short read sequencing.

We next assembled the genome using the 10x Genomics SuperNova assembler. We tested different version of this assembler for reproducibility, continuity, conserved gene completeness, and repetitive content of the resulting genomes.

We were able to show that 10x Genomics Chromium data can be used to efficiently, cost-effectively and rapidly produce genome assemblies for species of conservation concern, as our Painted Dog genome assemblies had a quality similar to that of the domestic dog genome (one of the highest quality mammalian assemblies), but for a small fraction of the costs. This research opens up the possibility to produce reference assemblies for many endangered species and thus promote high-resolution genetic monitoring of threatened populations.

2) Genetic diversity (Heterozygosity) within Painted Dog

The generation of three reference genome assemblies for the Painted Dog, along with genomic reads from two previously published individuals (Campana et al. 2016; from South Africa and Kenya) allowed us to investigate heterozygosity (the amount of genetic diversity an individual harbors) for this species. Surprisingly, we found a very high within-individual heterozygosity in Painted Dogs compared to other carnivores of conservation

concern, such as the Iberian lynx (*Lynx pardinus*), the cheetah (*Acinonyx jubatus*) or the island fox (*Urocyon littoralis*), which show a nearly 10-fold lower heterozygosity. This higher than expected heterozygosity could be a result of the Painted Dog's social structure, as only unrelated individuals come together to form new packs through dispersal. This could be very good news for the survival of this species if external pressures (such as poaching,habitat fragmentation, etc.) can be reduced.

This further allowed us to show that, at least within the two individuals from Hwange National park, we did not detect inbreeding to be a major factor. In an extension to this project, we aim to sequence (genotype) more individuals to see whether that holds true for other populations of Painted Dogs in Zimbabwe and across their range.

3) Setting the stage for cost-effective large-scale monitoring of Painted Dogs

The generation of such high-quality genome assemblies will now enable us to look into ecological adaptation and carry out more efficient low-cost genetic monitoring of Painted Dog populations. In order to do so, we hope to sequence more individuals throughout Zimbabwe and the Painted Dog's species range. Mapping the obtained genetic reads back to the generated reference genomes makes this approach much easier, cheaper, and effective.

In the original proposal, we aimed to look at ecological adaptation using a comparative approach (by comparing the Painted Dog genome to other canid genomes). However, sampling more individuals coupled with our generated high-quality reference will allow us to investigate adaptation on a much higher resolution than what a comparative approach would allow us to do. Thus, we

decided to delay this analysis until we have more samples/genomes available and can utilize our high-quality reference.

Beside information on adaptation and a broad view of genetic diversity and inbreeding in Painted Dog populations, the available genomes along with more sequencing will allow us to develop a cost-effective genetic monitoring strategy. This can be achieved by using only a subset of informative mutations gathered from the sequenced genomes. Amplification of these mutations will then enable us to genotype Painted Dogs using trace samples, such as scat or hair, which will allow us to easily and non-invasively track the movements and status of the population over time.