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Ecological surveys 2005, 2008, 2010 and 2013 at Conkouati-Douli National Park, Républic of Congo

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ABSTRACT

Counts of elephant dung piles and ape nests along line-transects are the most commonly used survey techniques used to estimate elephant and great ape density and numbers in forest environments where limited accessibility and visibility impose on survey designs that rely on direct observations.

Using the results of large mammal sign encounter rates along line-transects from a pilot survey conducted in 2004, a line-transect design was developed for systematic surveys at Conkouati-Douli National Park (CDNP). The design was applied in 2005 with funds from the USFWS (AfE-0338) to collect baseline data on relative abundance and distribution of large mammals and human impact and to establish densities of elephants and great apes. The design was repeated in 2008 with funds of USAID/CARPE, in 2010 with funds of USFWS (GA-0653) and in 2013 with funds from USFWS (AfE-0856) to look at changes over time to help locate pressures and animal hotspots for patrol planning for better protection of the Park. In 2005, 2008 and 2010 the survey design included around 100 line transects of 1000m spread throughout CDNP. For 2013 around 190 line transects of 500m were used based on the hypothesis that observers fatigue reduced sign monitoring and is less likely to happen when transect length is halved. In theory, many short transect samples spread over an area will be a better representation of reality than a few long transect samples. Halving the transect length should theoretically not have an effect on density estimates.

For great apes, survey results suggest 6193 (CV%17.6) apes in 2005, 6368 (CV%16.3) in 2008, 6534 (CV%14.4) in 2010 and 8608 (CV%14.6) in 2013 of whom approximately 7609 (CV%15.56) are chimpanzees and 914 (CV%38.43) gorillas. This represents a general increase of 3% between surveys, except for the 2010-13 change that represents an increase of 32%. The elephant population at CDNP goes up from 470 (CV%26.4) elephants in 2005, to 510 (CV%20.4) in 2008, 659 (CV%19.1) in 2010 and 947 (CV%19.3) in 2013, representing an increase of 9% between 2005 and 2008, of 29% between 2008 and 2010 and as much as 44% between 2010 and 2013. The increase in elephant numbers suggests that CDNP may act as a refuge for elephants since 2008. A large chunk of the 32% increase of great apes can only be attributed to survey design, which suggests that a portion of the 44% elephant increase is likely also the effect of survey design. It is better to use 500m transects to reduce effects of observers fatigue, especially if surveys are done by rangers and junior park staff who do not totally comprehend the theory behind practice.

1. INTRODUCTION

1.1. The site

Located in the south of Congo next to the border of Gabon, the 5050 km2 park consists of approximately 1200 km2 of marine park and serves as a refuge for wildlife as well as an important tourist attraction for the region. It has been identified as a priority site for the conservation of great apes (IUCN) and designated a RAMSAR site for its importance for wetlands and birds. The Conkouati Douli National Park (CDNP) is the most biodiverse protected area in Congo, harbouring about 7500 central chimpanzees (*Pan Troglodytes*) and 1000 gorillas (*Gorilla gorilla gorilla*), and 1000 forest elephants (*Loxodonta Africana cyclotis*) in 2014. Five species of marine turtles nest on the CDNP beaches that are amongst Africa's most important for the nesting of leatherback turtles (*Dermatochelys coriacea*). The CDNP coastal waters equally house a resident group of around 50 rare humpback dolphins (*Sousa teuzsi*).

The rapidly expanding port city of Pointe Noire with almost 1,000,000 people today lays at less than 150km from CDNP. The park is connected to Pointe Noire by one road that splits at the park boundary into a coastal leg road that elongates the coast and dissects the park and a forest road that elongates the South-eastern boundary of the Park. Some 28 villages house ~7000 people evenly spread along the coastal road and the forest road. Demographic growth is slow around the park due to an exodus of the young to the nearby city of Pointe Noire.

The park is divided into Integrally Protected or IP zones where access is limited to working park staff on mission, paying tourism and research, and Ecodevelopment or ECO zones that regroup all legal fishing camps and other human habitations and that allow sustainable use of natural resources by resident communities. The park also has a 5km buffer zone on the southeast and by residents of CDNP we understand all people living inside the park and in the buffer zone.

1.2. History and Management

The coastal people are essentially of Vili ethnic origin, a fishers and traders tribe that settled in the area since the 13th century. People along the forest road settled less than 100 years ago and come from a large number of different tribes who arrived together with the logging companies. Today the coastal people mainly live from fishing and agriculture. The forest people live from employment in the active concessions, hunting, agriculture and wood extraction for building and charcoal.

In the 1990's IUCN engaged in a large project to turn the 1300km2 Conkouati Reserve into à 5050km2 National Park with support of the local communities. CDNP's official creation happened in 1999, and since 2000, the park has been managed by the Ministère de l'Economie Forestier et du Developpement Durable (MEFDD) with the support of Wildlife Conservation Society (WCS) as the technical

partner, a collaboration that is defined in a written agreement. On site the park coordination is represented by a conservator assisted by an assistant conservator from the MEFDD, and a Principal Technical advisor assisted by an administrator-accountant from WCS.

In 1999 CDNP wildlife was so depleted after decades of unrestricted resource exploitation to fuel the growing demand for bushmeat and wood in Pointe Noire that even poachers complained about the lack of wildlife. Industrial threats were intense, local authorities were involved in traffic and local community support from and for conservation did not exist.

Today the park counts 80 permanent employees and 30 part-time employees of whom more than 95% are recruited locally. Baseline data was collected in 2005 on the densities and distribution of great apes and elephants and the relative abundance and distribution of all large mammals and human impacts. Repeat surveys to establish changes were done in 2008, 2010 and 2013. Wildlife populations increased substantially and allowed to start ecotourism in 2008. Since 2011, tourists pay park entrance fees that for the Government and a fee for the local communities. Most local communities benefit in some way or other from park related activities and interventions and from tourist fees.

1.3. Threats

CDNP threats are numerous and dynamic. CDNP deals with industrial and commercial threats, corrupted governance and internal threats, and local threats. Intelligence and perseverance backed by essential financial support to materialize adaptive approaches are key to countering threats successfully.

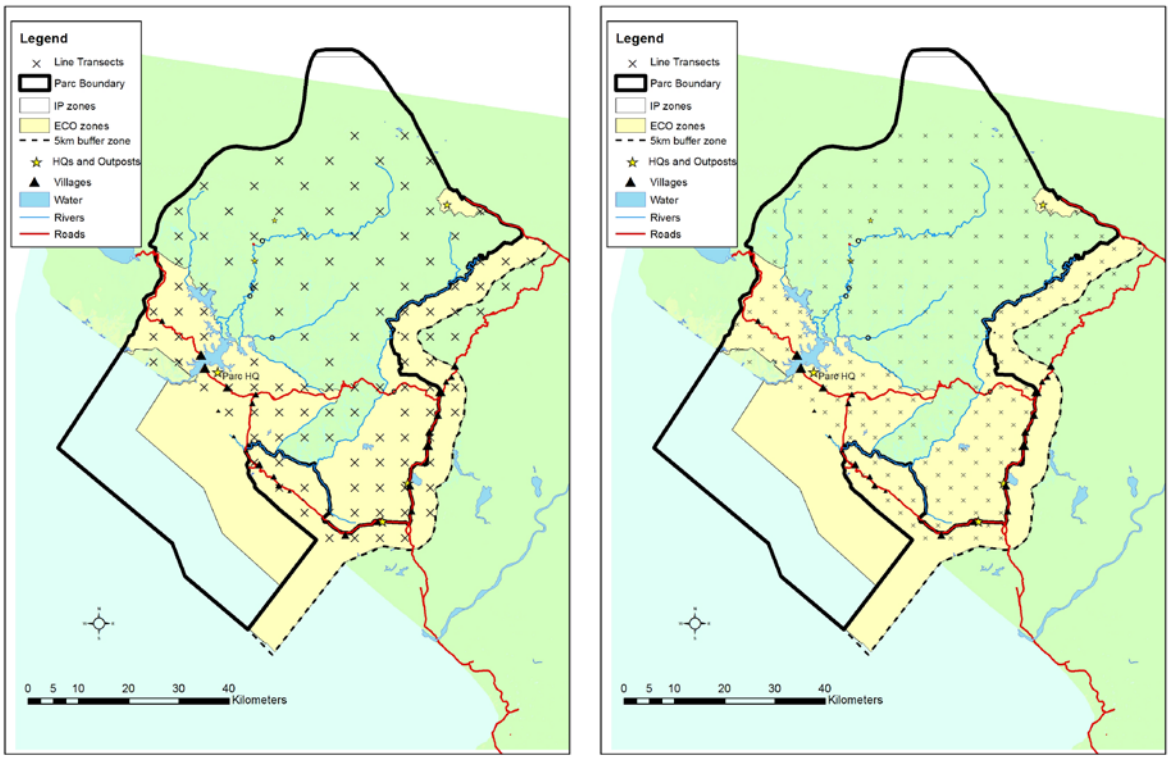
2. METHODS

In 2004 a pilot total survey was conducted to develop a repeatable survey design adapted to CDNP. The CDNP baseline data was collected in 2005 and repeat surveys were done in 2008, 2010 and 2013. The survey design included around 100 line-transects of 1000 meters of which 45% cover the IP zone and 55% in the ECO zone. The density of transects in the ECO zone is higher than in the IP zone because the encounter rates of animal signs is lower there. For the 2013 survey, transect around 190 line transects of 500m were monitored (Fig 1). Doing so was logistically heavier but hypothesized to account for observers fatigue slowing the motivation of monitoring all signs along the second half of a 1000m transects. In general many small samples (short transects) of an environment will better represent reality than a few large samples (long transects).

Since large mammals tend to follow or elongate roads and rivers, transects were positioned perpendicular to large rivers and roads (Fig 1). Seasons at CDNP are somewhat different from the rest of Congo, with the dry season covering a six

months period between May and October and the wet season a six months period between November and April. The first survey in 2005 was done at the end of the wet season in April-Mai 2005 with funds of USFWS-AECF. Although that this survey allowed to establish the baselines for CDNP and the wet season habitat occupation, the timing proved poorly chosen because water levels would be at their highest and a substantial part of CDNP is seasonally inundated. Subsequent surveys in 2008 and 2010 would be conducted at the end of each dry season, in October-November.

Figure 1: Systematic survey design for 2005, 2008 and 2010, and for 2013 at CDNP



To conduct the surveys quickly, eight teams of four people were trained and each team conducted three field missions of 10 to 14 days with three days' rest in between missions. Teams consist of a team leader who is an experienced research assistant responsible for data recording, GPS (GARMIN GPSmap 62CSx) navigation and distance measuring a 50m measuring tape. The person in the front, guided by the team leader, clears the way in the front and stops every 50 meters. The measuring tape rests on the floor and represents the transect centerline. Two experienced observers walk the 50 meters very slowly, each focusing on one side of the transect centerline. They stop at every human or animal sign encountered and communicate the distance measurement along the line transect centerline to the team leader who notes it down and takes GPS waypoints. For elephant dung piles and great ape nests, the perpendicular distance is measured from the center of each dung/ nest to the line transect centerline. These measurements are used to calculate nest and dung density and to convert those to animal densities using the program Distance 6.0 (Thomas et al., 2009).

2.1. APE AND ELEPHANT DENSITY ANALYSIS

Essential factors in the conversion of nest density to ape density or dung density to elephant density are daily nest production and nest decay rates for apes and dung defecation and dung decay rates for elephants.

Ape or Elephant density (per km^2) = D x d/r, where

- D is the number of nests or dung (per km^2),
- r is daily nest production or dung defecation rate,
- d is daily nest or dung decay rate

For Apes and elephants the value of "d" on long term study sites can relatively easily be obtained by tagging elephant dung or ape nests and following their rates of decay. At Conkouati, nest decay hasn't been studied but dung decay has, through the monitoring of 57 fresh dung piles between March and September 2005. Dung piles were marked and the habitat, canopy cover and slope were recorded for each dung pile. Dung piles were monitored on a weekly basis and their stages of decay classified according to Barnes and Jensen (1987). Dung piles were considered fully decayed when they reached stage E. As the exact number of days between the final observation of dung as stage D and its transition to stage E was unknown, a random number between one and seven was added to calculate survival time and decay rate (Barnes et al., 1997; Breuer and Hockemba, 2007). Mean survival time of dung piles was 158.3 days (SD ±12.6, SE±3.6, 95% CI 155-161) and the mean rate of decay was 0.00637 per day (SD ±0.0007, 95% CI 0.0618-0.0656). There was no significant difference in the survival time of dung piles by habitat type, canopy cover or slope (Vanleeuwe and Probert, 2013).

In most studies the value of "r" is borrowed from the literature because it is difficult in the wild to monitor a large enough sample of elephants long enough to establish accurate rates of defecation per day. Theuerkauf and Gula (2010) studied the results of 16 studies of defecation rates and found that defecation increased with rainfall following a power regression model, with seasonal variations. Using their regression model, annual defecation rates can be estimated as D_{annual} = 2.01R0.287 (r^2 = 0.850, $P < 0.001$) with a coefficient of variance or CV_{annual} = 0.74R-0.287. Dry season defecation rates can be estimated as D_{dry} = 1.25R0.352 (r^2 = 0.919, $P < 0.001$) and CV_{dry} = 0.87R-0.352 and wet season defecation rates as D_{wet} = 2.79R0.25 (r^2 = 0.630, P = 0.001) and CV_{wet} = 1.04R-0.25. Rainfall data for Pointe Noire was found at two different sites on the internet (Table 1).

Table 1: Rainfall data from Pointe Noire

	PNR	Factor	**Rain or R in mm**	POWER_ D or ^	**D = 2.01R^0.28 7**	POWER _CV	**CV = ((R^-0.287)*0.74)* D**	%
2005	Annual1	2.01	1589	0.287	**16.67**	0.74	1.49	8.9%
2008	Annual1	2.01	1453	0.287	**16.25**	0.74	1.49	9.2%
2010	Annual1	2.01	1724	0.287	**17.06**	0.74	1.49	8.7%
2013	Annual1	2.01	1217	0.287	**15.44**	0.74	1.49	9.6%
2005	Annual2	2.01	653	0.287	**12.92**	0.74	1.49	11.5%
2008	Annual2	2.01	1051	0.287	**14.81**	0.74	1.49	10.0%
2010	Annual2	2.01	1448	0.287	**16.23**	0.74	1.49	9.2%
2013	Annual2	2.01	1356	0.287	**15.93**	0.74	1.49	9.3%
2005	Dry	1.25	181	0.352	**7.79**	0.87	1.09	14.0%
2008	Dry	1.25	143	0.352	**7.18**	0.87	1.09	15.1%
2010	Dry	1.25	156	0.352	**7.40**	0.87	1.09	14.7%
2013	Dry	1.25	93	0.352	**6.17**	0.87	1.09	17.6%

Rain data varies considerably between stations and CDNP spans a large area going from the coast where the ocean influences the climate to more than 60 km inland where a mountain chain influences climate. Using the Theuerkauf and Gula (2010) equation, most annual rates result in a dung defecation rate D of around 16 per day. However, using dry season rainfall data the estimated value of D using the regression model is questionably low (average 7). Until more in-depth studies are done on this, and more accurate data on rainfall is available for CDNP, we opt for the conservative value of 16 (SE1.1) for Distance analysis in this report (Table 2). For CDNP ape nest analysis, the value of ape nest decay (d) was taken from the study of Morgan et al. (2006) at 91.5 (SE 2.85) days, and the nest production rate at 1.09 (SE0.05). For Distance analysis the best-fitting detection curves were plotted to the data and data was truncated to produce the best %CV (Table 2).

Table 2: Treatment of elephant dung pile and ape nest data for Distance analysis

	Year	N° of transects	Transect Length in m	Detection key function	Dung pile decay rate	Dung pile defecation rate	Right data trunk.
Elephants	2005	108	1000	Half-normal/ cosine	158.3 (SE3.55)	16.00 (SE1.09)	6%
	2008	115	1000	Half-normal/ cosine	158.3 (SE3.55)	16.00 (SE1.09)	1%
	2010	116	1000	Half-normal/ cosine	158.3 (SE3.55)	16.00 (SE1.09)	None
	2013	193	500	Half-normal/ cosine	158.3 (SE3.55)	16.00 (SE1.09)	None
Apes	2005	117	1000	Half-normal/ cosine	91.5 (SE2.85)	1.09 (SE0.05)	1%
	2008	115	1000	Half-normal/ cosine	91.5 (SE2.85)	1.09 (SE0.05)	2%
	2010	117	1000	Half-normal/ cosine	91.5 (SE2.85)	1.09 (SE0.05)	10%
	2013	192	500	Half-normal/ cosine	91.5 (SE2.85)	1.09 (SE0.05)	3%

Chimpanzee and gorilla nest data were pooled for density analysis because of potential observers' bias in nest identification. For the 2013 survey, estimated nest height was also recorded allowing producing more accurate results for separate analysis of chimpanzees and gorillas. In general, there are a lot more chimpanzees

than gorillas at CDNP. For the much lower numbers of gorillas there are not enough sightings to come up with a figure with low confidence intervals but since both the chimpanzee and the pooled results show a very low CV%, we assume that we can quite confidently assume that the difference represents gorilla density.

2.2. LARGE MAMMAL AND HUMAN IMPACT DISTRIBUTION MAPS

Over time several digital GIS layers of CDNP roads, rivers, streams, contours, villages, fishing camps, boundaries and vegetation have been assembled.
In Excel, a table is developed in which each row represents one transect, located by its middle point (lat/long). Several columns are linked to the middle point with values for the sum of elephant dung, great ape nests, and all signs for small primates, mandrills, forest hog, sitatunga, bushbuck, leopard, duikers, as well as signs of people. The square root of those values was taken to reduce the value range, producing more nuanced distribution maps.

The distribution maps were developed in ArcGIS, where the data file was converted to a point shapefile and interpolated to an IDW (Inversed Distance Weighted) raster image in which data values of points are weighted against each-other. The image was clipped to fit the area covered by the surveys using the Mask function.

3. RESULTS

3.1. APE AND ELEPHANT DENSITY ANALYSIS

The results from 4 total surveys are shown in Table 3. Table 3 shows a steady increase in elephants. Especially the 2010 and 2013 increases are very steep, suggesting that CDNP may act as a refuge, attracting elephants from outside. Table 3 shows a very slow increase of 3% in great ape numbers between 2005 and 2008 and 2010, though a much higher increase of 32% between 2010 and 2014. Unlike for elephants this cannot be attributed to an influx from apes coming from outside and we therefore think that to a certain extent, the 2010-13 increase is attributed to survey design.

In 2005, 2008 and 2010 around 100 transects of 1000m were spread throughout CDNP and monitored, whereas for the 2013 survey, around 190 transects of 500m were spread throughout CDNP. Transects were done at the same time of year between surveys and mostly by the same team leaders. Reducing transect length was done based on the hypothesis that observers fatigue increases with transect length and that there is some slack in monitoring of signs along the second half of a 1000m transects. Testing this hypothesis by using 500m transects should have no influence (in theory) on density estimates. Effectively, the CV% of the estimates turned out to be very similar for the results collected along the 500m transect

design used in 2013 and the 1000m transects design used in previous surveys, suggesting that data robustness at CDNP is not affected and that it makes no difference to use 1000m or 500m transects. However, we do observe a generally higher estimate both for elephants and great apes using 500m transects. Taking into account the time lapse between surveys and confidence limits of survey estimates, this difference may not be extraordinary (Sam, can we test for significance?) though results do support the hypothesis of the potential effect of observers fatigue in favor of using 500m transects if possible logistically, especially when surveys are done by junior assistants with little knowledge of the theoretical reasoning behind walking straight line transects.

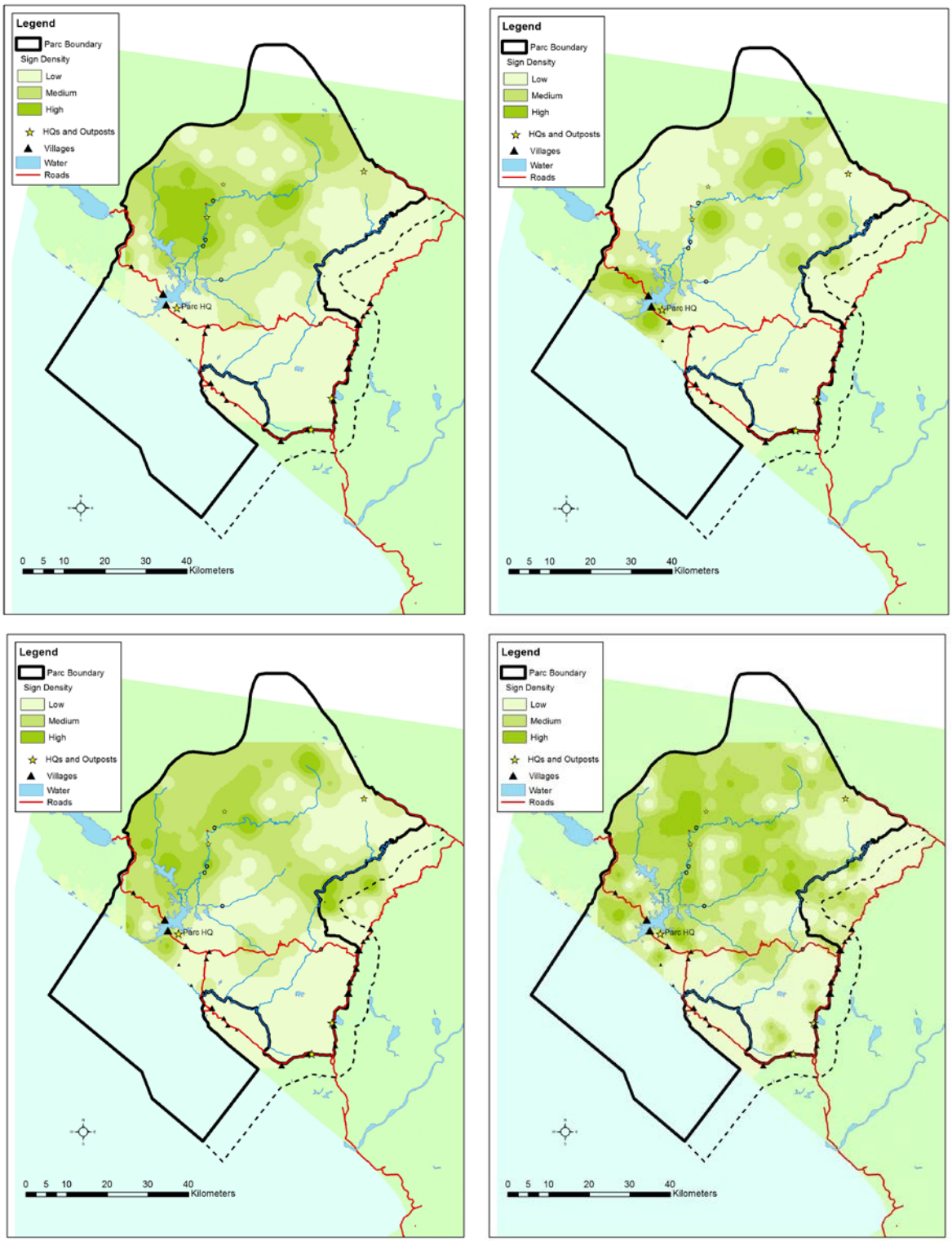
Table 3: Results for elephants and great apes for 2005, 2008, 2010 and 2013

	Date	Numbers	Densities	CV%	% increase between surveys
Elephants	2005	470	0.12	26.4	Baseline
	2008	510	0.13	20.4	9%
	2010	659	0.17	19.1	29%
	2013	947	0.25	19.3	44%
Apes	2005	6193	1.61	17.6	Baseline
	2008	6368	1.66	16.3	3%
	2010	6534	1.70	14.4	3%
	2013	8608	2.24	14.6	32%

3.2. LARGE MAMMAL AND HUMAN IMPACT DISTRIBUTION MAPS

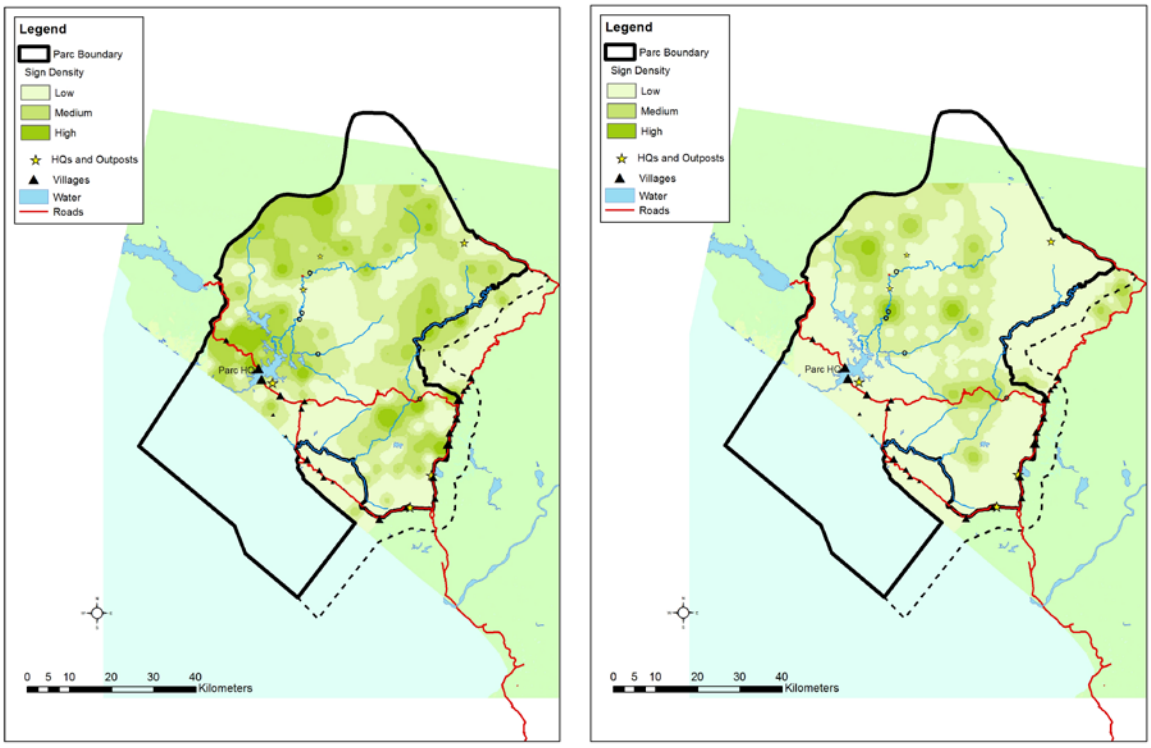
Figure 2 shows the distribution of elephants as found during the 2005, 2008, 2010 and 213 survey at CDNP. Elephants are famously avoiding human presence when possible and their reduction in a large portion of the north of the park in 2008 coincided with the discovery of several hundred illegal gold miners. They were evacuated and subsequently we find a rapid decolonization of these areas by elephants. Their spread over time corresponds with reduced human activity as a result of ecoguard patrols.

Figure 2: Clockwise from the left, elephants at CDNP in 2005, 2008, 2010 and 2013



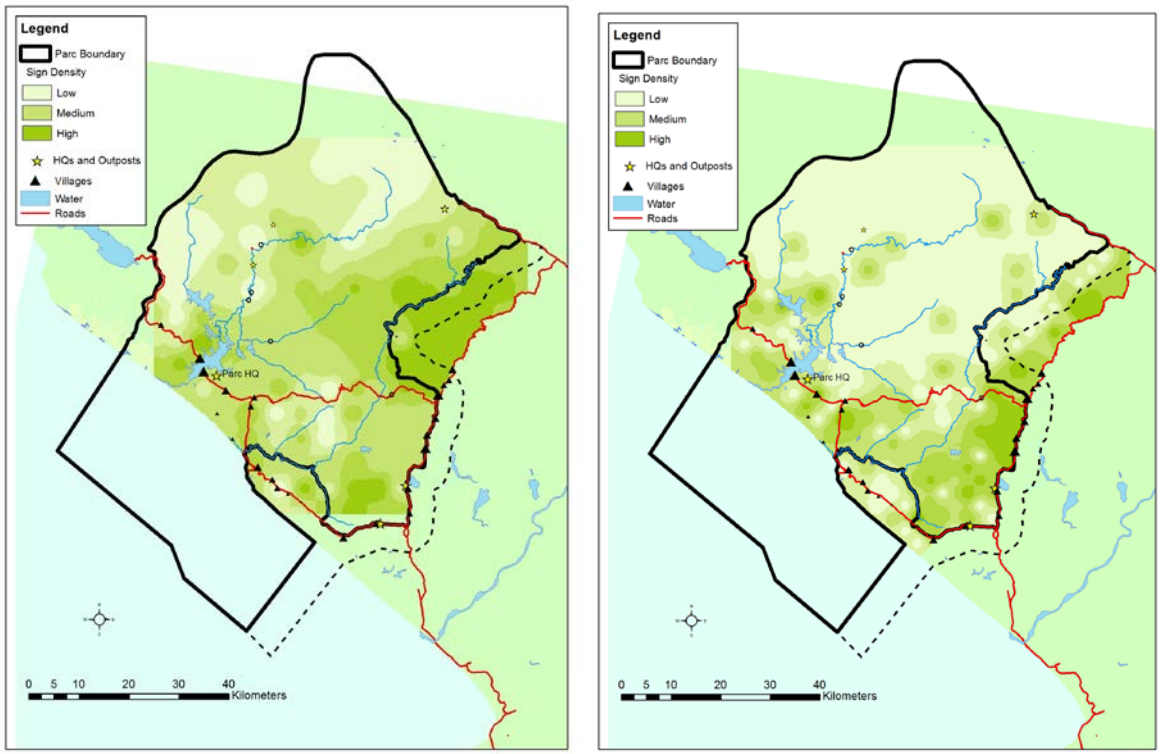
In most areas in Congo people consume chimpanzee and gorilla meat but the coastal population is essentially of Vili ethnic origin, one of few ethnical groups that do not eat chimpanzees. As a result they are found in large densities at CDNP, even in areas around human habitation (Fig 3). The gorillas are less fortunate although that there consumption is only linked to rituals.

Figure 3: Clockwise from the left, Chimpanzees and gorillas at CDNP in 2013



The strong reduction of impact signs at CDNP is the effect of 10 years of conservation and protection efforts (Fig 4). Human impact signs are almost entirely restricted to the ecodevelopment zones today.

Figure 4: Human impact signs in 2005 and 2013



4. CONCLUSION

Updates counts of great apes and elephants are essential to identify unanticipated reductions and allow to react accordingly, as well as to identify the results of protection efforts. At CDNP three of four total surveys were financed by USFWS, without which this would not have been possible.

Especially in the light of steadily increased poaching pressure on elephants for their ivory it is important to conduct updated density estimates with small %CV values to pick up important population changes. The distribution maps allow to better plan surveillance mission to better protect elephants and great apes. Finally, the surveys also allow testing new survey designs to potentially increase density accuracy. Through the 2013 survey we tested the effect of observers fatigue on data recording and found that reducing transects from 1000m to 500m helps avoid this, resulting also in likely more accurate overall numbers.

With 7609 (CV%15.56) of central chimpanzees and 914 (CV%38.43) of Eastern lowland gorillas in 2013, CDNP is rightly identified as a priority site in the IUCN great ape conservation action plan. CDNP is also a site used by five species of marine turtles and it is one of the world's priority sites for the nesting of leatherback turtles. CDNP equally houses an important resident group of the rare humpback dolphins and is becoming also increasingly important for elephants, acting as a safe haven and refuge. If elephant densities continue to increase at the current rate, it may become one of the most important parks also for elephants in the next 10 years in Congo and be a perfect exemple of how a strongly depleted park on paper can be transformed in a park worthy of its status provided long-term commitment of willpower and financial backup to make it happen.

ANNEXE I: Distance6 Great Ape results:

CDNP Great Ape estimates, 2005

	Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine					
D	1.6148	17.61	161.00	1.1436	2.2801
N	6193.0	17.61	161.00	4386.0	8744.0

CDNP Great Ape estimates, 2008

	Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine					
D	1.6605	16.29	181.99	1.2066	2.2852
N	6368.0	16.29	181.99	4627.0	8764.0

CDNP Great Ape estimate, 2010

	Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine					
D	1.7038	14.37	201.53	1.2853	2.2585
N	6534.0	14.37	201.53	4929.0	8661.0

CDNP Great Ape, Chimpanzee (Chim) and Gorilla (Gor) estimates, 2013

	Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine					
D	2.2447	14.64	358.63	1.6857	2.9891
N	8608.0	14.64	358.63	6465.0	11463.

	Estimate	%CV	df	95% Confidence Interval	
Stratum: Chim					
Half-normal/Cosine					
D	1.9842	15.56	349.39	1.4637	2.6898
N	7609.0	15.56	349.39	5613.0	10316.
Stratum: Gor					
Half-normal/Cosine					
D	0.23833	38.43	233.29	0.11472	0.49512
N	914.00	38.43	233.29	440.00	1899.0

ANNEXE I: Distance6 Elephant results:

CDNP elephant estimate, 2005

		Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine						
	D	0.12255	26.39	140.86	0.73368E-01	0.20471
	N	470.00	26.39	140.86	281.00	785.00

CDNP elephant estimate, 2008

		Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine						
	D	0.13288	20.42	237.62	0.89239E-01	0.19788
	N	510.00	20.42	237.62	342.00	759.00

CDNP elephant estimate, 2010

		Estimate	%CV	df	95% Confidence Interval	
Half-normal/Cosine						
	D	0.17189	19.14	201.17	0.11826	0.24983
	N	659.00	19.14	201.17	454.00	958.00

CDNP elephant estimate, 2013

Pooled Estimates:

	Estimate	%CV	df	95% Confidence Interval	
D	0.24695	19.25	99.74	0.16913	0.36056
N	947.00	19.25	99.74	649.00	1383.0

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