

Faunal Inventory of the Dja Faunal Reserve, Cameroon – 2018



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September 2018



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Recommended citation: Tom Bruce, Constant Ndjassi, Andrew Fowler, Malenoh Ndimbe, Oliver Fankem, Roger Bruno Tabue Mbobda, Anne-Stéphanie Kobla, Franck Annol Wabo Puemo, Rajan Amin, Tim Wachter, Sophie Grange-Chamfray, David Olson. 2018. *Faunal Inventory of the Dja Faunal Reserve, Cameroon – 2018*. Ministry of Forests and Wildlife (MINFOF), Zoological Society of London – Cameroon Country Programme, African Wildlife Foundation, Yaoundé, Cameroon.

Executive Summary

The Dja Biosphere Reserve (DBR) in southern Cameroon is notable for populations of forest elephant, Western lowland gorilla, Central chimpanzee, bongo, and many other species of wildlife. A faunal inventory of the Dja Faunal Reserve (the protected area at the center of the larger DBR) was carried out in 2018 to help protected area managers, the Ministry of Forests and Wildlife (MINFOF), assess the status and trends of populations of larger wildlife species. The inventory was supported by the *Programme de Conservation et Utilisation Rationnelle des Ecosystemes Forestiers en Afrique Centrale 6* (ECOFAC6) project for the Dja Biosphere Reserve (DFR), Cameroon. The full-reserve faunal inventory was carried out by the Ministry of Forests and Wildlife (MINFOF), Zoological Society of London (ZSL), and African Wildlife Foundation (AWF).

A total of 283, 1 km line transects were carried out, covering the entire DFR (a total distance of 1,979.58 km was walked within the reserve during the survey, 298.2 km was on line transects). Distance sampling analyses were used to estimate the density and abundance of forest elephants, central chimpanzee, and western lowland gorilla. Only forest elephant, central chimpanzee, western lowland gorilla, yellow-backed duiker, forest buffalo, bongo, sitatunga, and leopard had sufficiently identifiable spoor to be reliably recorded. Encounter rates for arboreal primates and various ungulate species were recorded based on direct sightings. The survey was carried out between April and June 2018, the same time of year as a prior full-reserve faunal inventory conducted in 2015. Nineteen mammal species were encountered during the survey. The most frequently directly encountered ungulate were red duiker species at a rate of 0.025/km. The arboreal primate most often detected by either direct observation or vocalisation was the putty-nosed guenon (0.088/km). Encounter rates of African grey parrot were very low compared to other protected areas within the region.

Dung and nest decay rate field studies were conducted to support wildlife population estimates. These produced decay estimates of 83.2 (\pm 6.193) days for forest elephant dung and 96.6 (\pm 2.872) days for great ape nests to fully degrade within the DFR environment.

Forest elephant, Western lowland gorilla, and central chimpanzee all show declining populations compared to levels estimated in prior years. Estimated forest elephant populations suggest a decline of 50% since a prior inventory in 2015, to approximately 219 individuals (150 – 319, 95% CI) resulting in a density of 0.04 individuals/km². However, the 2015 inventory estimate for forest elephant may have been inordinately elevated due to methodological challenges and the 2018 estimate is more in line with pre-2015 estimates and trends in the decline of regional forest elephant populations. We estimate that the current population of forest elephant within the DFR is roughly 15% of an estimated carrying capacity of the landscape, a level consistent with declines in other protected areas in the Tri National Dja-Odzala-Minkébé (TRIDOM) conservation landscape.

Great ape populations declined in the DFR since the 2015 inventory. Western lowland gorilla displayed a significant decrease, with an estimate of 1,258 individuals (779 – 2,031, 95% CI) at a density of 0.24/km². Again, methodological differences in survey practice and analysis between this inventory and the 2015 inventory may be magnifying the apparent sharp declines in gorilla between the 2015 and 2018 inventories. The central chimpanzee population displayed a more modest decline. Estimates of 2,313 individuals (1,568-3,411, 95% CI) at a density of 0.43/km² were recorded during the survey. Both great ape species appear most abundant in the north-east corner of the reserve.

Indicators of human activity within the reserve are highest in the north-west and lowest in the southern sector towards the centre. The most frequently encountered sign of human activity were trails, machete cuts, and signs of human passage. Areas within the reserve that have few signs of human activity are uncommon.

Key findings are:

1. While forest elephant, western lowland gorilla, and central chimpanzee occur within the Dja Faunal Reserve, these populations are diminished compared to what the landscape and habitat could theoretically support and all show population declines compared to prior surveys. Hunting for the illegal wildlife trade and bushmeat are likely the primary driver of the declines.
2. Central chimpanzee populations have declined the least and remain similar to levels recorded in 1995. The dramatic decline of western lowland gorilla numbers—a fivefold decrease—is likely due to an overestimate in the 2015 inventory. If disease outbreaks, such as ebola, were responsible for the gorilla decline this would likely result in population crashes of both great ape species as observed in Minkébé and other reserves. Poaching would also be expected to have a similar effect on both species.
3. Most human sign was recorded in the north-west of the reserve. The low encounter rates of wildlife in this area other than around Bouamir Research Station suggest human activity continues to impact wildlife within the reserve. We recommend that three areas could be key to conserving wildlife within the reserve and warrant extra protection from patrols and surveillance: (1) the area around Bouamir Research Station (a hotspot for the elephant population), (2) the north-east corner of the reserve where great apes were most frequently encountered, and (3) the habitat around Bali Bai and the east of the Southern Sector that has lower levels of human sign and where disturbance-sensitive species, such as leopard, golden cat and white-bellied duiker, most commonly occur.
4. Best practice and standard methods should be used by protected area managers when planning and reporting on future survey work. There were difficulties in drawing comparisons to previous inventories due to variable methods employed, lack of details provided in methodological details, and differences in results that are difficult to understand in ecological terms.
5. A focused survey of the wildlife corridor to the south-east of the reserve, the last unbroken forest linking the reserve to the wider TRIDOM landscape, would allow a better understanding of population dynamics and movements of wide-ranging species, such as forest elephant.

Table of Contents

1. Introduction	
1.1 - Introduction	6
1.2 - Inventory objectives	9
2. Methods	1
2.1 – Target Taxa	10
2.2 – Survey design – Minimum effort calculations	10
2.3 – Transect orientation & length	12
2.4 – Survey methodology & data recording	13
2.5 – Survey team composition	13
2.6 – Training	13
2.7 – Data cleaning – Transect & recce GPS data files	14
2.8 – Data analysis	14
3. Results	
3.1 – Effort	16
3.2 – Species encounters on transects and recces	17
3.3 – Transect data	18
3.4 – Interpolated distribution & abundance maps	21
3.5 – Wildlife abundance estimates	27
3.6 – Recce data	28
3.7 – Comparison to previous Dja Faunal Reserve surveys	31
4. Conclusions & recommendations	34
5. Acknowledgements	36
6. Literature Cited	37
Appendix 1 – Decay Rate Study for Elephant Dung and Great Ape Nests for the Dja Faunal Reserve – 2018	40
Appendix 2 – Medium-sized and Larger Mammal Species List for the Dja Faunal Reserve	57

Full-Reserve Faunal Inventory of the Dja Faunal Reserve, Cameroon – 2018

1. Introduction

1.1 Introduction

Populations of great apes and forest elephants (*Loxodonta cyclotis*) (Maisels *et al.* 2013) are currently facing dramatic declines throughout Central Africa. There are multiple factors leading to these declines acting at different spatial scales. These include poaching, habitat fragmentation and isolation, human-wildlife conflict, and disease outbreaks. For example, over 25,000 elephants are thought to have been lost over 10 years in Minkébé National Park, Gabon primarily due to poaching (Poulsen *et al.* 2017). In the same park, both western lowland gorillas (*Gorilla gorilla gorilla*) and central chimpanzees (*Pan troglodytes troglodytes*) are estimated to have only remnant populations left due to disease outbreaks of Ebola. The protected area was previously home to large populations of both species (Huijbregts *et al.* 2003). The rapid rate at which populations of these endangered megafauna are declining highlights why monitoring population trends is a vital component of effective conservation and protected area management in Central African forests.

The Dja Biosphere Reserve (DBR), constituting the Dja Faunal Reserve (DFR) and surrounding buffer zones, is located in southern Cameroon (Fig. 1). The protected area was established in 1950 and was reclassified as a Biosphere Reserve in 1981 and further upgraded to a World Heritage Site in 1987 (Muchaal & Ngandjui 1999). The center of the reserve is located roughly 240 km southeast of the capital Yaoundé in southern Cameroon (Fig. 1). It covers an area of approximately 5,260 km², extending between latitudes 2°49'–3°23'N and longitudes 12°25'–13°35'E (UNESCO 2015). Approximately 80% of the reserve is surrounded by the Dja River. This provides a natural barrier and some limited protection to the reserve (Nguiffo 2001), though crossing in canoes is common. The density of human populations around the reserve is low, estimated in 2001 at 1.5 people per km², with many small villages surrounding the reserve (Nguiffo 2001), though population numbers have likely risen considerably due to the arrival of rubber plantations and the development along roads since 2001. Expanding settlements and transport corridors to the south and east of the reserve are rapidly clearing natural forest. The Biosphere Reserve outside of the formal Dja Faunal Reserve is largely comprised of Forestry Management Units (FMUs), settlements, and community forests, though there are rubber plantations and a hydroelectric dam with a reservoir on the Dja River in the western buffer zone.

The reserve is a relatively flat plateau of round-topped hills (UNESCO 2015) and ranges in altitude from 600–800 masl (MINFOF & IUCN 2015). The topography is mainly shallow valleys on either side of a ridgeline that cuts through the reserve east to west (MINFOF & IUCN 2015). In the floors of the valleys, swamp habitat becomes more common and tributaries throughout the reserve flow into the Dja River (UNESCO 2010, MINFOF & IUCN 2015). The three major types of forest in the reserve are mixed species forest *terra firma*, monodominant forest where *Gilbertiodendron dewevrei* is the most abundant species, and periodically flooded forest (Djuikouo *et al.* 2010). The Dja Faunal Reserve supports a rich medium-sized and larger mammal fauna (Appendix 2).

There are four main seasons: the long rains (August–November); the dry season (November–March); the small rains (March–May); and a shorter dry season (June–July) (MINFOF & IUCN 2015). During the dry season there is on average <100 mm of rainfall and a mean annual rainfall of approximately 1,570 mm (UNESCO 2010). The mean annual temperature is 23.5°C–24.5°C (Sonké 1998). The maximum temperature is reached in February and the minimum in July (MINFOF & IUCN 2015).

Within and around the reserve, poaching occurs for subsistence (largely through non-traditional means, such as guns and wire snares) and for the commercial and illegal wildlife trade. Hunting

isintense and widespread (Muchaal & Ngandjui 1995, UNESCO 2010). Around the Dja Faunal Reserve other significant threats include mining (a proposed concrete plant, logging, agricultural clearance, rubber plantations and the associated demands for bushmeat, and the ecological impacts of existing and planned hydroelectric dams (Muchaal & Ngandjui 1995, 1999, MINFOF & IUCN 2015).

Cameroon’s Ministry of Forests and Wildlife (MINFOF) is responsible for the management of the Biosphere and Faunal Reserve (the Faunal Reserve is imbedded within the larger Biosphere Reserve). In order to facilitate management, the Faunal Reserve has been divided into four sectors with a base responsible for each sector in the nearest town; Lomié (East Sector), Djoum (South Sector), Meyomessala (West Sector), and Somalomo (North Sector).

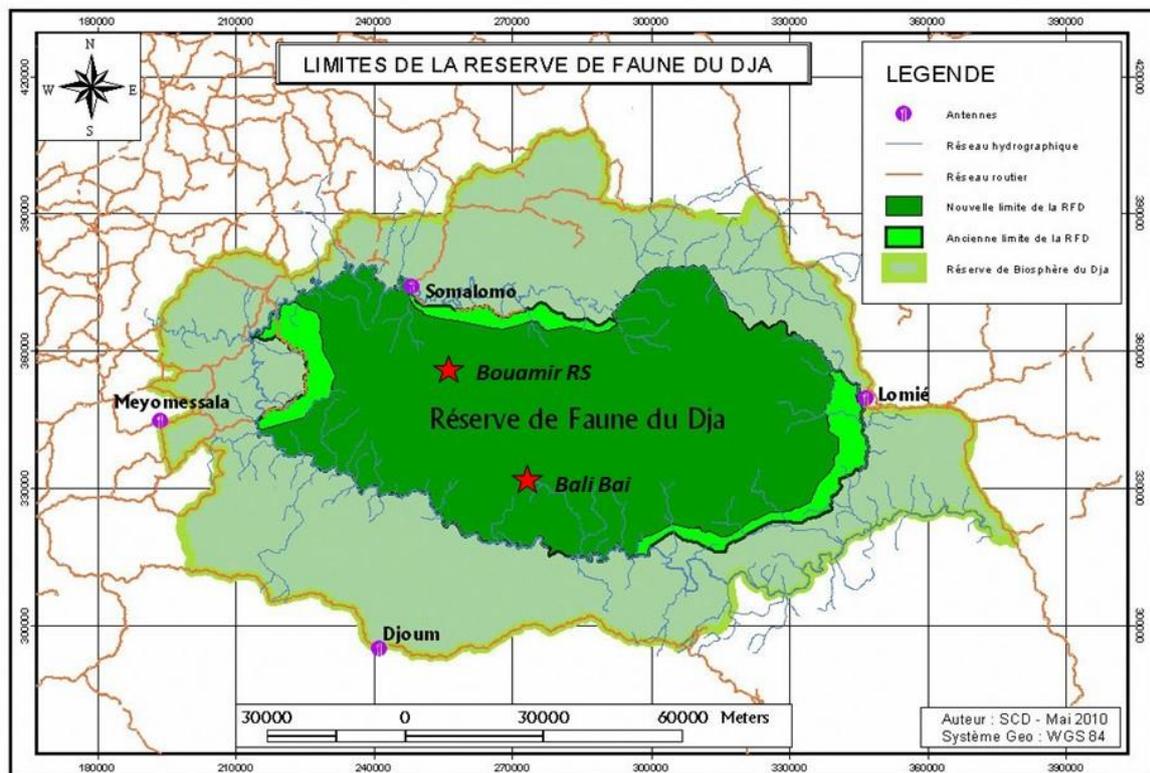


Figure 1. Dja Biosphere Reserve in southern Cameroon. The location of Bali Bai and Bouamir Research Station are shown.

1.2 Inventory Objectives

The primary objective of the 2018 Full-Reserve Faunal Inventory for the Dja Faunal Reserve (DFR) is to assess the 2018 status of forest elephant and great apes throughout the DFR. This extant megafauna is considered one of the Outstanding Universal Values of the Dja Biosphere Reserve (UNESCO 2018). Distance sampling carried out through transect and recce surveys provides a robust method to approximate population sizes of these taxa, particularly great apes, whose nests are observable, and forest elephant whose dung are reliably observed if present. Data was not collected for smaller forest antelope or other terrestrial mammals as confidence in identifications is generally low (Van Vilet *et al.* 2008). Arboreal primates and African grey parrots (*Psittacus erithacus*) were recorded when encountered. In order to enhance accuracy of forest elephant and great ape population estimates, a concurrent dung and nest decay rate study was carried out in the DFR (Appendix 1; see Hedges & Lawson 2006, Kühl *et al.* 2008).

For each target taxa, the population size within the DFR as a whole was estimated using Distance Sampling analyses (Buckland 2011). These estimates can be used by MINFOF protected area managers to better understand the overall distribution of certain species throughout the reserve during the inventory period and season. Such information can inform ecoguard patrol strategies and identify hotspots of abundance within the reserve that may deserve increased attention. The inventory also gathered information on the type, frequency, and distribution of different kinds of human activities within the DFR. When combined with the information on the distribution of species, human activity data can provide insight into the importance of hunting pressure and human disturbance in diminishing wildlife populations and the scale at which impacts operate. For both species and human activity data, distribution and abundance trends over time are assessed by comparison to prior species and human activity surveys (MINFOF & IUCN 2015).



2. Methods

2.1 Target Taxa

Several threatened species for which distance sampling can provide relatively accurate population estimates were the primary targets for this inventory. These include forest elephant, western lowland gorilla, and central chimpanzee. Larger antelopes, such as yellow-backed duikers (*Cephalophus silvicultor*), bongo (*Tragelaphus eurycerus*), and sitatunga (*Tragelaphus spekii*), were also sampled from droppings or direct sightings. This inventory does not take into account the indirect sign of the medium-sized ungulates. The red duikers' were grouped at the familial level as identifying species from dung (Van Vilet *et al.* 2008) and identifications from the usually short encounters in the forest are unreliable. The group of red duikers is made up of four species within the reserve—Peters' duiker (*Cephalophus callipygus*), bay duiker (*Cephalophus dorsalis*), black-fronted duiker (*Cephalophus nigrifrons*), and white-bellied duiker (*Cephalophus leucogaster*)—all of which have been confirmed to be extant within the reserve using camera-trap surveys (Bruce *et al.* 2017, Bruce *et al. in press*). Leopard (*Panthera pardus*) were to be documented through scat, direct sightings, or vocalizations. Diurnal and arboreal primates and African grey parrots were also taxa of interest, identified through direct sightings for primates or direct sighting or vocalizations for parrots. Other species were recorded if confident, direct sightings occurred. Scratches and diggings were not considered adequate evidence for pangolins or other species as there are many different animals that make similar sign and one cannot associate such sign to any particular species with confidence.



Figure 2. Central chimpanzee nest (left) and western lowland gorilla nest including fresh dung (right).

2.2 Survey design – Examining available survey data to calculate the minimum effort required

Given the large size of the DFR and the relatively high cost of conducting a comprehensive inventory using distance sampling, it was important to calculate the minimum effort required to produce robust data that generates accurate estimates. Two prior surveys were compared to produce minimum sample estimates. Latour (2010) conducted transects in a subset of the Northern Sector of the reserve. IUCN and MINFOF conducted a full inventory of the DFR in 2015. In both prior surveys, data was gathered using a standard method employed throughout Central Africa to monitor wildlife, namely line transects using distance sampling for signs that can be reliably aged (White *et al.* 2000, Kühl *et al.* 2008, Maisels *et al.* 2009).

In order to estimate the minimum effort required for confident estimates, we evaluated the 2015 inventory data (MINFOF & IUCN 2015). The data gathered from this inventory was used to provide an estimate of the minimum effort required to adequately survey great apes and forest elephant populations. The least frequently encountered target species in 2015 was western lowland gorilla with 647 nests being encountered over 612 km producing an encounter rate of 1.05/km.

Buckland and colleagues (2011) suggest that one can determine the total length of transects needed by using knowledge of the encounter rate and the precision required:

$$L = \left[\frac{b}{(cv_t(\hat{D}))^2} \right] \left[\frac{L_o}{n_o} \right]$$

L : Number of kilometres to be walked in the final transect design (the total length of the transects in a stratum);

cv_t : Target coefficient of variation, expressed as a number between 0 and 1 (for example, 25% would be expressed as 0.25); remember that this means that “only when there is more than a 25% change in the population of target animals will this be detectable by the monitoring program”;

L_o : Total length of the transects covered by previous survey;

n_o : Number of objects detected along the transects in the previous surveys;

b does not actually have to be computed as an acceptable value for b for these purposes is 3 (Buckland 2011, Burnham *et al.* 1980).

In the 2015 inventory, 612 km of transects were walked and 647 nest groups were encountered. If the target c.v is set to be 10%, the equation would be as follows:

$$L = \left[\frac{3}{0.10^2} \right] \left[\frac{647}{612} \right] = 283.7 \text{ Km}$$

In the 2010 survey, the least frequently encountered target species was central chimpanzee, 43.35 km of transects were walked and 21 nest groups were encountered. If the target c.v is set to be 10%, the equation would be as follows:

$$L = \left[\frac{3}{0.10^2} \right] \left[\frac{21}{43.35} \right] = 619.2 \text{ Km}$$

This was an unrealistic distance to cover given our available resources, so we then used the next c.v. interval of 15%:

$$L = \left[\frac{3}{0.15^2} \right] \left[\frac{21}{43.35} \right] = 275.2 \text{ Km}$$

Therefore, by covering a minimum of 286, 1 km transects we have covered the minimum distance required to detect a 10% change in great ape and forest elephant populations according to the MINFOF and IUCN 2015 inventory. This survey effort will also allow a 15% change in central chimpanzee and 10% change of western lowland gorilla and forest elephant populations to be detected according to Latour’s survey of a more limited area in the northeast DFR.

We conducted 3.8 km recesses between the line transects. The distance between transects to allow 286, 1 km line transects to be evenly spaced within the boundary of the reserve was computed using the DISTANCE software package (Thomas *et al.* 2010).

In order to reduce seasonal influences on data, the surveys were planned to occur between April and June, which was during the same time period as the previous faunal inventory conducted by MINFOF and IUCN in 2015.

2.3 Transect orientation & length

All transects in the survey were orientated East to West (Fig. 3). This orientation was chosen as the major gradient within the reserve as the majority of watercourses run North–South. Human pressure likely comes from all sides of the reserve and is, in general, lower towards the centre of the reserve and towards the south where fewer settlements occur. Therefore, placing transects perpendicular to the human settlements that surround much of the reserve would not be possible. Furthermore, there are no detailed major habitat maps of the reserve available to guide the design process. As the limits of the management sectors (antennas) are not ecologically-based, they were not considered as important for pre-survey stratification.

We conducted 1 km transects to ensure that transects were short and, therefore, more likely to be as straight as possible, as longer transects are difficult to keep on a bearing in difficult terrain and understories. Shorter transects diminish the need for survey teams to concentrate for long durations as they would with longer transects and, therefore, improve data quality through less fatigue.

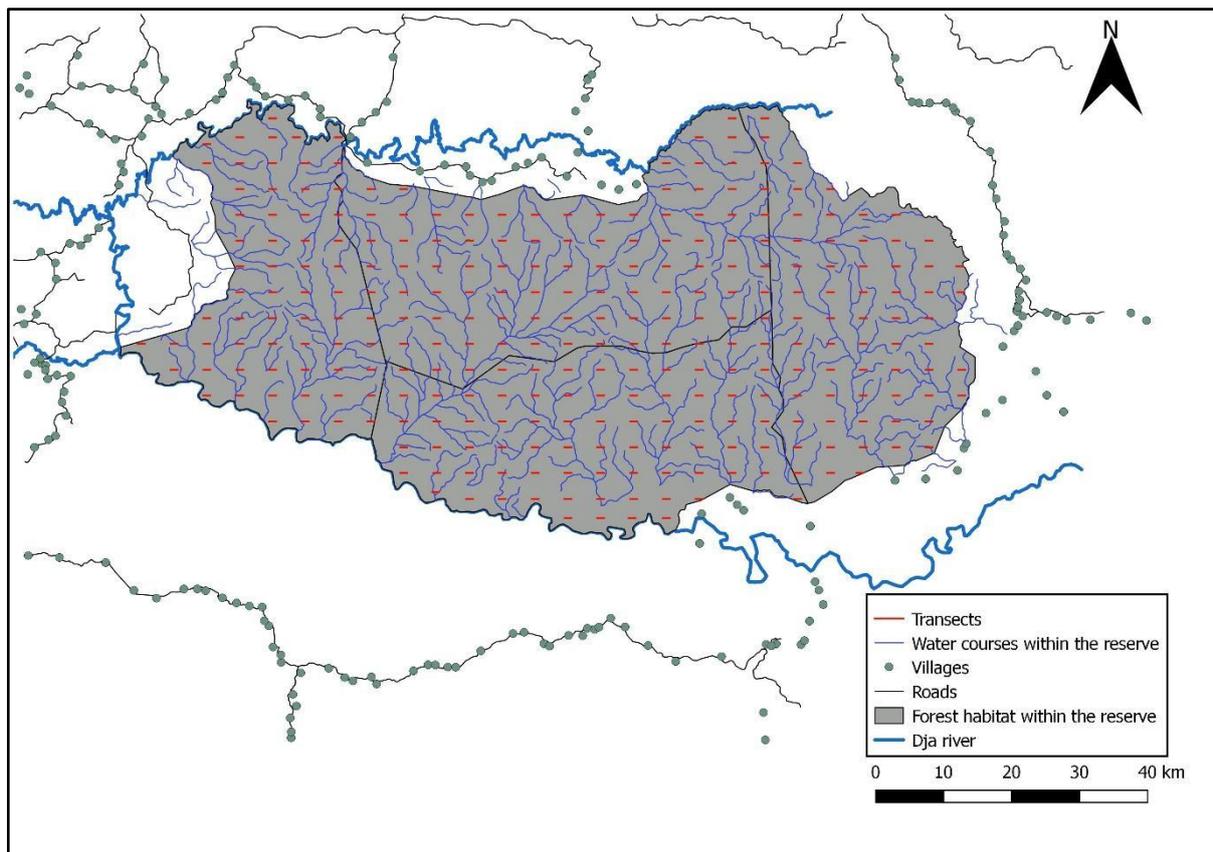


Figure 3. The survey design plan for the Dja Faunal Reserve, Cameroon.

2.4 Survey methodology & data recording

The survey follows a standard method used by large mammal surveys in Central Africa (White *et al* 2000, Kühl *et al* 2008, Maisels *et al* 2009). All wildlife dung and nests of species of interest, human sign, and direct sightings (including vocalisations) of all animals visible from the transects were recorded at any distance. Confidently recognizable footprints of species of interest and other sign within 1 m either side of the transects were recorded. All records were georeferenced. Forest elephant dung piles were aged according to the S-system (Hedges & Lawson 2006, Hedges 2012) and great ape nest aging categories were based on the system proposed by Tutin and Fernandez (1984) and Kühl and colleagues (2008), namely:

- New: <24 hours old, there will be fresh faeces or urine under the nest
- Fresh: Vegetation green or not wilted (up to a week old)
- Recent: Vegetation dry and changing colour (up to two weeks old)
- Old: Vegetation dead, but nest still intact (>2 weeks)
- Decayed: Nest beginning to disintegrate, holes visible in structure

The perpendicular distance at the centre of each individual dung pile and nest back to the line transect were measured to the nearest cm.

The survey design for great apes was constructed using the approach recommended on the Ape Populations Environments Surveys (A.P.E.S.) website (<http://apesportal.eva.mpg.de/database/archiveTable>) using Kühl *et al* (2008). Once a great ape nest was detected from the transect, an area of 50 m was searched around the nest for other nests. If another nest was found within 50 m, the search would begin again from that point. When no more nests within 50 m were found the search was ended and all data recorded for each individual nest found. All nests of the same age classification within these 50 m searches were classed as being within the same group.

Types of human sign recorded were trails, snares, signs of passage, machete cuts, shelters and camps, firearms & ammunition, timber exploitation, direct encounters with people, and gunshots heard. Camps were defined as any structures used for sleeping within the forest evident from cleared ground and the presence of a fire pit or structures. However, as a caveat, it is impossible to differentiate poacher's trails and cuts from those of ecoguards and NGO work within the reserve.

All data was recorded in notebooks and using Spatial Monitoring And Recording Tool – Ecological Records (SMART-ER) on Cedar Personal Digital Assistants (PDAs), and also in notebooks in case of failure of the Cedar device. An individual Global Positioning Satellite (GPS) point was taken for each observation and recorded in the notebook.

2.5 Survey team composition

Following the A.P.E.S. guidelines (Kühl *et al* 2008) and Monitoring the Killing of Elephants (MIKE) monitoring protocol (Hedges & Lawson 2006, Hedges 2012) teams followed a standard composition:

A path clearer and compass bearer – one member of this team would be clearing the path with secateurs whilst the other ensured he maintained the exact compass bearing.

Two observers, one looking up for great ape nests and visual observations of primates, while the other is looking at the floor and around ground level for dung, other species sign, human sign, and ground level great ape nests. This was to be their only responsibility and they were to carry no loads to allow optimal concentration.

Two data recorders, usually the Ministry of Forests and Wildlife (MINFOF) Ecoguard and the team leader. One was to be in charge of the GPS, PDA, and hip chain, whilst the other had the data sheets

for manual entry and the protocol. Four porters walked at a distance behind the team during transects and were responsible for carrying supplies and camping equipment.

2.6 Training

All of the team leaders were recruited on the basis that they had previously carried out line transect surveys in the past. However, there was a mixed level of experience and to ensure that the same protocol was being followed, a five-day training mission was carried out in the Southern Sector of the reserve. This training enabled everyone to spend time learning the various roles expected of each member of the survey teams, address any questions regarding the methodology, and to ensure everyone could safely navigate and work in the forest. While we were able to find many elephant dung piles of differing ages on a bai (clearing), we were unable to locate any fresh great ape nests, finding only two old central chimpanzee nests. This is similar to what was experienced during the MIKE training programme in 2003-2004 (Blake 2005). Following training, team leaders were assessed and one of the participants was paired with another more experienced leader to learn on the first mission and gain field knowledge before leading their own team in subsequent missions.



Figure 4. Team leaders during training.

2.7 Data cleaning – Transect & recce GPS files

In order to calculate the distances covered by the survey teams while conducting both surveys and recces, the two types of survey had to be separated from one another. This was done using the track logs (a point was placed every 5 minutes) recorded by the Garmin GPS units as their connection is likely to be more consistent than the Cedar devices. The start and end times of both recces and transects were taken from the Spatial Monitoring And Recording Tool (SMART) data. This was then used to clip the transects out of the track logs for each team within Garmin basecamp software. This was done to the nearest five minutes to the start or end time. To smooth the transects, the track lines were then decimated with one in every ten time waypoints kept.

2.8 Data analysis

All data was exported from the PDAs into SMART. All data entries within SMART were then checked against their paper counterparts to ensure that both were consistent with one another. Once the data was cleaned in SMART, it was imported into Excel and then converted into suitable formats for analysis in other software packages. All data analysis was conducted using the DISTANCE 7.1 software package. All maps were produced using Quantum Geographic Information System (QGIS).

In order to work out the encounter rate of direct and indirect observations of wildlife and human activity, the total distance covered for either transects, recces or the entire reserve divided by the number of sign encountered. This produces a rate of sign encountered per kilometer, which can provide a crude index of abundance, all other things being equal. However, it is worth noting that this does not take into account the influence of other variables, such as detectability.

Data analysis - density

As the locality for the nearest published survey of the decay rates of great ape nests and elephant was from Lobéké National Park, SE Cameroon (Kobla 2015), Anne-Stéphanie Kobla, a decay rate specialist, was hired to conduct a study of the decay rates of these signs within the Dja Faunal Reserve (Appendix 1). This was done using the same methodology employed by WWF in Lobéké (N'Zoo *et al* 2016). Here, seven day missions are carried out to find and mark forest elephant dung and great ape nests (<48 hours old). In total, there were seven missions followed by a revisit mission to assess what age category the nests and dung have become during the duration of the study and, therefore, establish the rate of decay within the environment at the same time of year the survey is being conducted. This is termed the prospective method and was the only option we had due to the retrospective method requiring to start a year in advance of the survey, at which point the resources for this inventory were not available.

The decay rate survey took place between April 2018 and September 2018. In total 85 elephant dung piles and 119 great ape nests were found within the 48 hour window of and included in the study. The data was analysed in R and Microsoft excel (Microsoft Office Professional Plus 2016, Version 1809), the logistic regression method was used to estimate the average decay rate. The decay rates in the DFR were as follows; Forest elephant dung was estimated to have decayed after 83.2 (± 6.193) days and great ape nests after 96.6 days (± 2.872).

Along with the decay rates estimated as part of this inventory, the following production rates were used in the density analysis. These were the same as those used in the MINFOF and IUCN (2015) survey. Forest elephants produced 19.77 dung piles per day in Santchou Faunal Reserve, Cameroon (Tchamba & Martin 1992), great apes produced nests at a rate of 1.09 per day in the Goualougo Triangle, Republic of Congo (Morgan 2006).

Distance analysis - Great ape nests

For the great ape nest groups, we used the average perpendicular distance to a nest group, as the first nest detected was not always recorded by the survey teams. A nest group was defined as nests <50 m from one another of the same age category. Their location was double checked in QGIS to ensure that all groups were correctly recorded.

For the central chimpanzee nest analysis, the data suggested that there was under-detection of nests close to the line. We, therefore, explored models using left truncation and removal of data within 3 meters of the line. As left truncation is known to produce a positive bias, we used the model that removed the data within 3 m of the line to ensure our estimate was more conservative. Following the removal of the data, we reassigned the distance bins as appropriate. We recommend that in subsequent inventories to have someone dedicated solely to searching for arboreal chimpanzee nests. Nests directly overhead may be missed at times due to their construction camouflaging them well with the frequently dense understory of the habitat within the reserve.

3. Results

3.1 Effort

The survey lasted from 4 April 2018 to 3 June 2018. During this time 283 transects were conducted covering a total distance of 298.2 km. Two transects had to be abandoned due to flooding. One was abandoned due to entering a village. Recces covered a total distance of 1681.38 km (Fig. 5). A total of 1.979.58 km was walked within the reserve during this survey.

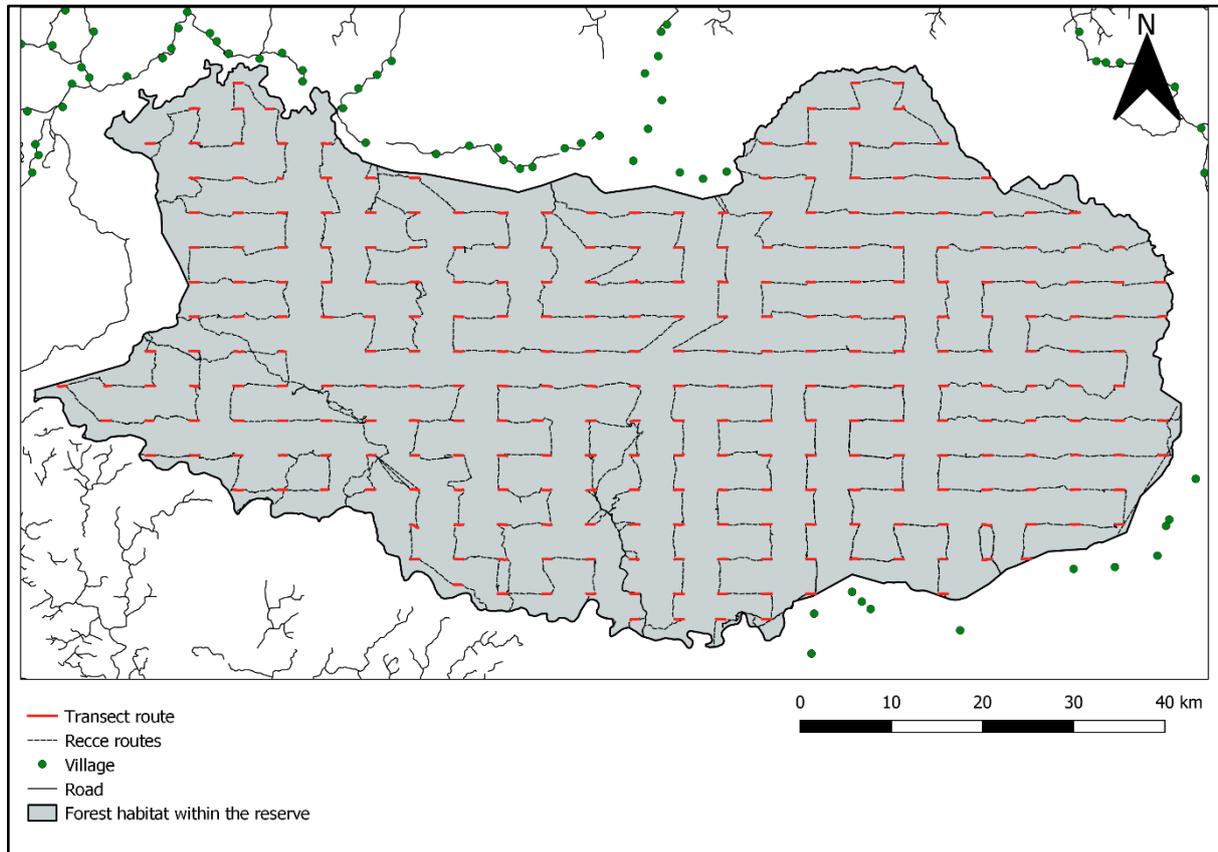


Figure 5. The completed transects within the Dja Faunal Reserve and their associated recces from the 2018 full-reserve faunal inventory.

3.2 Species encounters on transects and recces

Nineteen targeted species were encountered on the transects during the survey (Table 1). One of the least frequently recorded species, water chevrotain (*Hyemoschus aquaticus*) was directly observed twice. A single leopard scat was found. White-bellied pangolin (*Phataginus tricuspis*) and black-bellied pangolin (*Phataginus tetradactyla*) were found dead in the reserve.

Table 1. Encounter rate for all documented target species in both transects and recces using all available sign and direct sightings in the Dja Faunal Reserve, Cameroon. Encounter rate records vary very widely for different species so are not comparable between species.

Order	Species	Number of encounters	Rate/km
Proboscidea			
	Forest elephant (<i>Loxodonta cyclotis</i>)	2424	1.225
Primates			
	Central Chimpanzee (<i>Pan troglodytes troglodytes</i>)	934	0.472
	Western Lowland Gorilla (<i>Gorilla gorilla gorilla</i>)	817	0.413
	Agile mangabey (<i>Cercocebus agilis</i>)	25	0.013
	Moustached guenon (<i>Cercopithecus cephus</i>)	8	0.004
	De Brazza's guenon (<i>Cercopithecus neglectus</i>)	8	0.004
	Putty-nosed guenon (<i>Cercopithecus nictitans</i>)	174	0.088
	Crowned monkey (<i>Cercopithecus pogonias</i>)	4	0.002
	Black & White colobus (<i>Colobus guereza</i>)	12	0.006
	Satanic colobus (<i>Colobus satanas</i>)	6	0.003
	Grey-cheeked mangabey (<i>Lophocebus albigena</i>)	10	0.005
	Primate <i>sp.</i>	19	0.024
Artiodactyla			
	Red duiker <i>sp.</i>	49	0.025
	Blue duiker (<i>Philantomba monticola</i>)	15	0.008
	Yellow-backed duiker (<i>Cephalophus silvicultor</i>)	683	0.345
	Water Chevrotain (<i>Hyemoschus aquaticus</i>)	2	0.001
	Forest buffalo (<i>Syncerus caffer nanus</i>)	27	0.014
	Bongo (<i>Tragelaphus eurycerus</i>)	46	0.023
	Sitatunga (<i>Tragelaphus spekii</i>)	152	0.077
	Red river hog (<i>Potamochoere porcus</i>)	12	0.006
Carnivora			
	Leopard (<i>Panthera pardus</i>)	1	0.001
Pholidota			
	Black-bellied pangolin (<i>Phataginus tetradactyla</i>)	1	0.001
	White-bellied pangolin (<i>Phataginus tricuspis</i>)	2	0.001
Psittaciformes			
	African grey parrot (<i>Psittacus erithacus</i>)	43	0.003

3.3 Transect data

Encounter rates on transects

The encounter rates on 298.2 km of transect of dung, footprints, direct observations, and vocalisations of primates and other species are presented in Figs. 6–10. The most frequently encountered species based on dung and footprints were forest elephant (Figs. 6, 7). For the smaller diurnal primates, the most frequently directly encountered species was the greater spot-nosed guenon (Fig. 8). The most frequently encountered sign of great apes was central chimpanzee nests (Fig. 9). Direct observations most frequently documented medium duikers (Fig. 10). African grey parrots were most commonly encountered by hearing their calls (Fig. 10.). The top three most frequently encountered signs of human activity were trails, machete cuts, and signs of passage (Fig. 11).

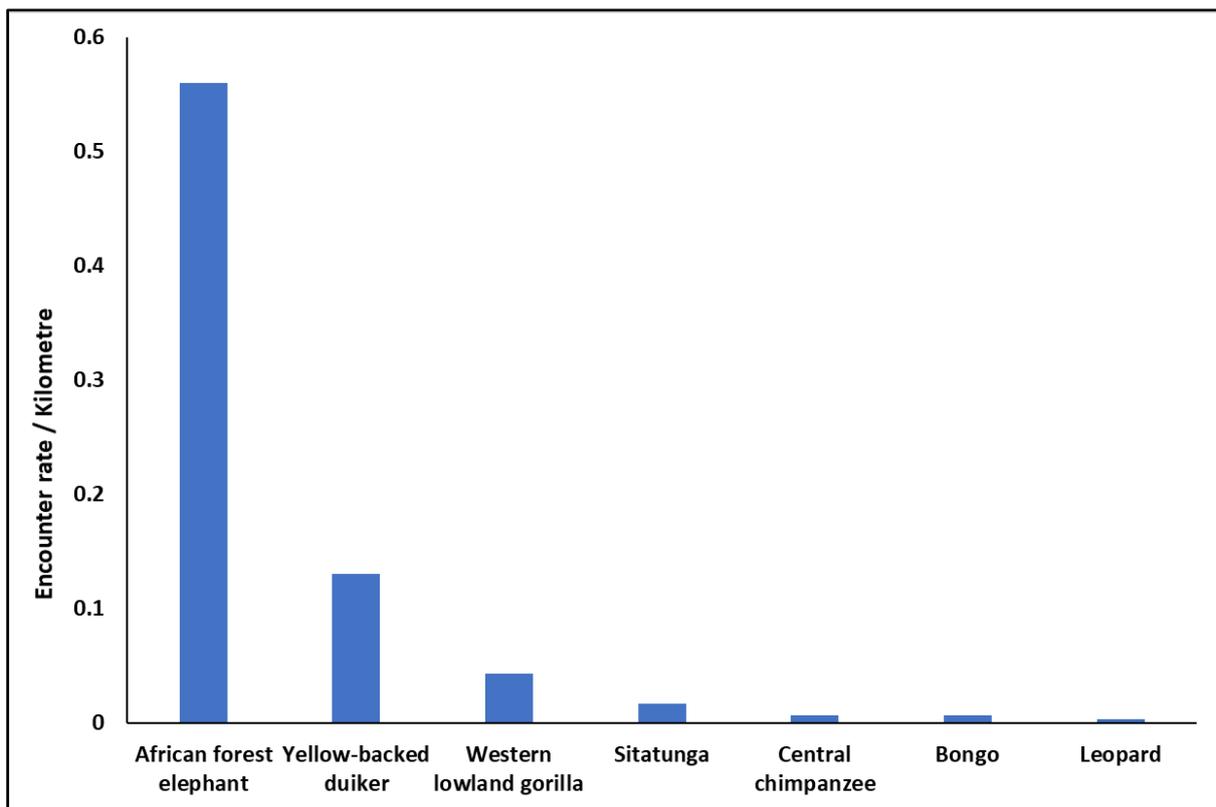


Figure 6. Encounter rates per km of dung on transects during the 2018 Dja Faunal Reserve inventory.

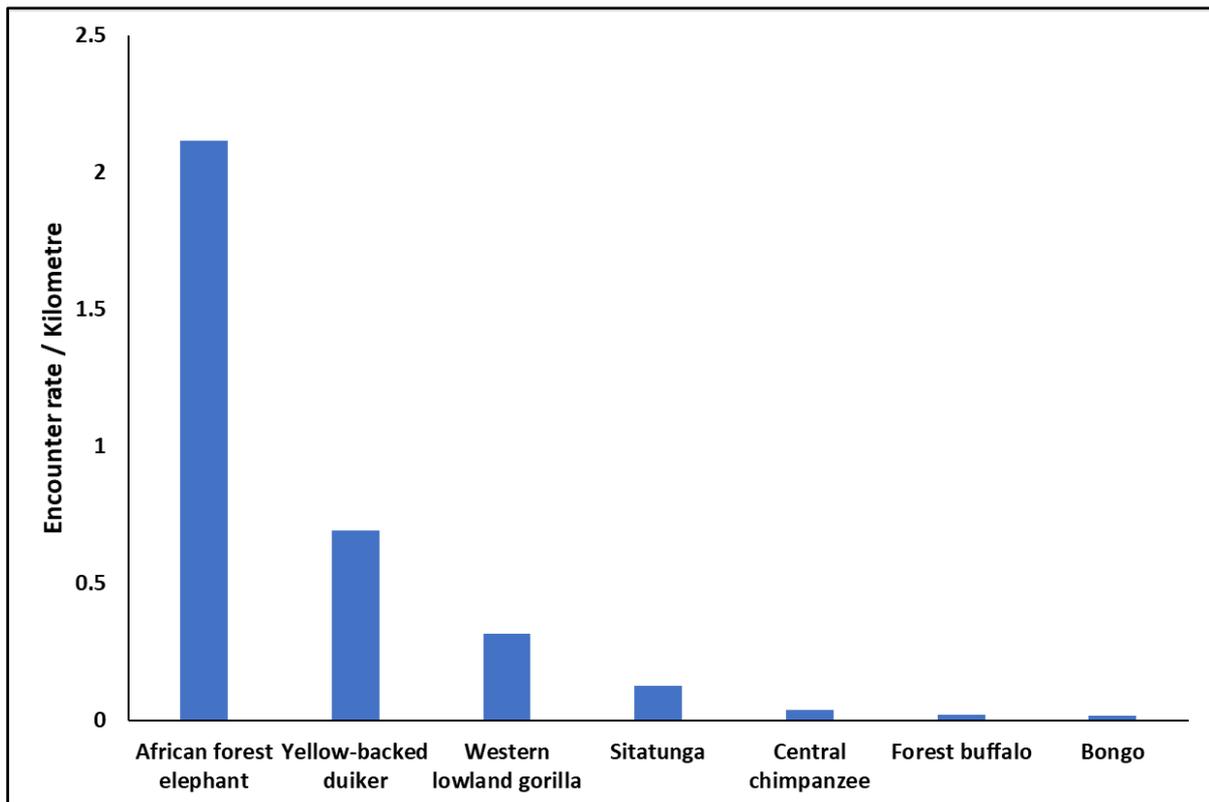


Figure 7. Encounter rates per km of footprints on transects during the 2018 Dja Faunal Reserve inventory.

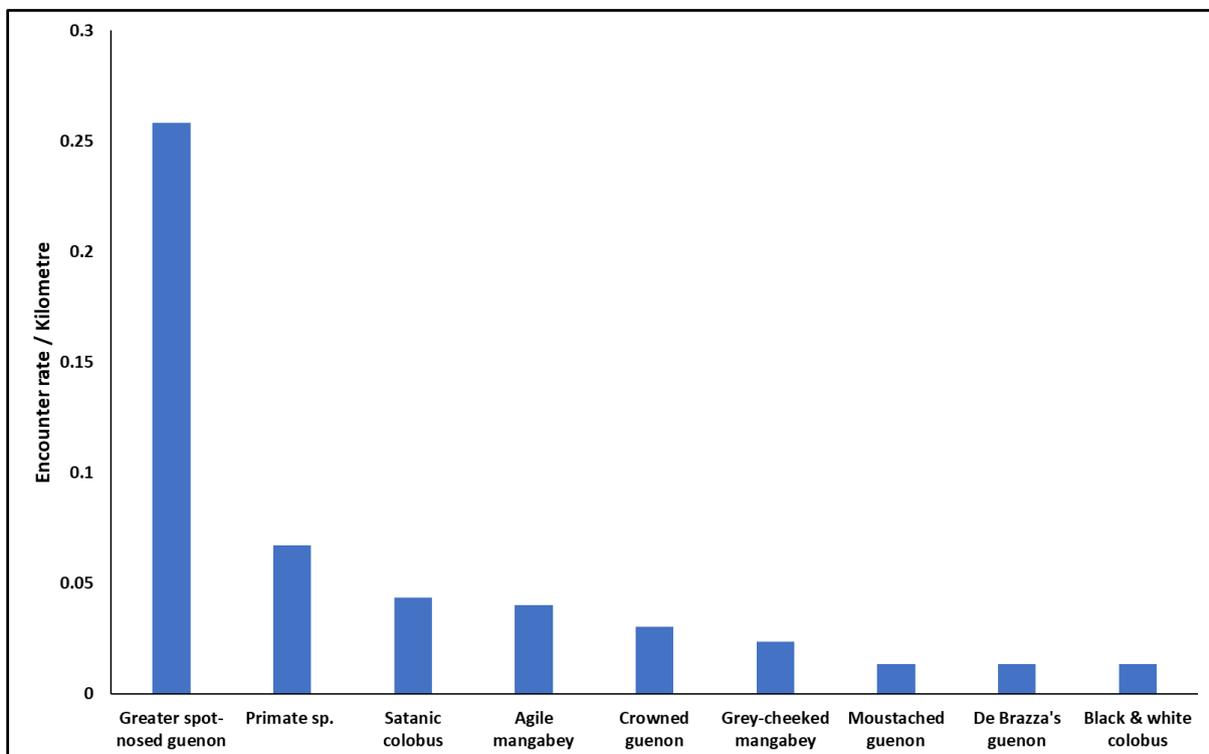


Figure 8. Encounter rates of direct encounters (observations and vocalisations) per km of primate species on transects during the 2018 Dja Faunal Reserve inventory.

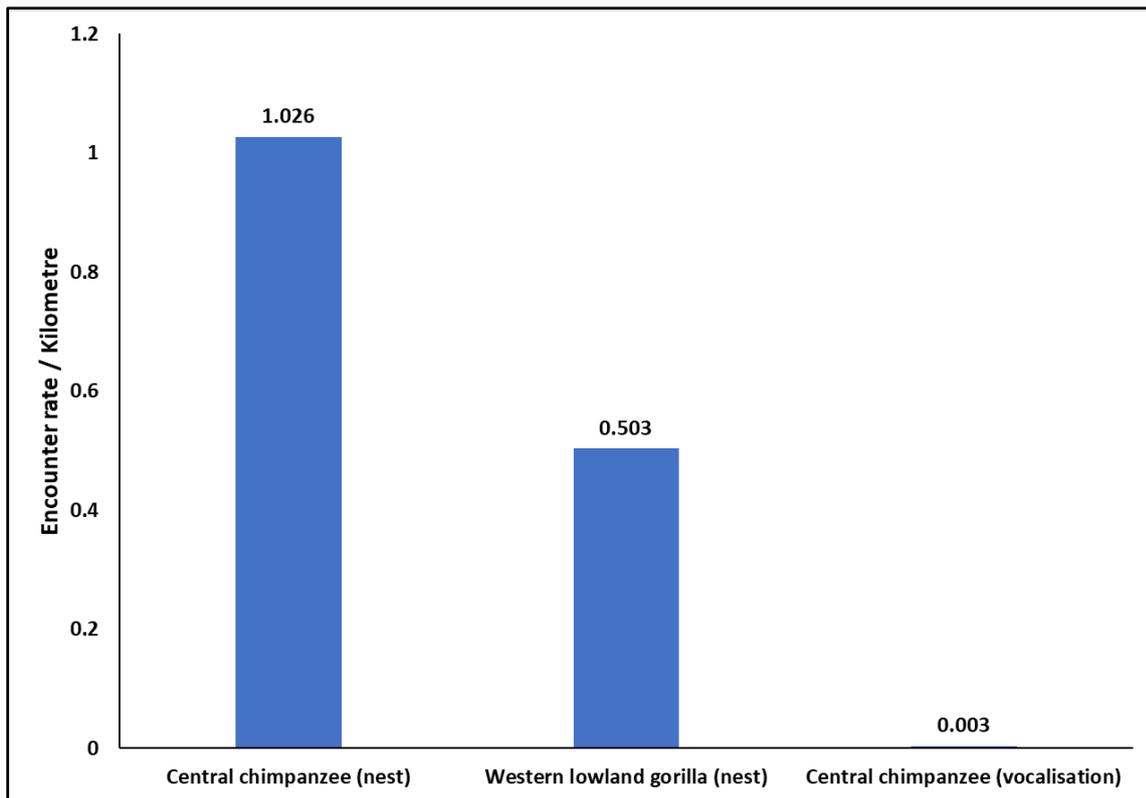


Figure 9. Encounter rates per km of great ape nests and vocalisations on 2018 Dja Faunal Reserve transects.

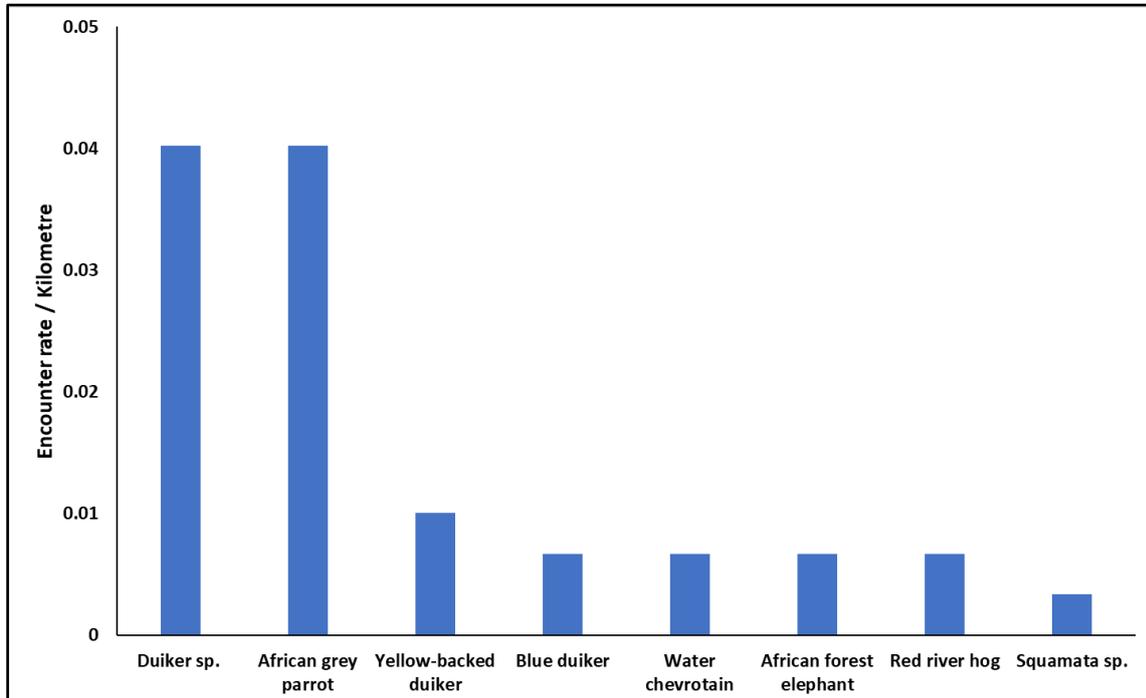


Figure 10. Encounter rates per km of direct encounters (observations and vocalisations) of all target species other than primates on 2018 Dja Faunal Reserve transects.

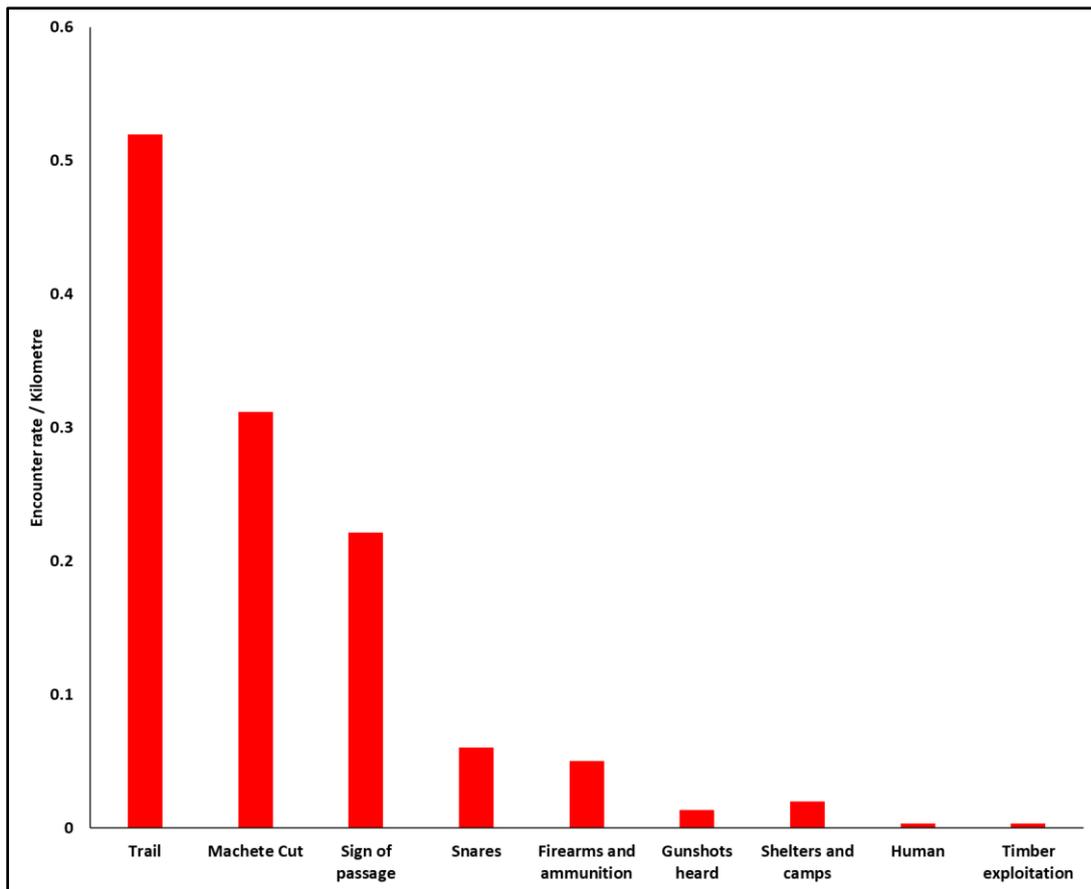


Figure 11. Encounter rates per km of human sign on 2018 Dja Faunal Reserve transects.



3.4 Interpolated distribution and abundance maps based on transect data

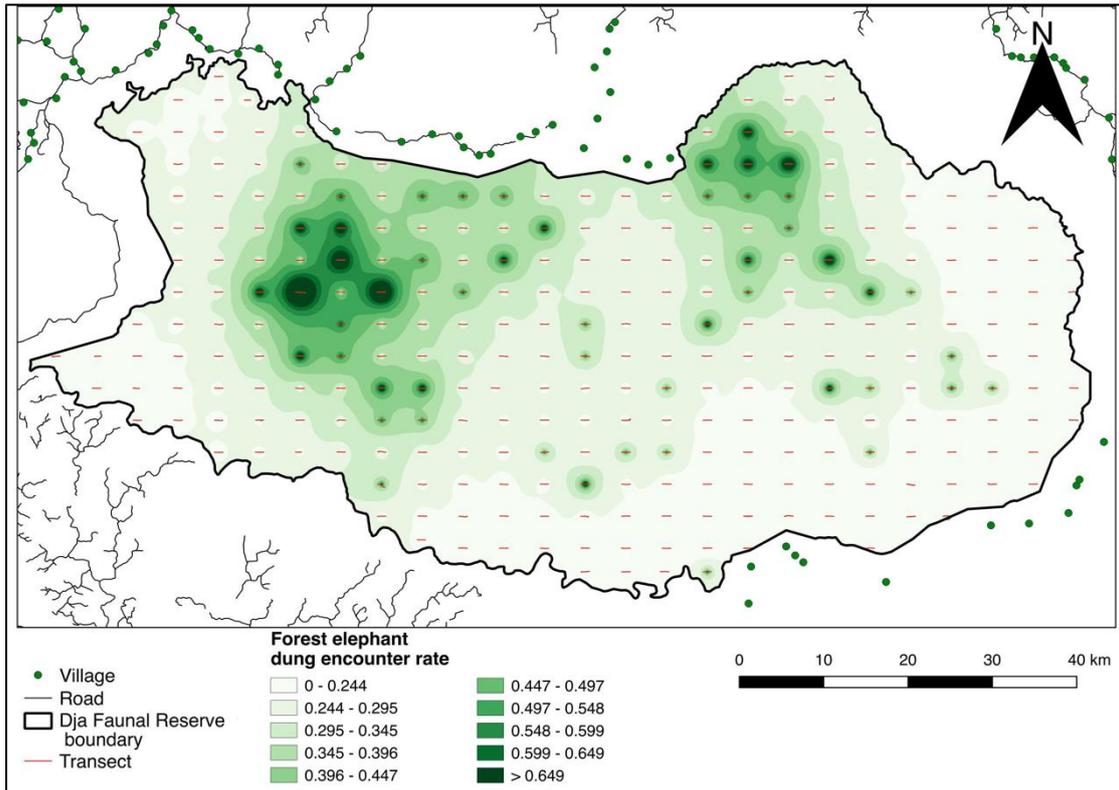
Interpolated maps are used to estimate and display the density of wildlife sign at unknown points from points that have been surveyed. The main advantage of this is it allows us to identify high priority areas, that we haven't been able to survey entirely, as it's physically impossible to survey every part of the reserve. However, it is worth noting this is a prediction and other environmental variables could be influencing the temporal and spatial nature of these distributions.

Only encounter rates of human sign, forest elephant and yellow-backed duiker dung, and western lowland gorilla and central chimpanzee nests detected on the transects were used to produce the interpolated maps (Figs. 12-16). This is to prevent inconsistencies with detection probabilities and observer biases when on recce walks. The distribution of human sign and these taxa within the reserve, in general, seems to be focused in the north-east corner of the reserve despite there being moderate levels of human activity in this area.

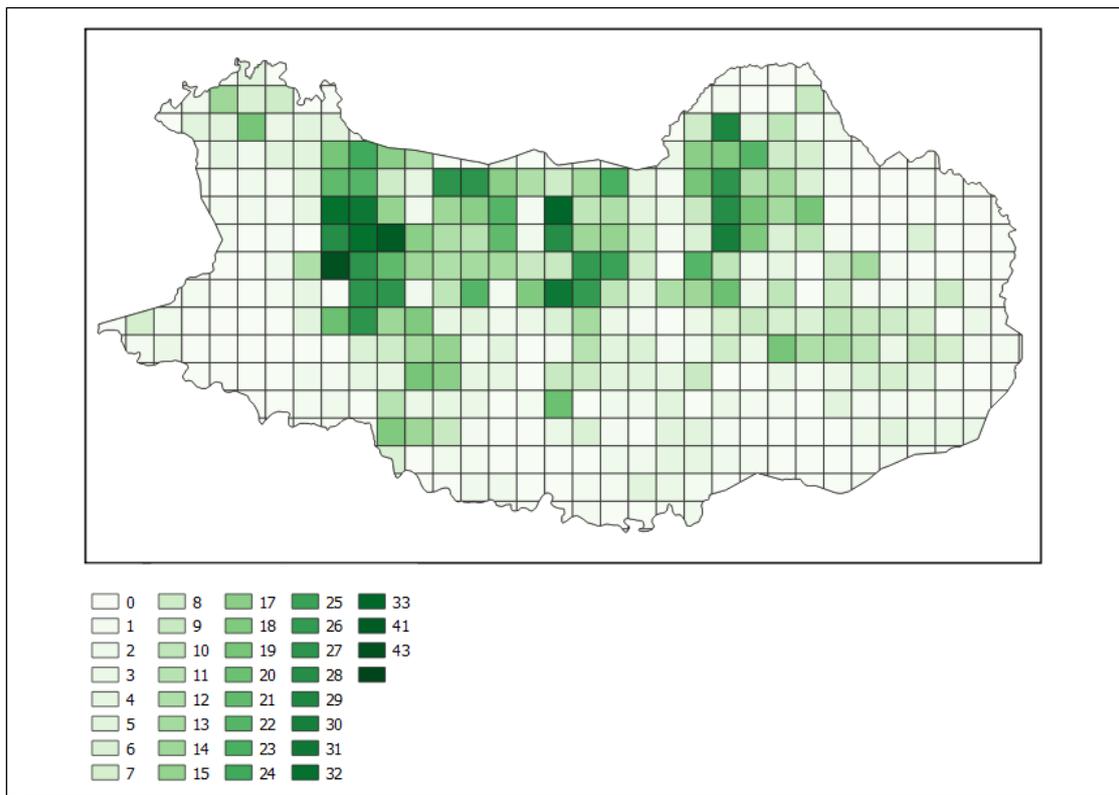
Forest elephant dung distribution

Forest elephant populations estimated during this survey seemed to be concentrated, at least during this particular inventory season, around the Bouamir area of the northwest of the reserve (Fig. 12ab). The reason for concentration is uncertain, but could possibly be due to the prevalence of large rocky outcrops in this area that are not found in other parts of the reserve that may support grasses (Porembski *et al.* 1996, Fitzsimons & Micheal 2017), or the area may act as a refuge from high hunting pressure as it is in the vicinity of the MINFOF/Congo Basin Institute's Bouamir Research Station. The presence of the trail from MINFOF Headquarters at Somalomo to Bouamir Research Station is also frequently patrolled, perhaps acting as a deterrent to poachers and thus functioning as a refuge from hunting by elephant. However, the reasons contributing to this concentration remain unclear. There is also a relatively high density of dung in the northeast corner of the reserve. Again, one must view this distribution map as a snapshot of elephant activity. Elephants may move over great distances in search of food, to avoid disturbance, or other reasons. Thus, a concentration of dung may simply reflect where elephants happen to be spending some time during the transect season. We also know from camera-trap surveys that elephants occur throughout the reserve and are commonly documented in the southern part of the reserve.

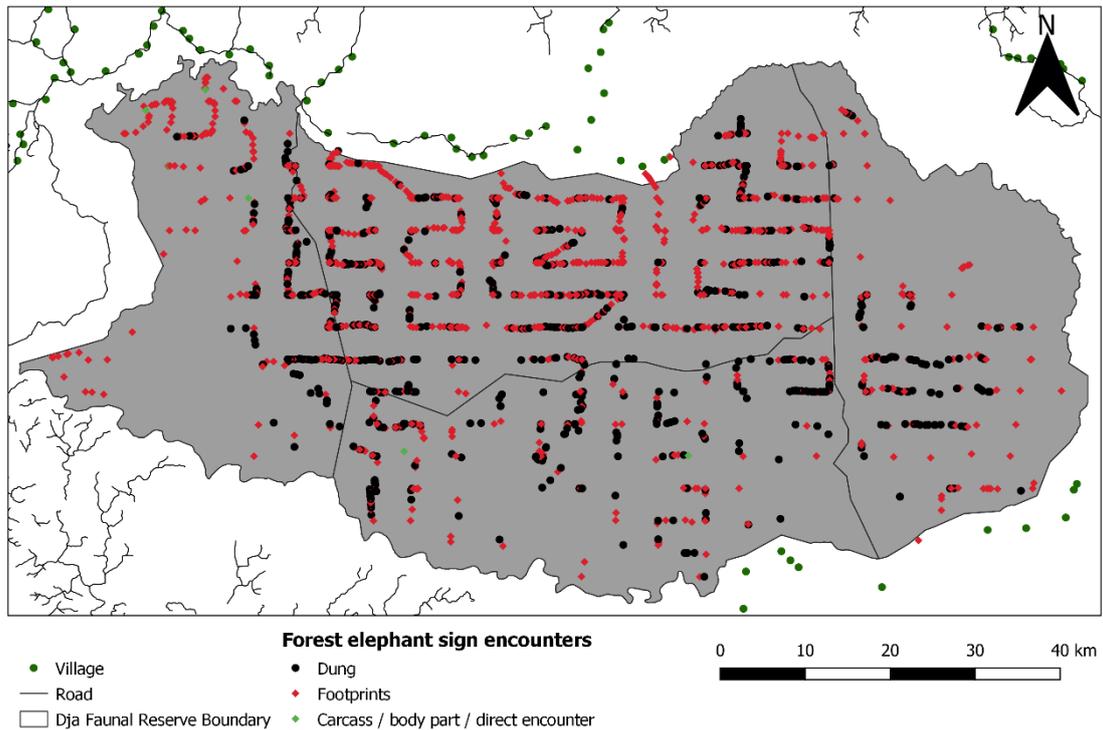




a



b



c

Figure 12abc. (a) Interpolated distribution of forest elephant dung throughout the Dja Faunal Reserve as estimated in the 2018 Dja Faunal Reserve inventory through transect data, (b) forest elephant dung encounter rates by grid for transect and recce data combined, (c) forest elephant dung, footprint, body part sign localities from recce and transect data. Note that elephant sign is found throughout the Dja Faunal Reserve.

Great ape nest distribution

Both central chimpanzee (Fig. 13ab) and Western lowland gorilla (Fig. 14ab) nests are more frequently encountered in the northeast corner of the reserve. They are rarely encountered in the western portion of the reserve. This could be due to the presence of a permanent large stream flowing through the northeast area that does not dry out during the dry season and the prevalence of swamp habitat in the area (Fig. 15). A preference of great apes for swamp habitat has been observed in other studies in the region (Poulsen & Clark 2004).

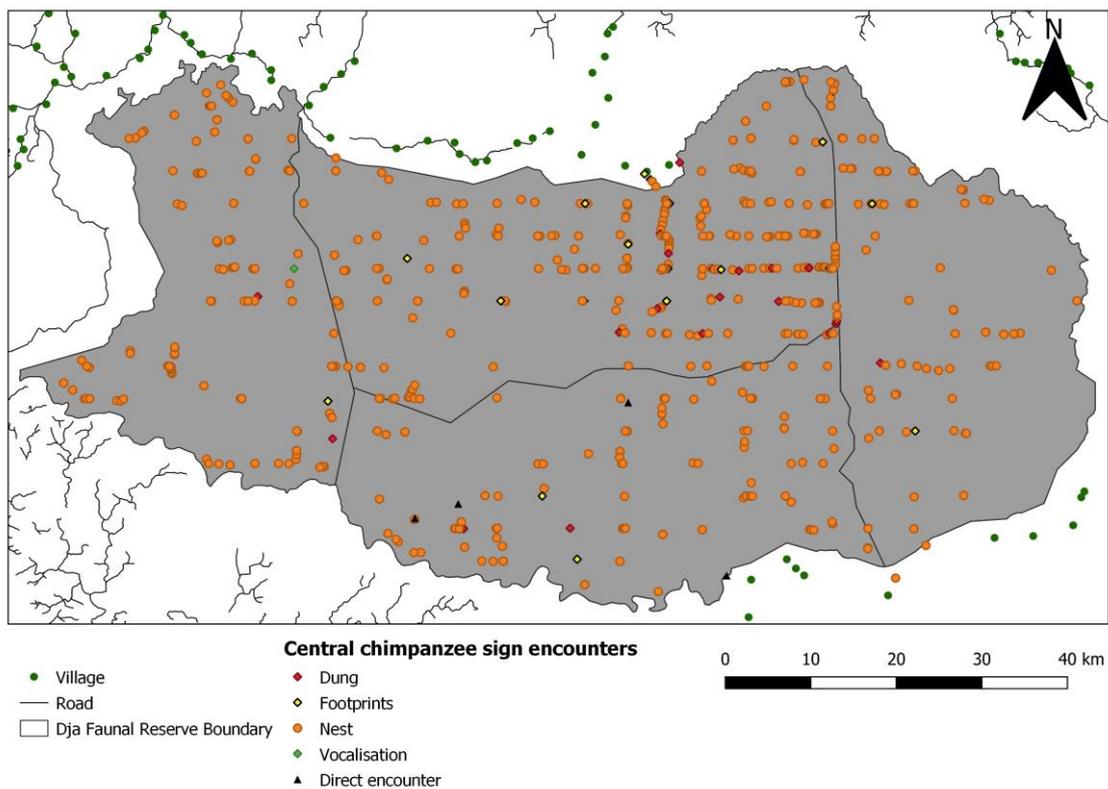
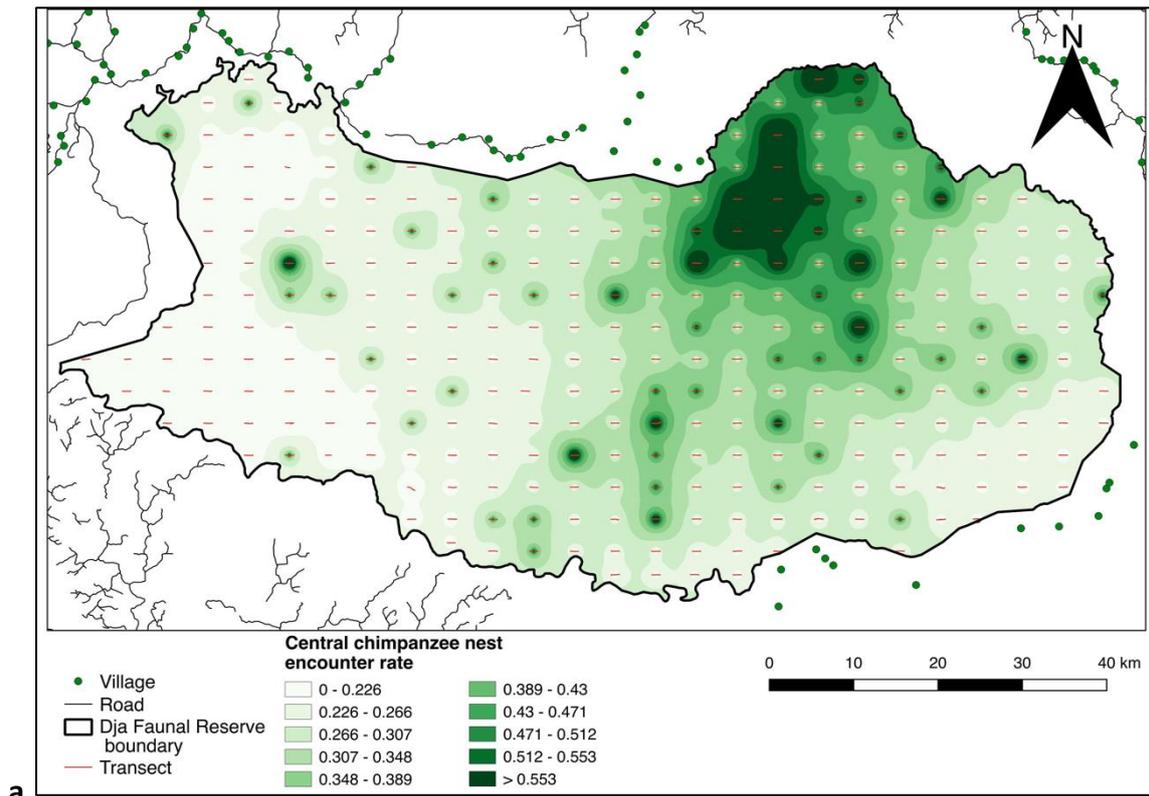
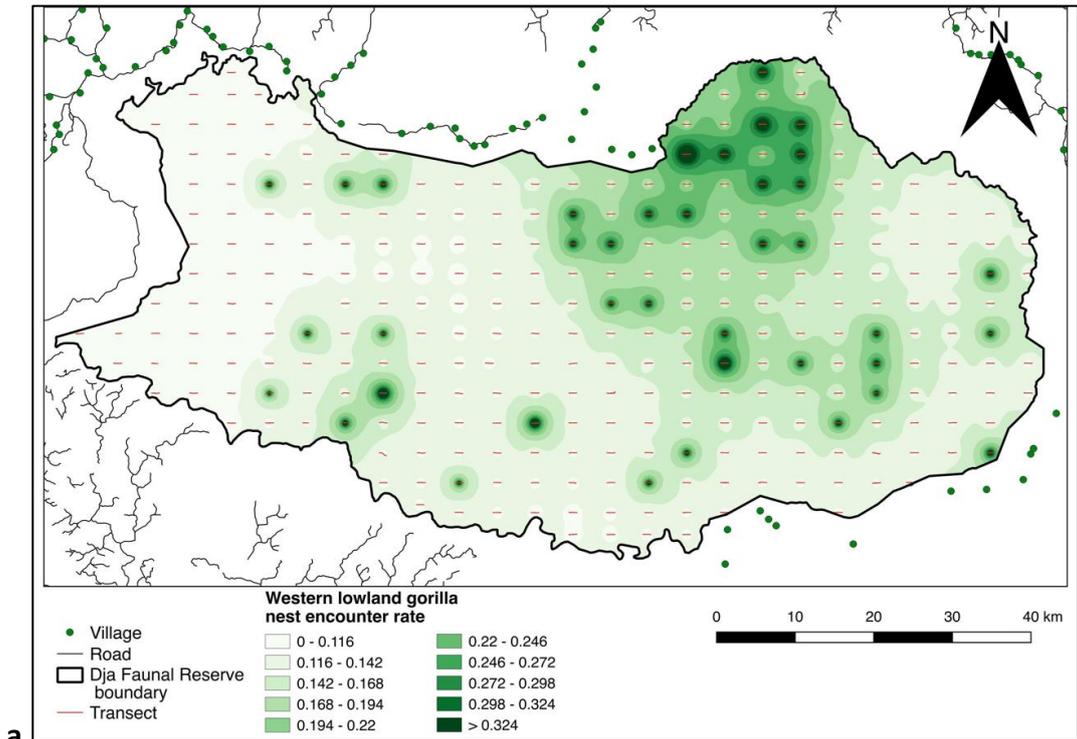
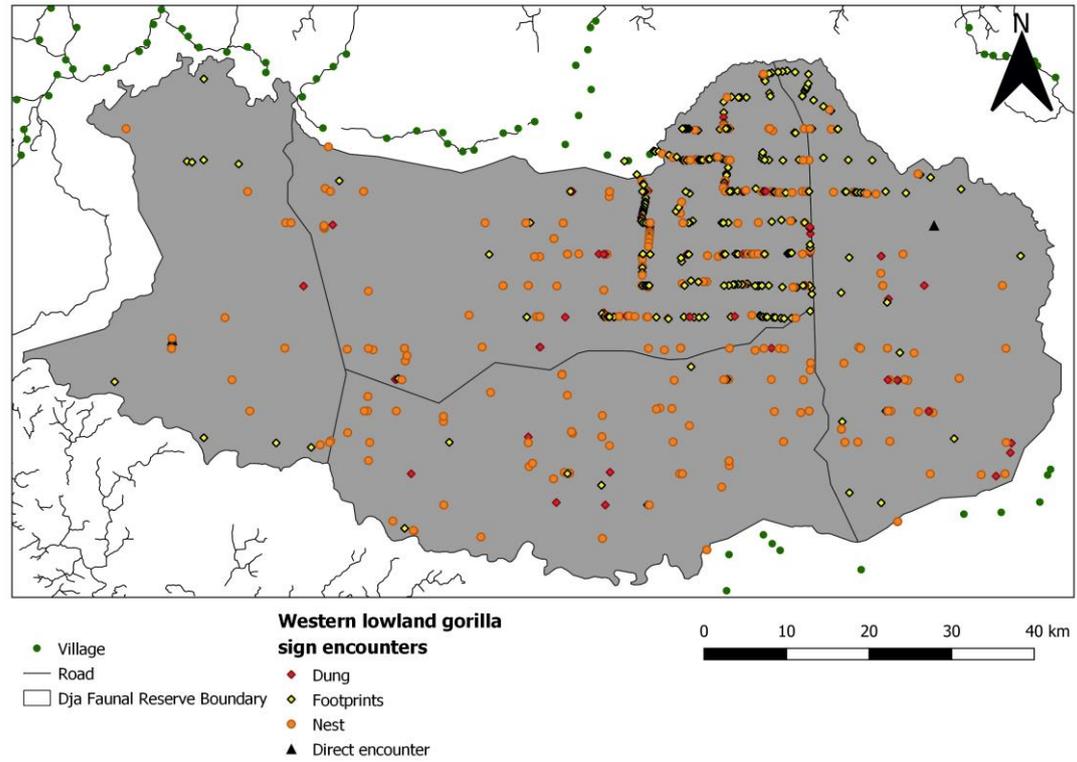


Figure 13ab. (a) Interpolated distribution of central chimpanzee nests throughout the Dja Faunal Reserve as estimated from the 2018 Dja Faunal Reserve inventory through transect data, (b) chimpanzee sign documented through transect and recce surveys during the inventory.



a



b

Figure 14ab. (a) Interpolated distribution of western lowland gorilla nests throughout the Dja Faunal Reserve as estimated through the 2018 Dja Faunal Reserve inventory through transect data, (b) gorilla sign documented through transect and recce surveys during the inventory.

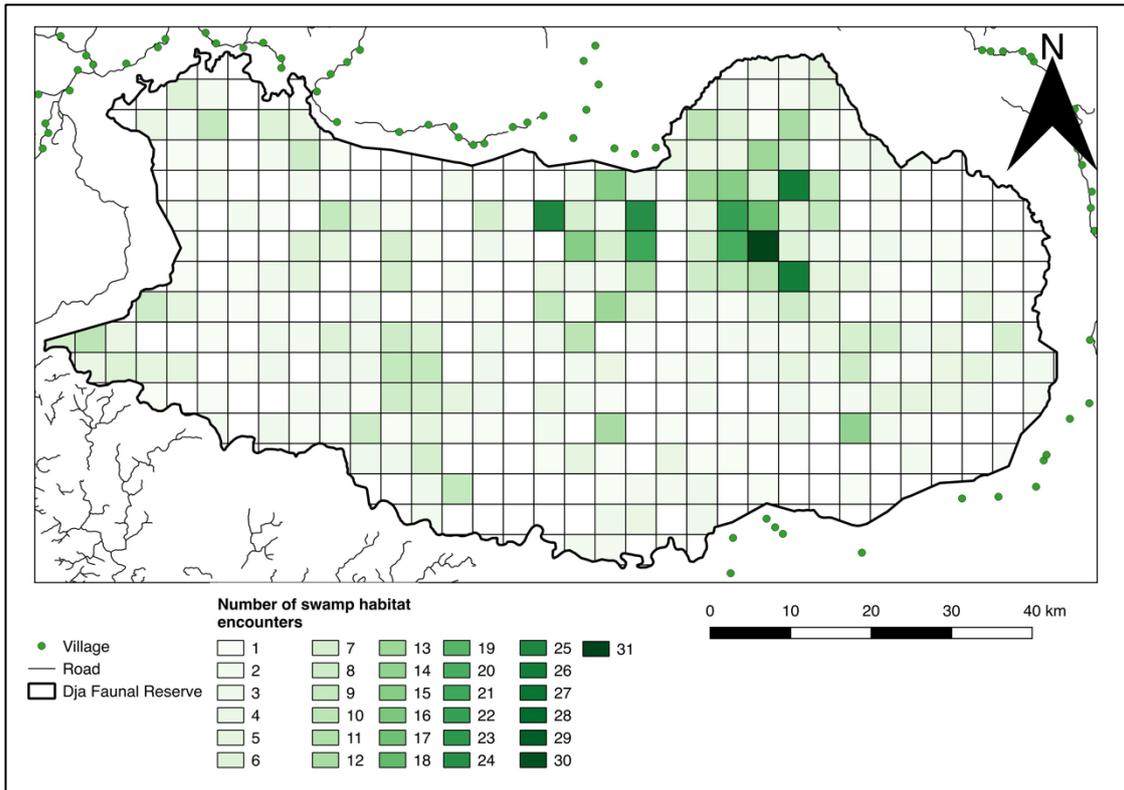


Figure 15. Number of encounters in 3.8 km grids of swamp habitat on transects and recces in the Dja Faunal Reserve.



Yellow-backed duiker dung distribution

Yellow-backed duiker dung displayed a somewhat similar distribution to that of forest elephant dung. There was a relatively high concentration around Boamir. The Bouamir Research Station, managed by the Congo Basin Institute and MINFOF, has been suggested to provide a refuge from hunting for some poached species resulting in elevated wildlife numbers in the vicinity. However, the largest encounter rate was in the centre of the reserve to the east of the northern sector (Fig. 16).

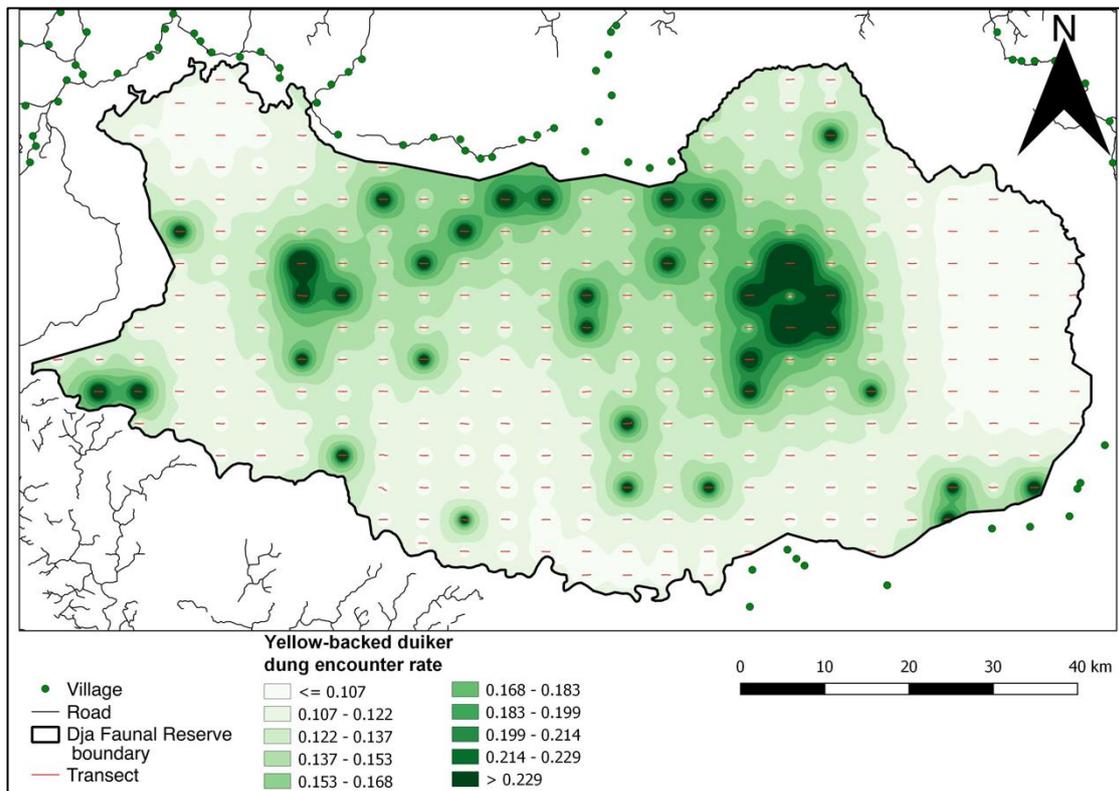


Figure 16. Interpolated distribution of yellow-backed duiker dung throughout the Dja Faunal Reserve as estimated by the 2018 Dja Faunal Reserve inventory through transect data.



Human sign

Most human sign was encountered in the north-west corner of the reserve and occurs all the way to the centre (Fig. 17). The area with the lowest human sign, according to the transect data, are in the Southern Sector, particularly on the southern border of the reserve penetrating into the core in the eastern side. This confirms that hunting and human encroachment continue to occur within the protected area, particularly in the northern and western sectors. Human signs of trails, signs of passage, and machete marks do not necessarily denote sign of human activity with intentions to disturb or harm wildlife or the forest, in general, as these may be made by ecoguard patrols, researchers, or conservation NGO field missions. However, it is likely that where these signs of passage and cutting are most frequent there is an elevated amount of hunting activity. This correlation, however, remains to be tested.

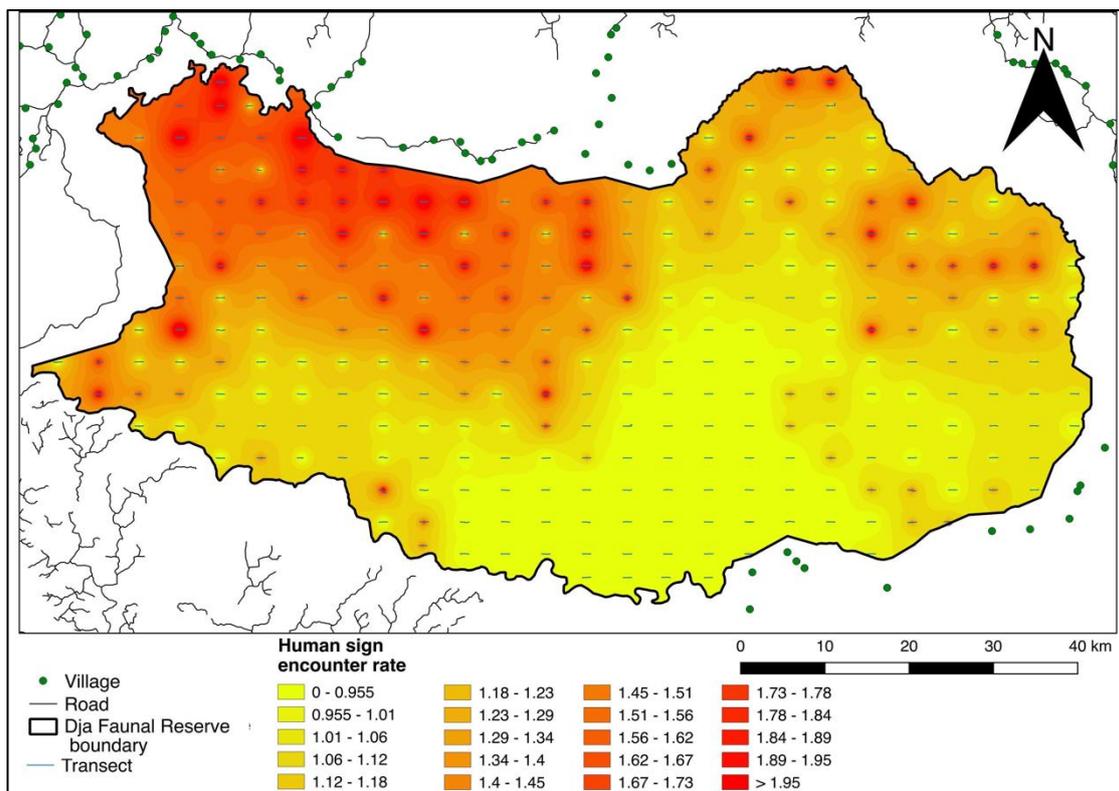


Figure 17. Interpolated distribution of encounter rates of human sign throughout the Dja Faunal Reserve as estimated from the 2018 Dja Faunal Reserve inventory through recce and transect data.

3.5 Wildlife abundance estimates from transect data

Forest elephant abundance

In total, 167 dung piles were encountered on transects during the survey. Of these, 82 were between S1 – S3 categories and taken forward for distance analysis. The sample size was adequate to obtain a 19.40% coefficient of variation (c.v.) during the survey. We obtained an estimate of 219 (150–319, 95% confidence interval (CI) forest elephants within the reserve. This equates to a density of 0.04 individuals/km².

Central chimpanzee abundance

There were a total of 185 nest groups detected. In total, 89 nest groups were of a suitable age category for distance analysis. This resulted in an estimate of 2,313 (1,568–3,411, 95% CI) individuals with a c.v. of 19.96%. The density of central chimpanzees would, therefore, be estimated at 0.43/km².

Western lowland gorilla abundance

77 nest groups were detected in total during the survey, of these 43 nest groups were available to estimate western lowland gorilla populations within the reserve. We estimate there to be a population of 1,258 (779–2,031, 95% CI) western lowland gorillas. There is a 24.6% c.v. associated with this estimate. This results in a density estimate of 0.24/km² within the reserve.

3.6 Recce data

The data from all of the recces was used to calculate encounter rates for target species and their sign (Figs. 18-22). The most frequently encountered great ape sign was central chimpanzee nests followed by western lowland gorilla nests (Fig. 19). The most frequently directly observed by vocalisation or sighting, non-primate species was the African grey parrot (Fig. 21). However, this was still a low encounter rate for grey parrots with a total of 30 events. Encounter rates in other reserves in southeast Cameroon are significantly higher: 2.7 and 2.8 in Lobéké NP, East and West, respectively (CITES 2013). As in the 2015 survey by MINFOF and IUCN, the most prevalent sign of human activity was machete cuts and trails facilitating access into the reserve (Fig. 22). However, it is impossible to differentiate poacher's trails and cuts from those of ecoguards and research work within the reserve. The relatively high encounter rate of snares (n=106), firearms and ammunition (n=207), and shelters and camps (n=109) shows high human activity within the reserve.

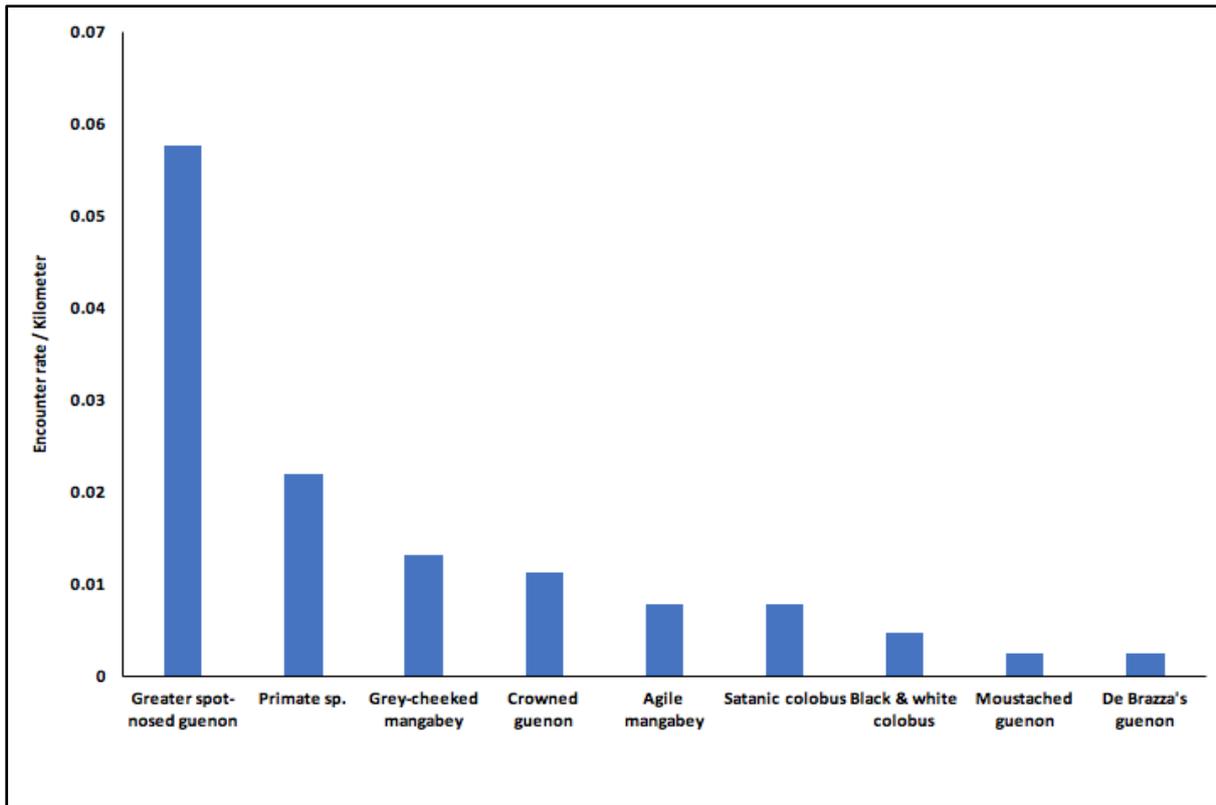


Figure 18. Encounter rates per km of direct encounters (direct observation & vocalisations) of primate species on recces documented through the 2018 Dja Faunal Reserve inventory.

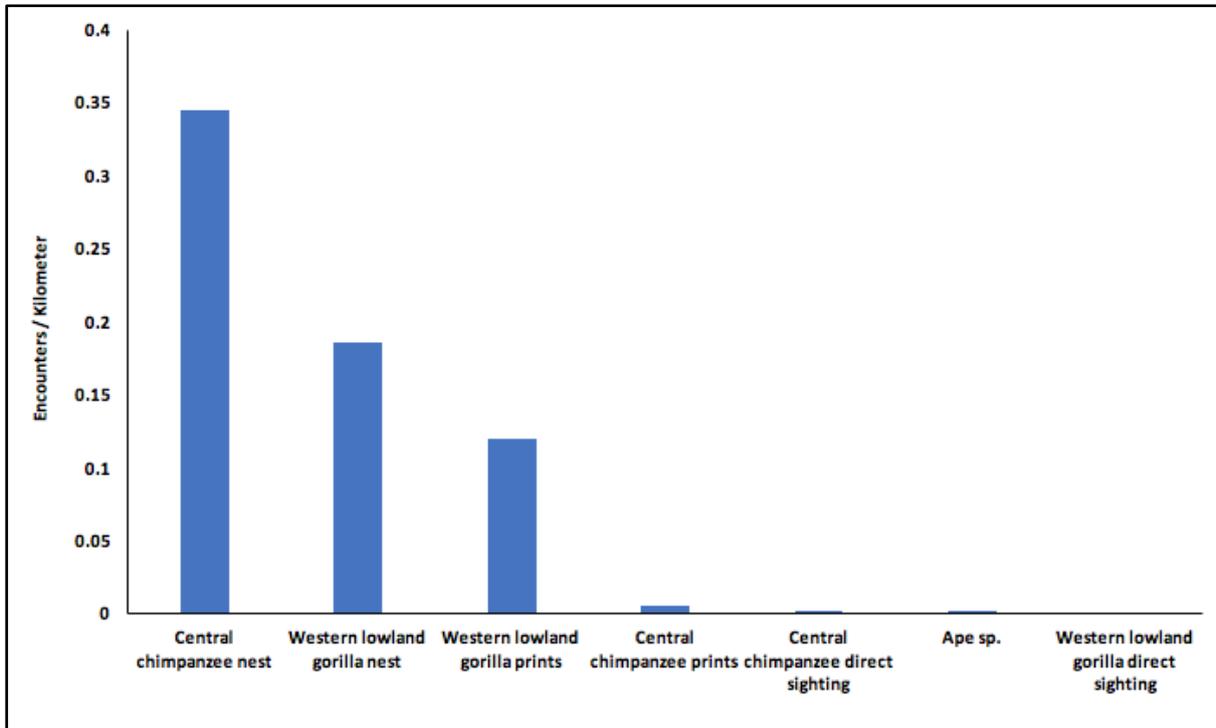


Figure 19. Encounter rates per km of great ape species on recces documented through the 2018 Dja Faunal Reserve inventory.

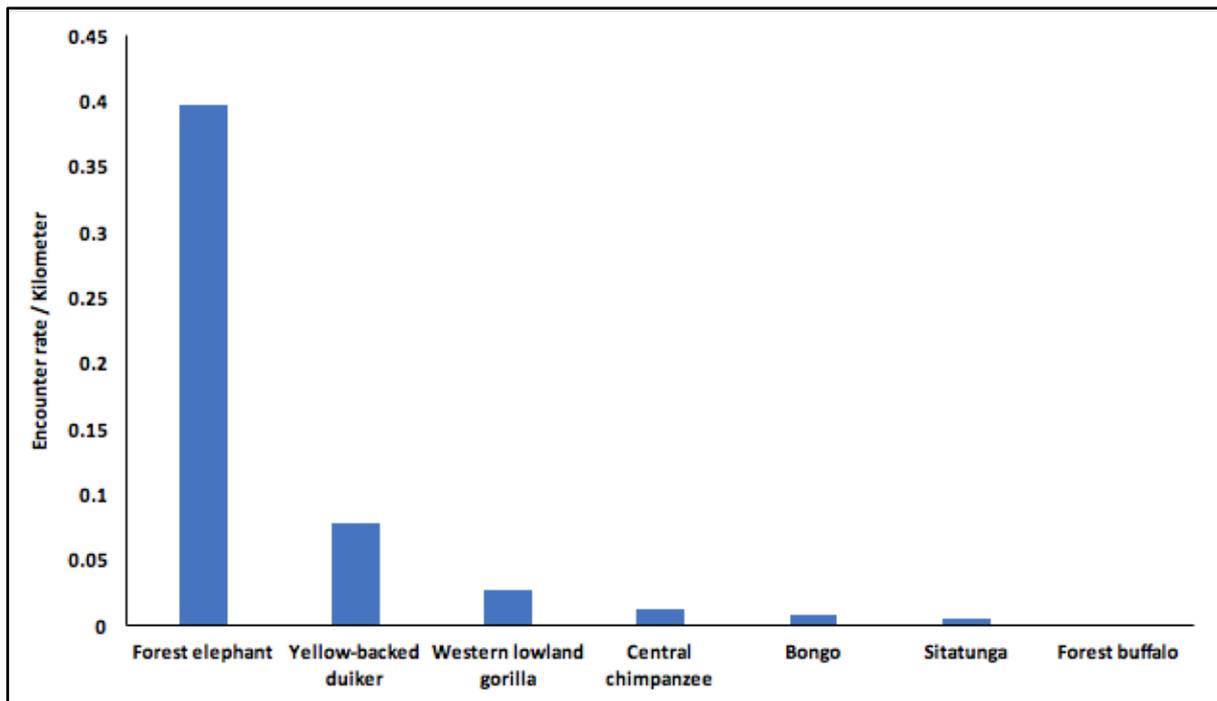


Figure 20. Encounter rate per km of mammalian dung on recces documented through the 2018 Dja Faunal Reserve inventory.

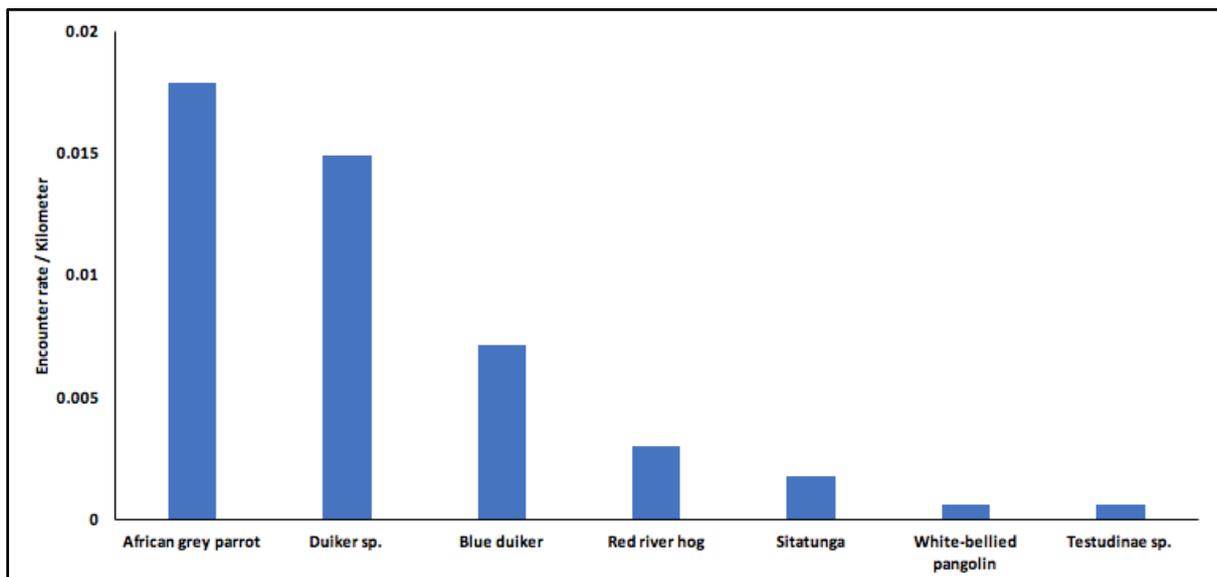


Figure 21. Encounter rate per km of direct encounters (observation and vocalisation) of all species except primates on recces documented through the 2018 Dja Faunal Reserve inventory.

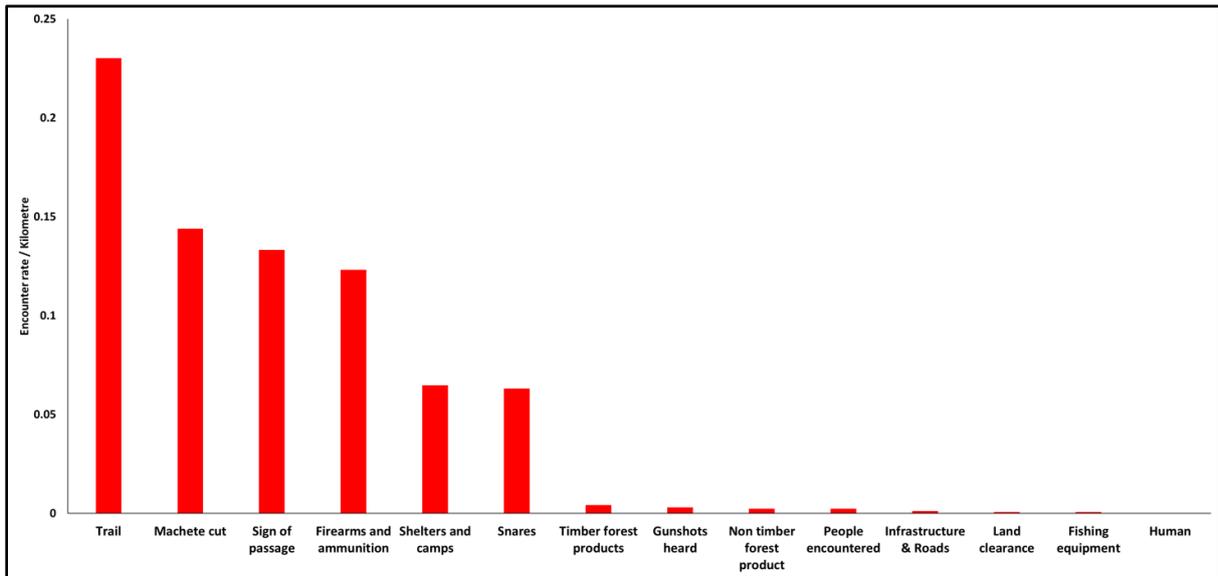


Figure 22. Encounter rate per km of each type of human sign on recces documented through the 2018 Dja Faunal Reserve inventory. Note that no evidence of commercial timber exploitation was observed in the DFR.



MINFOF CS Ecoguard examining a spent shotgun cartridge found in the Dja Faunal Reserve.

3.7 Comparisons to earlier DFR surveys

Subtle differences in methodology with regards to spatial scales and transect orientations employed between different surveys and studies within the DFR make it challenging to compare encounter rates and densities from earlier published surveys for the DFR. The main methodological differences between this survey and the one conducted in 2015 were that transects were all orientated in the same direction during this survey according to the major environmental gradient within the reserve. Transects were only 1 km rather than 2.5 km. Another factor that became apparent during data analysis is that our effective strip widths were much wider than those in the 2015 survey. However, in lieu of other baseline data available on the populations of great apes and forest elephants, we tentatively compare our results to those from the past 23 years in the reserve. Comparisons are also challenging as some earlier surveys only sampled subset area of the reserve. For example, Williamson and Usongo (1995) and Latour and colleagues (2010) only carried out survey transects in a subset of the Northern Sector of the DFR.

Ideally, encounter rates of forest elephant dung and great ape nests would be compared with those of the inventory conducted in 2015, as these are the only two surveys to cover the entire reserve. However, these metrics were not provided in the MINFOF/IUCN report (2015) so only estimated abundances and densities can be compared.

Between 1995 and 2018, there is a declining trend in estimates of density for forest elephants and great apes (Table 2). In comparison to the 2015 inventory, density estimates of forest elephants have declined by 50%. Western lowland gorilla displayed the greatest decline in estimated densities between the two surveys, with a roughly five-fold decrease in density (Table 2). Central chimpanzee, whilst declining in density, appear to have declined less than gorillas and elephants within the reserve (Fig. 23). However, methodological differences in survey practice and analysis may be magnifying these apparent sharp declines between the 2015 and 2018 inventories. This is supported by the fact that great ape and forest elephant population estimates from surveys completed prior to the 2015 inventory are more in line with a more gradual decline in numbers for great apes and forest elephant (for example, N'Goran *et al* 2017). Moreover, Poulsen and colleagues (2017) estimate a loss of 78% to 81% of forest elephant from Minkébé National Park, Gabon (7,570 km² in area, approximately 100 km to the south of the DFR) over the last decade (2004 to 2014). They estimate that in 2004 there was a population of 32,851 forest elephants (a density of 4.34 individuals/km²) in the park compared to just 7,370 in 2014 (a density of 0.97 individuals/km²) based on dung surveys. Given that the Dja Faunal Reserve is 5,260 km² and using the 1995 density estimate of Williamson and Usongo, we can approximate a 1995 population of 2,945 forest elephants. In order to facilitate this rough estimation, we assume that carrying capacity of the habitat for elephants is similar for the Dja and Minkébé regions though this remains unconfirmed. Our 2018 estimate of 219 forest elephants in the DFR represents roughly an 85% decline in estimated forest elephant numbers since 1995, a trend which is in line with the proportional 78-81% decline estimated for nearby Minkébé National Park by Poulsen and colleagues (2017) for 2004 to 2014. This decline is largely attributed to poaching of elephant for ivory for the illegal wildlife trade.

If the density of forest elephants in 2004 estimated for Minkébé National Park is applied to the DFR, then this protected area, all else being equal, has the potential to support approximately 22,800 elephants. Minkébé may have more favourable habitat for forest elephant, but the gross difference between this potential number and the 1995 population estimate by Williamson and Usongo (1995) of 2,945 suggests that forest elephants in the Dja Faunal Reserve had experienced considerable hunting pressure prior to 1995 and that intensive illegal hunting of elephants for ivory may not have significantly impacted elephant populations in Minkébé NP in 2004.

Using the DFR western lowland gorilla densities estimated by Williamson and Usongo (1995), we can estimate 8,971 gorilla in 1995. The 2018 population estimate for western lowland gorilla in the DFR is

1,371, suggesting a decline of approximately 83% in numbers since 1995 (note, that both Williamson and Usongo [1995] and Latour [2010] only estimated population densities for the north-east sector of the reserve). For central chimpanzee, the 1995 estimate would be 4,155 individuals with a decline of roughly 30% in 2018.

Table 2. Density (individuals/km²) results for forest elephant and great apes comparing two DFR full-reserve faunal inventories (2015 & 2018) and two sub-surveys conducted in 1995 and 2010.

Species	Williamson & Usongo 1995	Latour 2010	MINFOF & IUCN 2015	ZSL, AWF & MINFOF 2018
Forest elephant	0.56 individuals/km ²	-	0.08	0.04
Western lowland gorilla	1.71	1.78	1.23	0.24
Central chimpanzee	0.79	0.67	0.69	0.43

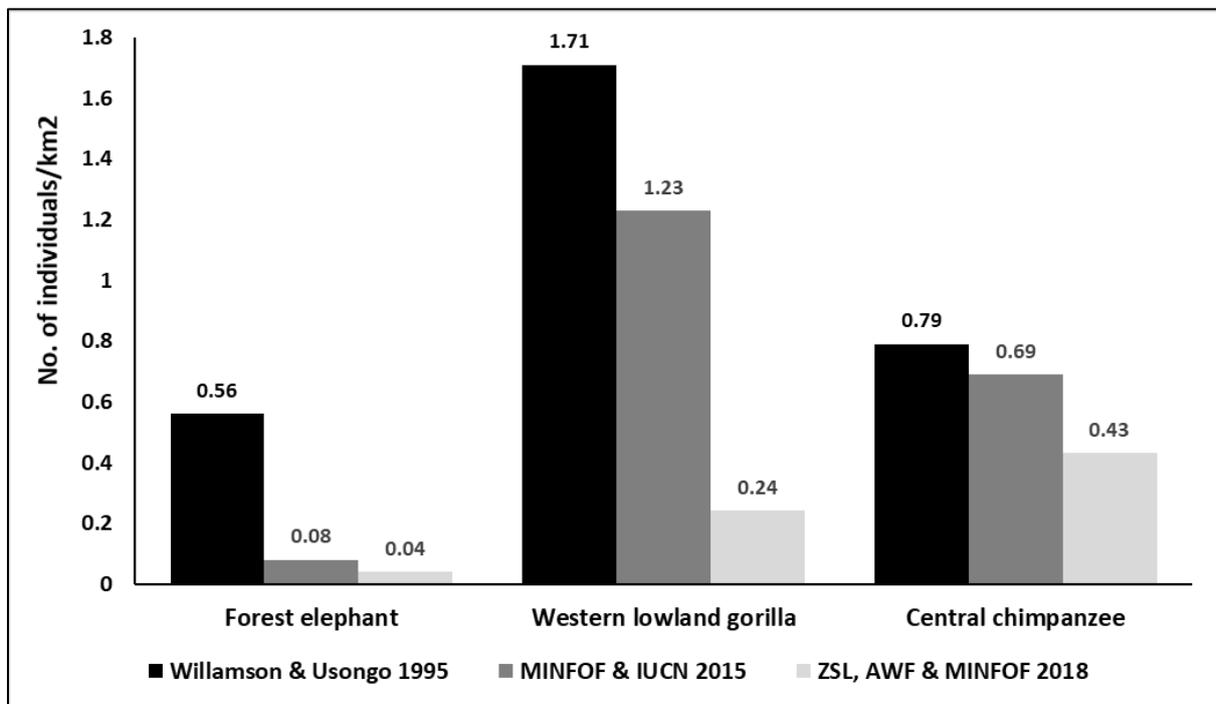


Figure 23. A comparison of estimated density of forest elephants, western lowland gorilla, and central chimpanzee populations within the Dja Faunal Reserve from inventories in 1995, 2015, and 2018.

Abundance estimates for western lowland gorilla show a significant decline between 2015 and 2018 (Fig. 25). These are considered to be significant due to non-overlapping 95% confidence intervals. However, whilst there is a decline in chimpanzee populations, it is not considered a significant one (Fig25). The decline in the population of forest elephants was marginally non-significant with 95% confidence intervals only very slightly overlapping between the survey in 2015 and 2018 (Fig 24).

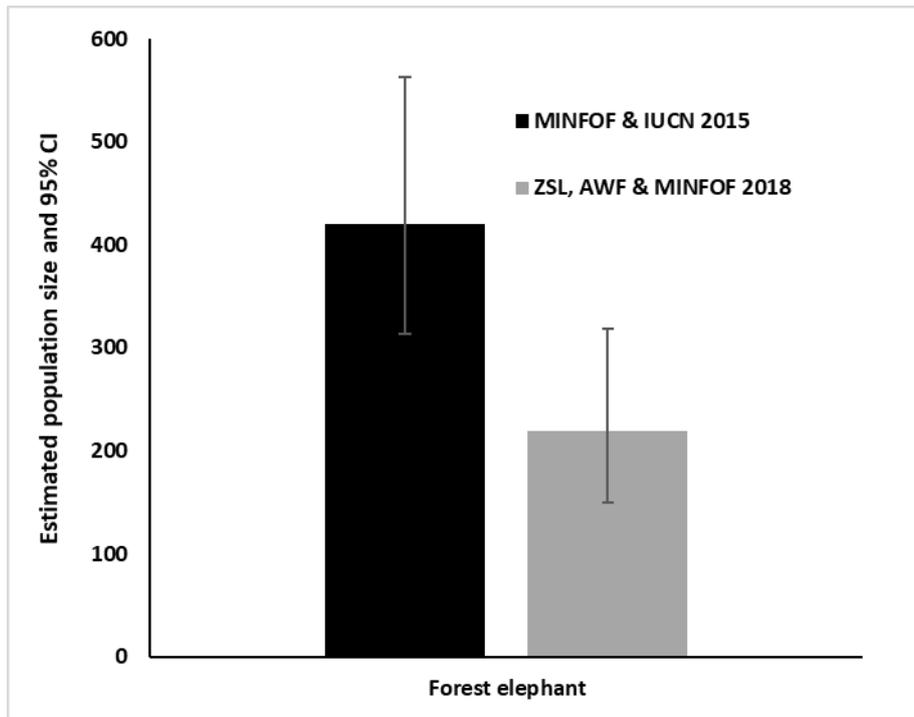


Figure 24. Absolute abundance estimates for forest elephants in 2018 compared to 2015 in the Dja Faunal Reserve from two full reserve inventories.

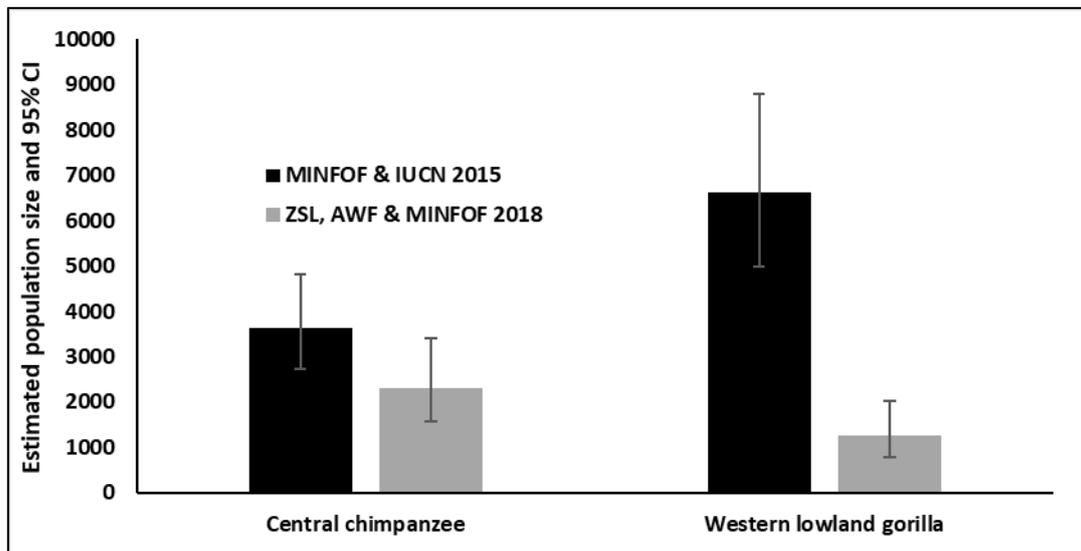


Figure 25. Absolute abundance estimates for western lowland gorilla and central chimpanzee in 2018 compared to 2015.

4. Conclusions & Recommendations

Forest elephant, western lowland gorilla, and central chimpanzee continue to be present in the DFR, but at diminished numbers relative to earlier surveys and what the habitat is projected to be able to support. This is particularly the case for forest elephant and western lowland gorilla. The driver for these declines are most likely high hunting pressure over several decades and, in particular, an intensification of illegal wildlife trade-related poaching in recent years throughout the region (Maisels *et al* 2013, Abernethy *et al* 2013, N’Goran *et al* 2017). Populations of all three of the focal species have declined since estimates in 1995 and in 2015. Given that both forest elephant and western lowland gorilla populations have declined over 80% since 1995, it is likely that their ecological role in seed dispersal (both species) and maintaining forest clearings (forest elephant) has also been diminished. Intense and widespread poaching of forest elephant in the region is reflected in two recent large seizures of >100 elephant tusks in Djoum, the main town near the southern sector of the reserve. Furthermore, the decline in the DFR in forest elephant reflects similar losses experienced in other parts of Central Africa, including areas adjacent to the DFR, such as the Ngoyla-Mintom Forest Complex and Nki National Park (N’Goran *et al.* 2017). Approximately three forest elephants are estimated to be poached every day in the Tri-National Dja-Odzala-Minkébé (TRIDOM) landscape, Cameroon (Nzoo Dongmo *et al.* 2016). To assume that all of the recent Djoum seizures of ivory originated in Gabon could potentially minimise the seriousness of the situation of the elephant population within the DFR. Given the declines in elephant estimates within the DFR since 1995, any continuation of poaching will exert an intense pressure on the surviving elephants within the reserve given the length of time it takes for elephant populations to recover from perturbation (Maisels *et al* 2013). We also recommend future monitoring of the wildlife corridor to the southeast of the reserve which will help improve knowledge of movements of wildlife, such as forest elephant, into and out of the DFR and adjacent TRIDOM forests. This would help to gain an understanding of the population trajectories and dynamics within the reserve.

Central chimpanzee populations, whilst declining slightly, remain at similar densities to those recorded in 1995. However, the same cannot be said for western lowland gorillas whose populations have declined dramatically. The estimated density of 0.24 individuals/km² is very low for a protected area in this region. Densities as high as 5.4 individuals/km² have been reported in Odzala NP in the Republic of Congo (Bermejo 1999). More recent surveys in the nearby Mengame Gorilla Sanctuary (Kom-Mengame Wildlife Complex) and the Goualogo Triangle reported densities of 2.53/km² (Halford *et al.* 2003) and 1.28/km² (Sanz *et al.* 2007), respectively. However, the apparent five-fold decline of western lowland gorilla densities in three years needs to be placed into context with the findings of other surveys. Given the estimate produced by Williamson and Usongo (1995) were over 19 years ago and the trend of decline in other areas of Central Africa (N’Goran *et al* 2017), it seems likely that the results of the 2015 survey were an overestimate of the great ape population within the reserve, as opposed to a loss of thousands of individuals in three years. Whilst this level of decline can occur due to an ebola outbreak (Huijbregts *et al.* 2003), there is no evidence this is the case in the DFR and it would be unusual for central chimpanzees not to demonstrate a simultaneously drastic decline from ebola or other epidemic disease. Disease, however, should continue to be monitored as a potential contributing factor to the decline of great apes within the reserve.

Overall, we are confident that this inventory has provided a robust baseline of data to be used in the future to monitor the effectiveness of management of the Dja Biosphere Reserve. The population and density estimates, as well decline trends, appear to be in line with populations seen in other protected areas in south-east Cameroon (Table 3.).

Table 3. Predicted densities of forest elephants, western lowland gorilla, and central chimpanzee in other protected areas in southeast Cameroon.

	Lobéké NP (Nzooh <i>et al.</i> 2016a)	Nki NP (Nzooh <i>et al.</i> 2016b)	Bouma-Bek NP (Nzooh <i>et al.</i> 2016b)	Dja FR 2018 (ZSL, AWF & MINFOF 2018)
Forest elephant	0.47	0.18	0.06	0.04
Western lowland gorilla	1	0.95	1.61	0.24
Central chimpanzee	0.29	0.16	0.24	0.43

Protected area managers should continue to adhere to best practice methods for distance survey design (Kühl *et al.* 2008, Hedges 2012). For example, previous methodologies used a mixed orientation of transects with little consideration for the effect of ecological gradients and the impact this could have on estimates. Reporting should continue to be as transparent as possible with standardised metrics reported. For example, confident comparisons to previous DFR inventories were hampered by multiple versions of survey reports with different estimates and gaps in details of methods. For all the calculations performed to establish wildlife population estimates, the coefficient of variation is greater than 15%, this could be due to wildlife being non-homogenously distributed within the reserve which can result in higher levels of coefficient of variation (Maisels *et al.* 2009)¹. For future inventories, it would be necessary to increase the number of transects or increase the distances of each transect in order to decrease this value. The additional transect distance needed for a 10% c.v. (Coefficient of Variation) for forest elephant, according to our data, is estimated to be around 1,091 km of transects or roughly three times what was covered. This could suggest populations are now so low and the area is so big that transect sampling may become less efficient in the DFR in the future. A required increase in transect length to achieve a c.v. of 10% for gorilla is estimated at an additional 1,945 km. These estimates are based on nest and dung data that was carried forward into the distance analysis. Given the logistics of this type of survey, increasing the distance of individual transects, rather than the number of transects, seems the most feasible way of achieving greater transect distances if deemed necessary.

In general, the intensity of signs of human activity in the northwest area of the reserve and low encounter rates of great ape nests and forest elephant dung in this area (apart from around Bouamir Research Station), suggests that human perturbation continues to influence the distribution of wildlife within the DFR. There are three areas of the reserve where we feel that increased patrolling by ecoguards can act as deterrent to poaching and provide a temporal-spatial refuge for wildlife populations. These are the northeast corner of the reserve that is clearly of importance for great ape populations and, to a lesser extent, forest elephant. The area around Bouamir Research Station (Congo Basin Institute & MINFOF) in the Northern Sector also has a high concentration of elephant dung. Finally, the Southern Sector around Bali Bai (clearing) and the areas towards the east where the presence of golden cat (*Caracal aurata*), leopard, and white-bellied duiker recorded in camera-

¹ "Monitoring programs are designed to detect differences between monitoring cycles. The ability to detect a trend depends upon the precision of survey estimates. Where numbers of animals are concerned (or their density, or the density of their signs) this ability to detect differences is decided, a priori, to a target precision. This is expressed as the coefficient of variation. Practically speaking, a target coefficient of variation of 25% means that only when more than a quarter of the animals have disappeared will this be detectable by the monitoring program! Therefore, from a conservation point of view, it is desirable to have as small a coefficient of variation as is possible. However from a practical point of view, money spent on detection of change and money spent on, for example, anti-poaching, must be balanced- it is not useful to spend the entire budget on measuring something which would not have happened if there had been more spent on prevention of a decline. Therefore, the amount of effort spent on these two activities must be carefully balanced."

Source: Fiona Maisels, Rostand Aba'a

http://apes.eva.mpg.de/eng/pdf/guidelines/IUCN_SGA_Monitoring_Section_3_Survey_design_For_web.pdf

trap surveys are indicators of low hunting pressure (Bruce *et al.* 2018) are priority zones for targeted protection.

5. Acknowledgements

We thank the government of the Republic of Cameroon and the Ministry of Forestry and Wildlife (MINFOF) for their continuing support of this effort as part of their overall program to protect and manage Cameroon's wildlife. We thank the European Union for supporting this survey through the *Programme de Conservation et Utilisation Rationnelle des Ecosystemes Forestiers en Afrique Centrale 6* (ECOFAC6) project for the Dja Biosphere Reserve (DFR), Cameroon. We thank Conservator Hilaire Ndinga of the Dja Biosphere Reserve and the Chef d'Antenne of each sector for their ongoing support of conservation research within the protected area. We thank Zacharie Nzooch Dongmo and Kouamé Paul N'goran from WWF, Leonard Usongo from IUCN, and Fiona Maisels for technical consultation and advice on developing the inventory methodology. We thank the team leaders Simon Nijal Njock, Elvis Mouyakan A Moumboc, Hermann Franklin Donfouet Zebaze, Yannick Djouguela, Olivier Ngangue, Thomas Ngangpou, Franck Annol Wabo Puemo for all of their contributions to the inventory and overcoming adverse conditions. We thank Anne-Stéphanie Kobla and Malenoh Ndimbe for carrying out the robust dung and nest decay rate survey in support of the inventory. We thank John Coppock for cleaning the data as part of his MSc project. We thank Joeri Zwerts for allowing Hermann Donfouet to join us on the inventory, despite him also being needed for Joeri's field research.



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APPENDIX 1 – Elephant Dung and Great Ape Nest Decay Study for the Dja Faunal Reserve, Cameroon, 2018.



**RAPPORT DE L'ETUDE DE LA DEGRADATION DES CROTTES
D'ELEPHANTS ET DES NIDS DE GRANDS DANS LA RESERVE
DE FAUNE DU DJA**

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Octobre 2018

Sommaire

Liste des tableaux	i
Liste des figures	i
Liste des photos	i
Liste annexes.....	i
Liste des abréviations.....	i
Résumé	ii
1. Introduction.....	1
1.1 Contexte et Justificatif.....	1
1.2 Objectif de l'étude.....	1
1.2.1 Objectif global	1
1.2.2 Objectifs spécifiques	1
1.3 Limites de l'étude	1
2. Matériels et méthode	1
2.1 Présentation de la zone d'étude.....	1
2.2 Matériels.....	2
2.3 Méthodologie	2
2.3.1 Evaluation de la vitesse de dégradation.....	2
3. Résultats et discussions.....	6
3.1 Durée moyenne de dégradation des crottes d'éléphants.....	6
3.2 Durée moyenne de dégradation des nids de grands singes	7
4. Conclusion et recommandations.....	10
BIBLIOGRAPHIE.....	10
ANNEXES	Error! Bookmark not defined.

Liste des tableaux

Tableau 1 : Nombre de crottes marquées et retrouvées dans la RFD	6
Tableau 2: Nombre de nids marqués et retrouvés dans la RFD.....	8

Liste des figures

Figure 1 : Réserve de Faune du Dja	2
Figure 2 : Courbe de survie des crottes d'éléphants.....	7
Figure 3 : Courbe de survie des nids de grands singes	8

Liste des photos

Photo 1: Crotte fraîche d'éléphant	3
Photo 2: Matérialisation des nids de chimpanzé	4
Photo 3 : Code d'un nid	5
Photo 4: Nid de gorille dégradé.....	5

Liste annexes

Annexe 1: Fiche de collecte des données	12
Annexe 2: Carte de revisite.....	1
Annexe 3: Calcul des coefficients de régression avec R pour les nids de grands singes	2
Annexe 4: Calcul des coefficients de régression avec R pour les crottes d'éléphants	3

Liste des abréviations

GPS : Global Positionning System
PNL : Parc National de Lobéké
RFD : Réserve de Faune du Dja
WWF: World Wild Fund for nature
ZSL: Zoological Society of London

Résumé

La présente étude portant sur la dégradation des crottes d'éléphants et les nids de grands singes dans la Réserve de Faune du Dja (RFD) a été menée entre avril 2018 et septembre 2018. L'objectif était de déterminer le temps moyen de dégradation des crottes d'éléphants et des nids des grands singes afin de contribuer à l'estimation fiable des densités des populations de ces espèces. A cet effet, sept (07) missions espacées de 15 jours ont été effectuées et un nombre minimum de 20 indices par mission pour chaque indice était visé. Elles consistaient à rechercher et marquer les crottes et les nids frais (48 heures maximum) et les revisiter quand on estimera que 90% de ces indices ont disparu pour voir à quel stade de dégradation ils se trouvaient. Ainsi, 85 crottes et 119 nids frais ont été enregistrés et marqués. Tous les indices marqués ont été revisités. Le modèle de régression logistique avec le logiciel R a permis de déterminer les différents coefficients et Excel 2016 nous a permis de modéliser la courbe de régression et de déterminer le temps moyen de dégradation des crottes et des nids. En ce qui concerne les crottes d'éléphants, il a été estimé à $83,2 \pm 6,193$ jours et pour les nids à $96,6 \pm 2,872$ jours.

1. Introduction

1.1 Contexte et Justificatif

Dans la plupart des inventaires basés sur le comptage indirect, il est important de réaliser des études sur les facteurs de conversion des indices (étude de la dégradation et de production) afin d'avoir des données fiables lors de l'estimation des densités animales. C'est dans cette optique que la Zoological Society of London (ZSL) a entrepris de conduire conjointement avec les inventaires fauniques une étude sur la dégradation des crottes d'éléphants et des nids de grands singes dans la Réserve de Faune du Dja.

1.2 Objectif de l'étude

1.2.1 Objectif global

Cette étude contribue à une estimation fiable des densités des populations d'éléphants et de grands singes dans la Réserve de Faune du Dja.

1.2.2 Objectifs spécifiques

Spécifiquement :

- Déterminer de la durée moyenne de dégradation des crottes d'éléphants ;
- Déterminer de la durée moyenne de dégradation des nids de grands singes ;

1.3 Limites de l'étude

Cette étude s'est déroulée dans un contexte présentant les contraintes suivantes

- L'absence des données sur le suivi écologique pouvant nous permettre de déterminer les zones à forte concentration d'animaux
- La durée des missions (07 jours) ne nous a pas permis d'atteindre l'objectif visé de 20 indices par mission car les distances parcourues étant très grandes.
- La contrainte climatique

2. Matériels et méthode

2.1 Présentation de la zone d'étude

Située dans la partie méridionale du Cameroun entre le 3° 00' 00" Nord et 13° 00' 00" Est, la Réserve de Faune du Dja est à cheval entre les provinces de l'Est et du Sud respectivement dans les départements du Haut Nyong et le Dja et Lobo. Elle couvre une superficie de 526.000 Ha et la réserve de biosphère qui l'englobe fait 1 500 000 ha.

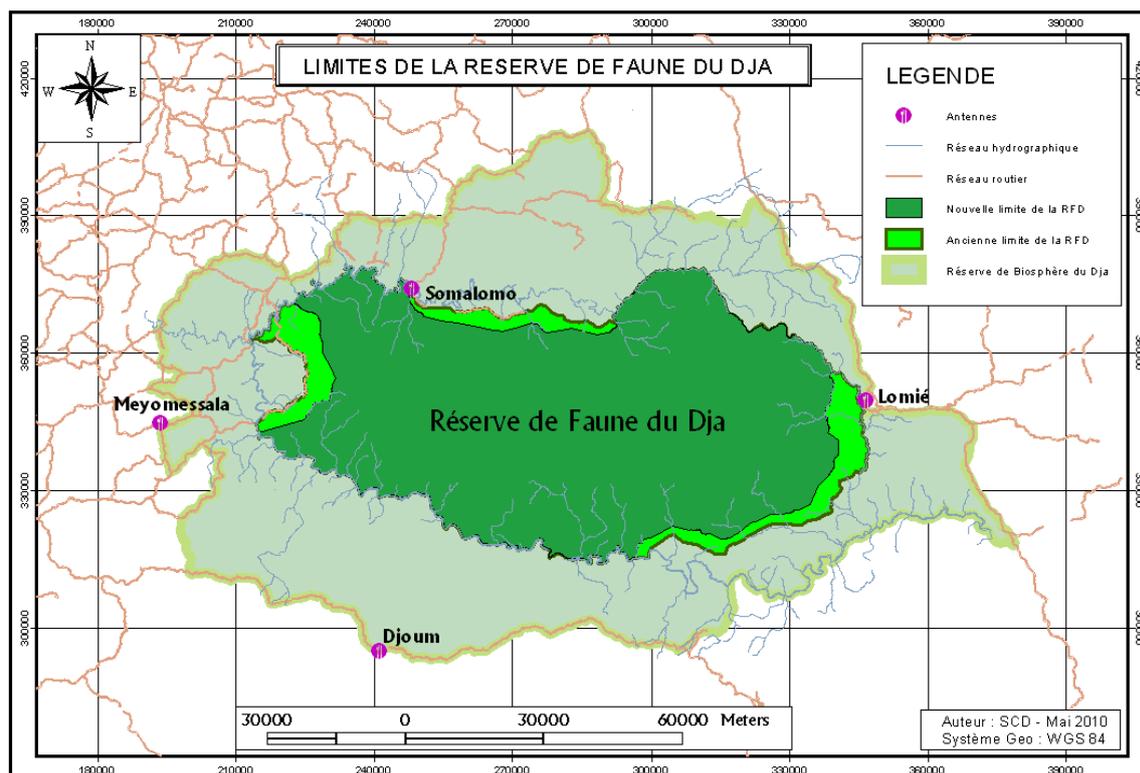


Figure 1 : Réserve de Faune du Dja

2.2 Matériels

Les matériels suivants ont été utilisés pour la collecte des données :

- crottes fraîches d'éléphants ;
- nids de grands singes (gorille et chimpanzé) ;
- GPS (Global Positioning System) Garmin 64s pour prendre les positions des indices marqués et pour la navigation ;
- peinture à huile (couleur rouge vive) ;
- diluant ;
- un ruban fluorescent blanc rouge ;
- boussole type Sunto ;
- marqueurs permanent permettant d'inscrire le code de l'indice sur le ruban ;
- fiches de collecte.

2.3 Méthodologie

La collecte de données a été assurée par une équipe de 6 personnes dont un chef d'équipe chargé d'orienter l'équipe lors de la navigation sur le terrain et d'enregistrer les informations ; un pisteur autochtone chargé de la recherche des indices frais ; un écogarde assurant la sécurité de l'équipe ; trois porteurs aidant dans le transport des rations, du matériel de camping et à la recherche des indices.

2.3.1 Evaluation de la vitesse de dégradation

Il existe plusieurs approches pour l'étude de dégradation des indices de présence notamment des nids de grands singes, des crottes des éléphants et des ongulés : la méthode prospective et

la méthode rétrospective. La méthode rétrospective développée par Laing *et al.*, (2003) a été celle utilisée lors de cette étude.

2.3.1.1 Le marquage

Des missions de 7 jours visant à rechercher et marquer les indices (crottes et nids) ont été organisées à intervalle de temps de 14 jours. Au total, sept missions de marquage ont été réalisées. Un total de 20 indices par mission et par type d'indice (20 crottes et 20 nids) était visé. Seuls les indices frais (48 heures maximum) ont été recherchés et enregistrés (photo 1)



Photo 1: Crotte fraîche d'éléphant

Pour chaque indice marqué, les informations suivantes ont été enregistrées sur une fiche de collecte (annexe 1) :

- la nature de l'indice; une fiche différente pour chaque type d'indice;
- le code de l'indice ;
- le type de micro habitat ;
- la position géographique relevée au GPS (Longitude, Latitude, Altitude) ;
- le diamètre des crottes en cm ;
- la pente du lieu de détection des indices au sol.
- la hauteur approximative du nid au-dessus du sol en mètres.

La position géographique ou le lieu de détection de chaque indice a été matérialisé sur le terrain par un ruban fluorescent de couleur blanche et rouge facilement repérable sur lequel le code de l'indice est lisiblement inscrit au marqueur permanent vert. Le ruban a été attaché sur un piquet et sur l'arbre le plus proche. La peinture à huile de couleur rouge a été appliquée sur les piquets et les arbres sur lesquels les rubans ont été attachés afin d'immortaliser le lieu de détection. La photo 2 illustre la matérialisation des nids dans un arbre.



Photo 2: Matérialisation des nids de chimpanzé

Les indices détectés ont été nommés en fonction du numéro de la mission de recherche, du groupe de l'indice, du nombre d'indices et de leur nature.

Noter :

- **M1, M2,..., M10** pour les numéros de missions
- **G1, G2,...Gn** pour les groupes d'indices détectés.
- **N1, N2,...Nn** pour les nids détectés dans un même groupe ;
- **C1, C2,...Cn** pour les numéros des crottes d'éléphants détectées dans un même groupe.
-

L'illustration du code final d'un nid est donné par la photo 3.



Photo 3 : Code d'un nid

Nous avons M5G1N1 comme code du nid numéro 1 (N1) détectée dans le groupe de nids numéro 1 (G1) lors de la sixième mission (M5).

2.3.1.2 La revisite

La revisite de tous les indices a été conduite à la fin de l'inventaire. Au total, 06 secteurs ont été revisités (Annexe 2). Lors de la revisite, la position géographique de tous les indices étaient enregistrés une seconde fois pour s'assurer de la fiabilité des résultats. Les informations relevées étaient le statut de l'indice (présent/absent) et le stade de dégradation (celui utilisé lors des inventaires) lorsque l'indice était encore présent.

Dans cette étude, un nid a été considéré comme dégradé lorsque sa structure n'a pas permis de l'identifier comme un nid (photo 4). Une crotte quant à elle était considérée comme dégradée lorsqu'elle était fossilisée (plus de matière fécale, présence seulement des débris végétaux fossilisés, présence de repousses).



Photo 4: Nid de gorille dégradé

2.3.2 Analyse des données

L'estimation de la durée moyenne de dégradation des crottes et des nids a été faite à partir du modèle de régression logistique avec les logiciels R et Excel 2016. Ce modèle a permis de tracer la courbe de survie des indices et de déterminer la durée moyenne de dégradation. La formule de calcul des probabilités de survie est la suivante :

$$E\left(\frac{y_i}{x_i}\right) = p(x_i) = \frac{e^{\alpha + \beta X + \alpha_i}}{1 + e^{\alpha + \beta X + \alpha_i}}$$

Où α (constante) et β (coefficient du temps) sont des coefficients déterminés en utilisant le Logiciel R ; X représente le temps.

La formule ci-dessus a permis de modéliser la courbe de survie des indices dans Excel. L'âge ayant une probabilité de survie égale à 0.5 a été considéré comme la durée moyenne de dégradation.

3. Résultats et discussions

3.1 Durée moyenne de dégradation des crottes d'éléphants

Un total de 85 crottes fraîches d'éléphants a été marqué lors de l'étude. Sur ces 85 crottes, toutes ont été retrouvées lors de la revisite.

Tableau 1 : Nombre de crottes marquées et retrouvées dans la RFD

N°mission	Nbre_crottes_marquées	Nbre_crottes_retrouvées	Nbre de jours	Pourcentage existant à la revisite
1	4	4	176	0,000
2	6	6	153	16,667
3	5	5	131	0,000
4	28	28	113	3,571
5	4	4	89	25,000
6	21	21	69	80,952
7	17	17	47	94,118
Total	85	85	/	31,473

Il ressort de ce tableau que lors des premières missions il n'y a pas eu beaucoup de crottes marquées en comparaison aux quatre dernières ceci expliquerait le pourcentage de crottes présentes lors de la revisite (31,5%).

En considérant l'âge des 85 crottes d'éléphants retrouvées et leur statut à la revisite (0 au cas où elle est absente et 1 dans le cas contraire), la courbe de probabilité de survie en fonction de l'âge (figure 2) a été obtenue.

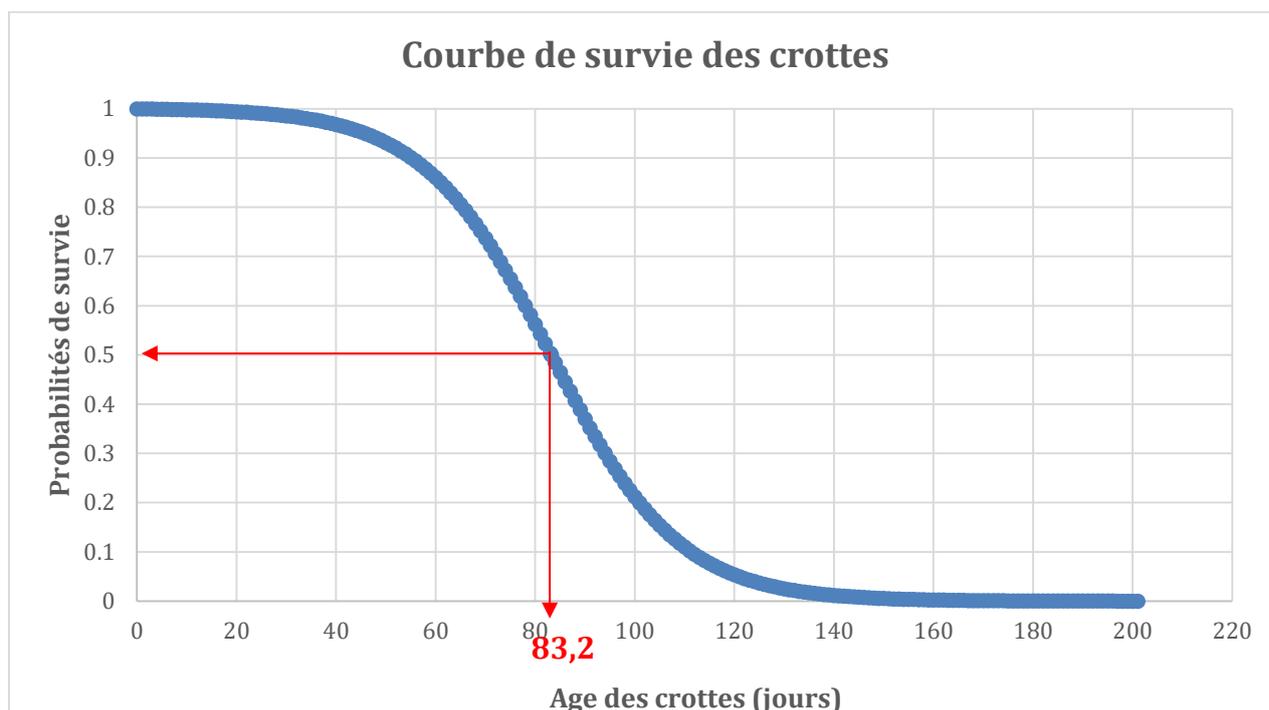


Figure 2 : Courbe de survie des crottes d'éléphants

Les taux de dégradation des crottes diffèrent d'un site à un autre en fonction du milieu, de la saison, du régime alimentaire (White, 1995; Barnes *et al.*, 1997). La durée moyenne de dégradation des crottes d'éléphant trouvée pour la Réserve de Faune du Dja est de $83,2 \pm 6,193$ jours. Elle diffère plus ou moins de celle trouvée dans d'autres sites :

- 126,58 jours obtenu par Ekobo à Lobéké en 1995,
- $51,3 \pm 2,81$ jours avec un écart type de 36,8 jours obtenu par Breuer et Hockemba (2007) dans les bais à Nouabele Ndoki,
- $67,299 \pm 7,258$ jours obtenus au Parc National de Boumba Bek par Maissels *et al.* En 2012,
- $80,6 \pm 9$ jours obtenu par Princee *et al.* à Dzanga-Sangha (2012)
- 138 jours (IC 95% : 123 – 157) obtenu par Murai *et al.* en 2013 en Guinée Equatoriale,
- $105,7 \pm 5,98$ jours obtenu à Campo en 2015 par Nzooh *et al.*
- Et $96,1 \pm 7,536$ jours obtenu en 2015 dans le PNL et sa zone périphérique par Nzooh *et al.*

3.2 Durée moyenne de dégradation des nids de grands singes

Un total de 119 nids frais de grands singes a été marqué dans la RFD. La totalité des nids a été retrouvée lors de la revisite. Le tableau 2 présente le nombre de nids de grands singes marqués pendant l'étude de dégradation.

Tableau 2: Nombre de nids marqués et retrouvés dans la RFD

N°mission	Nbre_nids_marqués	Nbre_nids_retrouvés	Nbre de jours	Pourcentage existant à la revisite
1	18	18	175	11,111
2	12	12	154	25,000
3	11	11	132	27,273
4	27	27	113	33,333
5	13	13	90	38,462
6	36	36	69	55,556
7	2	2	44	100,000
Total	119	119	/	41,533

Il ressort de ce tableau 2 que 58% des nids avaient disparu lors de la revisite des 3 premières missions ont tous disparu.

En considérant l'âge des 119 nids de grands singes retrouvés et leur statut à la revisite (0 au cas où elle est absente et 1 dans le cas contraire), la courbe de probabilité de survie en fonction de leur âge (figure 3, 4) a été obtenue.

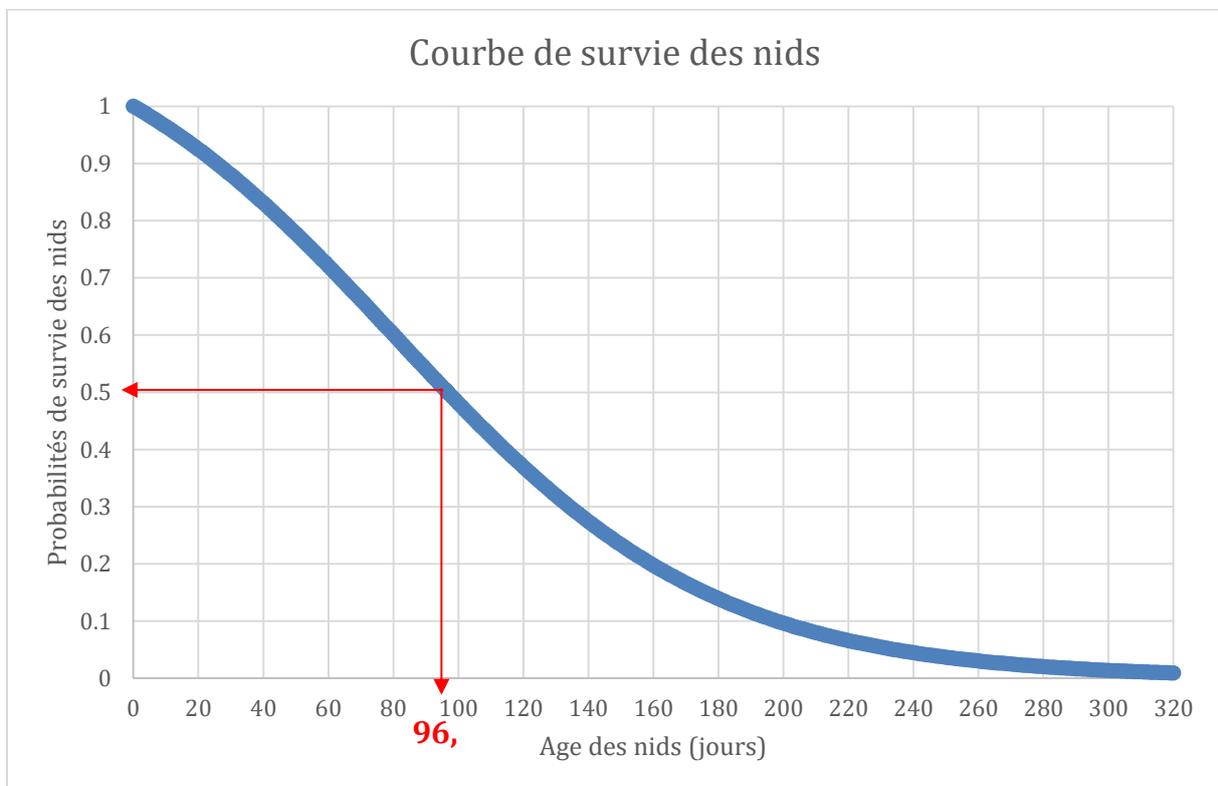


Figure 3 : Courbe de survie des nids de grands singes

De même que pour les crottes d'éléphants, la durée moyenne de vie d'un nid de grands singes variera en fonction des facteurs tels que le type de construction du nid, la saison de collecte, l'espèce qui construit le nid, la hauteur etc.

Plusieurs études ont été conduites pour estimer le temps moyen de dégradation d'un nid et la durée moyenne de dégradation obtenu lors de cette étude qui est de $96,6 \pm 2,872$ jours diffère plus ou moins de celle trouvée dans les autres sites. Comme exemple, nous avons :

- $91,5 \pm 1,67$ jours obtenu par Morgan *et al.* en 2006 à Nouabalé Ndoki ;
- 151 jours (IC 95% : 125 – 194) obtenu par Murai et al. en 2013 en Guinée Equatoriale,
- $132,5 \pm 3,76$ jours obtenu à Campo par Nzooch *et al.* en 2015 ;
- $135,3 \pm 6,508$ jours obtenu au PNL et sa zone périphérique par Nzooch et al. en 2015.

La différence entre la durée moyenne des nids trouvés dans cette étude et celle obtenu au PNL pourrait s'expliquer par la durée de l'étude. En effet, l'étude de la dégradation dans le PNL a été conduite de juillet 2014 à avril 2015 soit 10 mois alors que celle-ci a duré 6 mois.

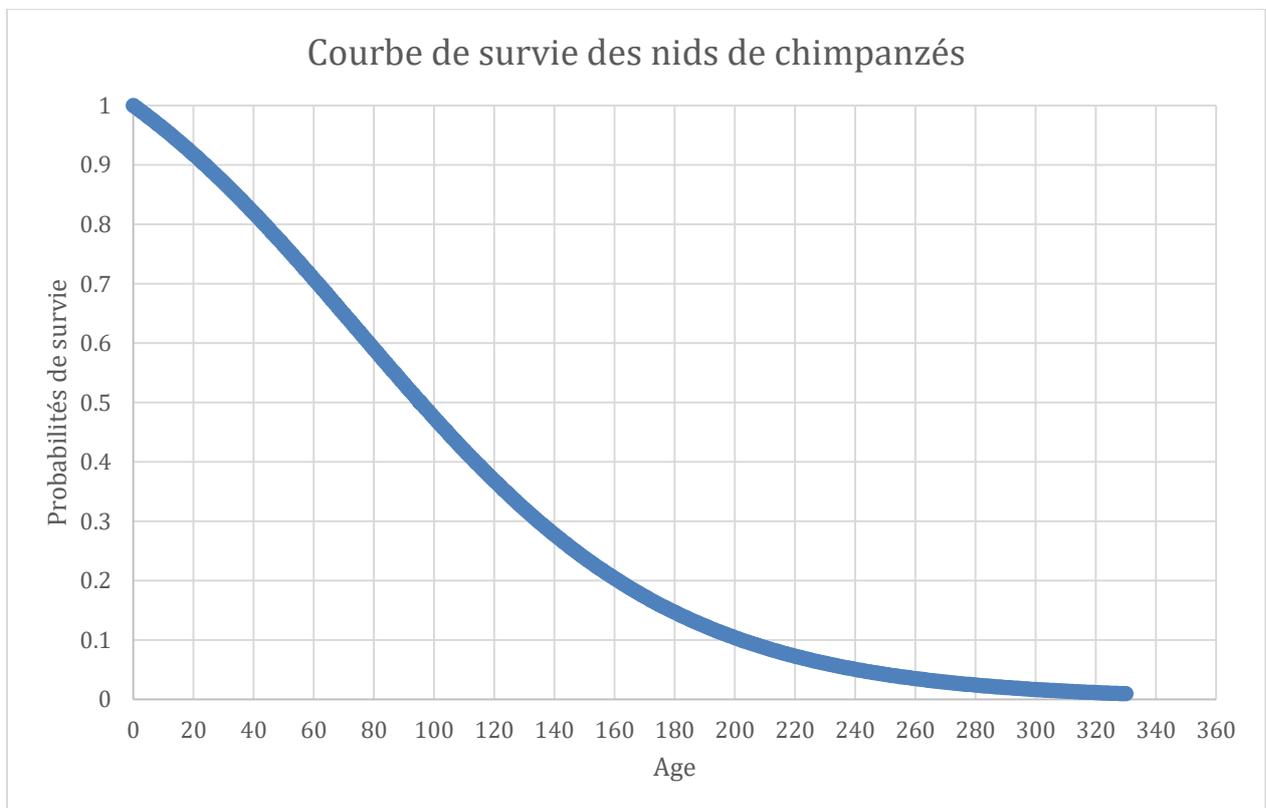


Figure 4 : Courbe de survie des nids de chimpanzés

Modèle de régression logistique

Nbre_nids_chimpanze	95
mean_decay	95,4
Standard_error	4,455466

4. Conclusion et recommandations

La présente étude a permis de déterminer la durée moyenne de vie des crottes d'éléphants et de grands singes dans la RFD. Afin d'atteindre les objectifs visés, la méthode développée par Laing *et al* (2003) a été utilisée. Après analyse des données, ont été obtenues les durées moyennes de dégradation des crottes d'éléphants et des nids de grands respectivement de $83,2 \pm 6,193$ jours et de $96,6 \pm 2,872$ jours. Ces durées sont différentes de celles trouvées par WWF en 2015 dans le PNL et sa zone périphérique $96,1 \pm 7,536$ jours et de $135,3 \pm 6,508$ jours. Conscient du fait que l'estimation des durées moyennes de dégradation est importante dans le calcul des densités animales pour leur aménagement, les recommandations suivantes sont proposées pour les prochaines études :

- Associer à l'étude l'effet des facteurs influençant la dégradation des indices (crottes, nids) afin de mieux expliquer les temps moyens de dégradation ;
- Conduire distinctement lors des prochains inventaires une étude de dégradation des nids de gorilles et une des nids de chimpanzés ;
- Mener d'autres études de production des signes des différents animaux concernés afin d'améliorer la qualité des résultats lors de l'estimation des données ;
- Commencer cette étude lors des prochains inventaires au moins 3 mois avant le début des inventaires.

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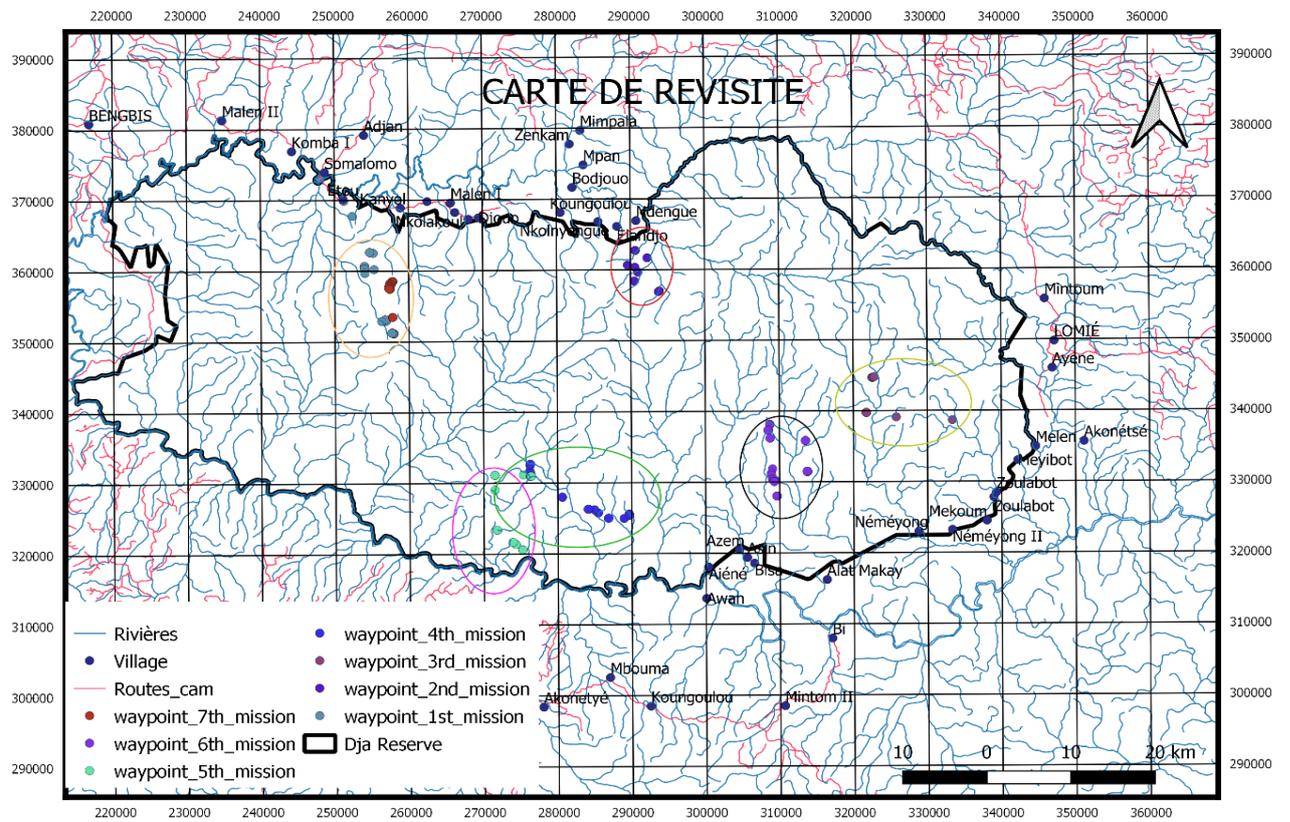
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Annexe 2: Carte de revisite



Annexe 3: Calcul des coefficients de régression avec R pour les nids de grands singes

```
library(readxl)
> Analyse_degradation1 <- read_excel("C:/Users/KOBLA/Desktop/proposition_Zsl/Analyse_degradation1.xlsx",
+   sheet = "dung_reduit")
> view(Analyse_degradation1)
> library(readxl)
> Analyse_degradation1 <- read_excel("C:/Users/KOBLA/Desktop/proposition_Zsl/Analyse_degradation1.xlsx",
+   sheet = "Nest_reduit")
> view(Analyse_degradation1)
> myreg=glm(Analyse_degradation1$Statut~Analyse_degradation1$Age, family = binomial(link = "logit"))
> summary(myreg)
```

```
Call:
glm(formula = Analyse_degradation1$Statut ~ Analyse_degradation1$Age,
    family = binomial(link = "logit"))
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.2898	-0.9134	-0.5220	1.0774	2.0390

Coefficients:

	Estimate	Std. Error	z value	Pr(> z)	
(Intercept)	1.648848	0.625469	2.636	0.00838	**
Analyse_degradation1\$Age	-0.020420	0.005779	-3.533	0.00041	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 156.80 on 118 degrees of freedom
Residual deviance: 142.16 on 117 degrees of freedom
AIC: 146.16

Number of Fisher Scoring iterations: 3

Annexe 4: Calcul des coefficients de régression avec R pour les crottes d'éléphants

```
library(readxl)
> Analyse_degradation1 <- read_excel("C:/Users/KOBLA/Desktop/proposition_Zsl/Analyse_degradation1.xlsx",
+   sheet = "dung_reduit")
> view(Analyse_degradation1)
> library(readxl)
> Analyse_degradation1 <- read_excel("C:/Users/KOBLA/Desktop/proposition_Zsl/Analyse_degradation1.xlsx",
+   sheet = "dung_reduit")
> view(Analyse_degradation1)
> myreg=glm(Analyse_degradation1$Statut~Analyse_degradation1$Age, family = binomial(link = "logit"))
> summary(myreg)
```

```
Call:
glm(formula = Analyse_degradation1$Statut ~ Analyse_degradation1$Age,
    family = binomial(link = "logit"))
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-2.3999	-0.4313	-0.0926	0.3400	3.3026

Coefficients:

	Estimate	Std. Error	z value	Pr(> z)	
(Intercept)	6.48926	1.28559	5.048	4.47e-07	***
Analyse_degradation1\$Age	-0.07803	0.01504	-5.187	2.14e-07	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 115.839 on 84 degrees of freedom
Residual deviance: 54.504 on 83 degrees of freedom
AIC: 58.504

Number of Fisher Scoring iterations: 6

Appendix 2. Medium- and Larger-sized Mammal Species List for the Dja Faunal Reserve, Cameroon.

The table below presents a list of mammal species (1) recorded by this inventory (2018) and through ZSL/MINFOF camera-trapping surveys in the Dja Faunal Reserve, Cameroon (2016 to 2018) and (2) expected in the Dja Faunal Reserve according to available distribution maps and literature, but not detected in surveys. Spotted hyena (*Crocuta crocuta*) were documented through camera-trap surveys in Nki National Park 90 km to the southeast of the DBR in 2016. Giant forest hog, ratel (honey badger), spotted hyena, and large-spotted genet have not been recorded in the DFR yet. Smaller mammals, such as most rodents, bats, shrews, and many nocturnal primates are not listed. A list of the herpetofauna of the Dja Faunal Reserve is provided by Lebreton (1999). Larger reptiles include Nile crocodile (*Crocodylus niloticus*) (unconfirmed, but known from Bek River, a tributary of the Dja River, WWF-Cameroon presentation), *Osteolaemus tetraspis*, *Python sebae*, and *Varanus ornatus*.

Family or Subfamily	Scientific Name	Local Name	IUCN Status
Bovidae	<i>Syncerus caffer</i>	African buffalo	LC
Bovidae-Antilopinae	<i>Neotragus batesi</i>	Bates' Pygmy Antelope	LC
Bovidae-Cephalophinae	<i>Cephalophus callipygus</i>	Peters' Duiker	LC
Bovidae-Cephalophinae	<i>Cephalophus dorsalis</i>	Bay Duiker	NT
Bovidae-Cephalophinae	<i>Cephalophus nigrifrons</i>	Black-fronted Duiker	LC
Bovidae-Cephalophinae	<i>Cephalophus silvicultor</i>	Yellow-backed Duiker	NT
Bovidae-Cephalophinae	<i>Cephalophus leucogaster</i>	White-bellied Duiker	LC
Bovidae-Cephalophinae	<i>Philantomba monticola</i>	Blue Duiker	LC
Bovidae-Tragelaphinae	<i>Tragelaphus eurycerus</i>	Bongo	NT
Bovidae-Tragelaphinae	<i>Tragelaphus spekii</i>	Sitatunga	LC
Cercopithecidae	<i>Cercocebus agilis</i>	Agile Mangabey	LC
Cercopithecidae	<i>Colobus satanas</i>	Black Colobus	VU
Cercopithecidae	<i>Cercopithecus nictitans</i>	Greater Spot-nosed Guenon	LC
Cercopithecidae	<i>Mandrillus sphinx</i>	Mandrill	VU
Cercopithecidae	<i>Colobus guereza</i>	Eastern Black-and-white Colobus	LC
Cercopithecidae	<i>Cercopithecus cephus</i>	Moustached Guenon	LC
Cercopithecidae	<i>Lophocebus albigena</i>	Grey-cheeked Mangabey	LC
Cercopithecidae	<i>Cercopithecus neglectus</i>	De Brazza's Guenon	LC
Cercopithecidae	<i>Cercopithecus pogonias</i>	Crowned Monkey	LC
Cercopithecidae	<i>Miopithecus ogouensis</i>	Northern Talapoin Monkey	LC
Cercopithecidae	<i>Colobus guereza</i>	Eastern Black-and-white Colobus	LC
Cercopithecidae	<i>Cercopithecus cephus</i>	Moustached Guenon	LC
Cercopithecidae	<i>Lophocebus albigena</i>	Grey-cheeked Mangabey	LC
Elephantidae	<i>Loxodonta africana</i>	African Elephant	VU

Felidae	<i>Caracal aurata</i>	African Golden Cat	VU
Felidae	<i>Panthera pardus</i>	Leopard	NT
Herpestidae	<i>Bdeogale nigripes</i>	Black-legged Mongoose	LC
Herpestidae	<i>Crossarchus platycephalus</i>	Cameroon Cusimanse	LC
Herpestidae	<i>Herpestes naso</i>	Long-nosed Mongoose	LC
Herpestidae	<i>Atilax plaudinosus</i>	Marsh Mongoose	LC
Hominidae	<i>Gorilla gorilla gorilla</i>	Western Lowland Gorilla	CR
Hominidae	<i>Pan troglodytes troglodytes</i>	Central Chimpanzee	EN
Hystriidae	<i>Atherurus africanus</i>	African Brush-tailed Porcupine	LC
Manidae	<i>Phataginus tricuspis</i>	White-bellied Pangolin	VU
Manidae	<i>Smutsia gigantea</i>	Giant Pangolin	VU
Nandiniidae	<i>Nandinia binotata</i>	African Palm Civet	LC
Nesomyidae	<i>Cricetomys emini</i>	Emin's pouched rat	LC
Orycteropodidae	<i>Orycteropus afer</i>	Aardvark	LC
Procaviidae	<i>Dendrohyrax dorsalis</i>	Western Tree Hyrax	LC
Sciuridae	<i>Sciurid sp.*</i>	Squirrel sp.*	N/A
Suidae	<i>Potamochoerus porcus</i>	Red River Hog	LC
Suidae	<i>Hylochoerus meinertzhageni</i>	Giant Forest Hog (no record)	LC
Tragulidae	<i>Hyemoschus aquaticus</i>	Water Chevrotain	LC
Viverridae	<i>Poiana richardsonii</i>	Central African Oyan	LC
Viverridae	<i>Genetta servalina</i>	Servaline Genet	LC
Viverridae	<i>Poiana richardsonii</i>	Central African Oyan	LC
Viverridae	<i>Genetta maculate</i>	Large-spotted Genet (no record)	LC
Mustelidae	<i>Mellivora capensis</i>	Honey Badger or Ratel (no record)	LC
Lorisidae	<i>Perodicticus potto</i>	Potto	LC
Manidae	<i>Phataginus tetradactyla</i>	Black-bellied Pangolin	VU
Tenrecidae	<i>Potamogale velox</i>	Giant Otter Shrew	LC

* This is likely to consist of five squirrel species, four of which are generalist and one is terrestrial, (Thomas's rope squirrel (*Funisciurus anerythrus*), Red-cheeked rope squirrel (*Funisciurus leucogenys*), Ribboned rope squirrel (*Funisciurus lemniscatus*), Fire-footed rope squirrel (*Funisciurus pyrropus*) and Lady Burton's rope squirrel (*Funisciurus Isabella*)), but due to issues with image quality positive identification was not possible in many cases.