Wildlife and human impact survey of the Ngombé Ntokou-Pikounda forest landscape, Republic of Congo.

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Figures

Tables

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Executive summary

Context

The landscape of Ngombe Ntokou and Pikounda, in the northern Republic of Congo, covers some 17,000km^2 of humid tropical forest. The landscape is bordered on one side by Odzala national park, and on the other by the Sangha River. It includes the Ngombé forest concession under the management of Industrie Forestiere de Ouesso (IFO), a Danzer Group Company, and the newly created National Park of Ntokou-Pikounda. The main Brazzaville to Ouesso road runs through the landscape, along which most of the human population is located.

In 1999-2000, an initial exploration was made by Mike Fay through the southern part of the landscape to investigate its conservation value. This exploration showed the southern part of the landscape, a mix of swampy/inundated forests and open canopy forests, to be of exceptional importance for wildlife (Fay 2005).

In 2007, IFO, WCS and the Forest Ministry formed a partnership to help conserve the area's wildlife. A landscape-wide survey was conducted to assess large mammal abundance and distribution using an internationally recognised standard methodology (line transects with 'distance' sampling: Thomas 2010). The results revealed a very large gorilla population and an important population of forest elephants (Malonga 2008). In 2009 IFO received certification from the Forest Stewardship Council (FSC). The management and monitoring of wildlife and threatened species is a key requirement of FSC certification, and the collaboration on wildlife management has been an important component of IFO's certified status.

This report presents the results of the first repeat survey of the area, carried out between March and September 2014, seven years after the initial baseline survey. The survey was jointly financed by WCS (using funds from US Fish and Wildlife Service) and IFO-Danzer. This enabled a much higher sampling effort than the initial survey, which has greatly improved the precision of population estimates and spatial distribution. The objective of the survey is to provide results that can be used to evaluate wildlife protection efforts over time, and improve the efficiency of anti-poaching efforts.

Methods:

A survey design was created based on the results of the previous survey, the evolving logging activity in the concession, and the density and distribution of the human population. Standard distance sampling methods used line transects to estimate the density of ape nests and elephant and ungulate dung; hunting pressure was assessed by the encounter rate of signs encountered. Four teams of experienced wildlife survey staff walked a total distance of 427 kilometers along 192 transects. Data analysis was carried out by Fiona Maisels and Samantha Strindberg, of WCS.

Data analysis used standard conversions to translate the density of ape nests and elephant dung into population estimates. The same production and decay rates used in 2007 were used, to enable the comparison between the first and second cycles monitoring cycles. Observation details of ape nests were used to separate chimpanzees from gorillas in the data analysis. Ungulate estimates are based only on dung density,

as insufficient information exists on dung production and decay rates to enable the calculation of population numbers.

Due to a change in the southern limit of the IFO concession since 2007, and the creation of the Ntokou-Pikounda national park, the data from 2007 was retrospectively re-stratified to enable a like for like comparison of the main strata across the two surveys.

Results

Ape abundance

The results indicated that, in 2014, an estimated 78,753 individuals (95% c.l. 61,514-100,820) gorillas live in the area; the same area in 2007 held 81,793 (95% c.l. 54,399-122,980). There was no significant difference in nest density 2007-2014 when the whole landscape was examined, but there had been a significant decline in gorilla nests within the National Park – Pikounda area.

Elephant abundance

The elephant population of the landscape is now estimated at 4,142 individuals (95% c.l. 2,994-5,731). In 2007 the elephant population was 4,992 individuals (3,192-7,806). Using the 5% significance level, there was no significant difference in dung density 2007-2014. Nine elephant carcasses were found during the survey, three of which showed obvious signs of the animals having been poached.

Ungulate abundance

The dung density of the small, medium and large ungulates (i.e. all duikers, sitatunga, and water chevrotain) was calculated for 2014 and compared with the results for 2007. In general there was a trend for ungulate dung density to increase in the National Park + Pikounda N 2007-2014; this increase was significant for the smallest sized ungulates, mostly blue duiker *Philantomba monticola*. There was also a trend for ungulate dung density decline in the Ngombe concession, but this trend was not significant at the 5% confidence level. The distribution maps show a decrease in ungulates in the north of the landscape, which corresponds to an increase in hunting pressure in that area.

Signs of hunting and poaching

The survey found that the density of human signs (Hunting camps, snares, cartridge cases, gunshots) were concentrated in the north of the landscape. The distribution has remained quite consistent when the two surveys are compared. There has been an expansion of hunting along the main road south from Ouesso. However hunting has also increased in the Ntokou-Pikounda National Park in particular along the Lengoue River.

Conclusions

Long term monitoring data can be used to inform company practices and increase the effectiveness of anti-poaching efforts. In light of these results, we recommend the following:

- An increase in the extent and intensity of anti-poaching activities carried out by the PROGEPP ecoguards to enable increased surveillance of the south of the concession and the Lengoue river corridor.
- The immediate establishment of an effective protection force dedicated to the Ntokou-Pikounda national park.
- Maintenance of the ongoing great apes disease surveillance program, and the expansion of effective surveillance of the Ntokou-Pikounda area.
- Planning for a repeat survey using comparable methods to be executed in 2018/9

Introduction

The landscape of Ngombe Ntokou and Pikounda, in the northern Republic of Congo, covers some 17,000km^2 of humid tropical forest. The landscape is bordered on one side by Odzala national park, and on the other by the Sangha river. It includes the Ngombé forest concession under the management of Industrie Forestiere de Ouesso (IFO), a Danzer Group Company, and the newly created National Park of Ntokou-Pikounda. The main Brazzaville to Ouesso road runs through the landscape, along which most of the human population is located.

In 1999-2000, an initial exploration was made by Mike Fay through the southern part of the landscape to investigate its conservation value. This exploration showed the southern part of the landscape, a mix of swampy/inundated forests and open canopy forests, to be of exceptional importance for wildlife (Fay 2005).

Industrie Forestiere de Ouesso (IFO), a Danzer Group company, has a long term concession agreement to manage the Ngombe forest management unit (FMU) in northern Congo. This concession, covering 11,596 km2, is the largest single FMU in Congo and is to date the largest management unit to achieve sustainable forest management certification. IFO approached WCS to organise and execute a wildlife survey across the area.

WCS and IFO have worked together with the Congolese forest ministry in partnership since 2007. The partnership, called PROGEP-PNOK[1], aims to protect the wildlife in the concession and to jointly manage the pressures on the natural environment related to timber extraction. This partnership is one of the few examples in Congo of successful public-private collaboration for conservation, and is a model that has greatly influenced forest policy in central Africa. In 2007, at the start of the partnership, WCS carried out a wildlife survey across the area to establish a baseline of wildlife abundance and human pressure, and to enable future evaluations of anti-poaching effectiveness. This survey provided a baseline for PROGEP. It also provided one of the justifications for the gazettement of the Ntokou-Pikounda national park.

This report concerns the first *repeat* survey of the area, completed seven years after the initial survey. The survey results are intended to help IFO improve the sustainable management of the area, and, in particular to improve the effective deployment of ecoguard patrols. The report also helps the company comply with FSC certification requirements. They also provide an important indication of the health of wildlife populations in the national park.

Great Apes and elephants in west Central Africa

Great Apes

Overall, the main threats to the world's great apes are habitat destruction, hunting, and disease (Williamson et al. 2013). In Africa, hunting and habitat destruction are greatly exacerbated by lack of effective protection

[1] Projet de Gestion des Ecosystèmes Périphériques au Parc National de Odzala-Kokoua

(Tranquilli et al. 2012). All species are Red Listed as either Critically Endangered or Endangered, and the populations of all are diminishing (IUCN 2014). Central Africa contains four species of great ape: western lowland gorilla, mountain gorilla, common chimpanzee and bonobo, of which two occur within West Central Africa (west of the Congo River): western lowland gorilla *Gorilla gorilla gorilla* and common chimpanzee *Pan troglodytes troglodytes* (IUCN 2014, Williamson *et al* 2013).

Because of the ongoing hunting throughout their range, and the additional high risk of the fatal disease Ebola (Fig. 1), western lowland gorillas are currently listed as Critically Endangered (Walsh et al. 2008). Central chimpanzees have been listed as Endangered since 1996 (Oates et al. 2008). The most recent IUCN Action Plan for the species was produced in 2015 (IUCN 2014) where maps of the two taxa can be seen, and where specific conservation activities are listed for each area of importance for great apes, of which the Ngombe-Ntokou-Pikounda landscape forms a part. Hunting is ongoing throughout Central Africa, but no case of Ebola has been recorded in great apes since 2005. In the late 1990s and early 2000s a well-documented Ebola epidemic killed thousands of gorillas in the region, striking north-eastern Gabon and western Congo- including part of Odzala (Bermejo et al. 2006; Walsh et al. 2003). Studies at a site in Odzala (immediately to the West of Ngombe: Fig. 4) showed that the population structure changed with the Ebola outbreak (the proportion of single males increased, as they were thought to be less likely to contract the disease from conspecifics) (Caillaud et al. 2006; Devos et al. 2008a; Devos et al. 2008b); group size six years after Ebola was smaller than pre-Ebola groups (Genton et al. 2012, 2014).

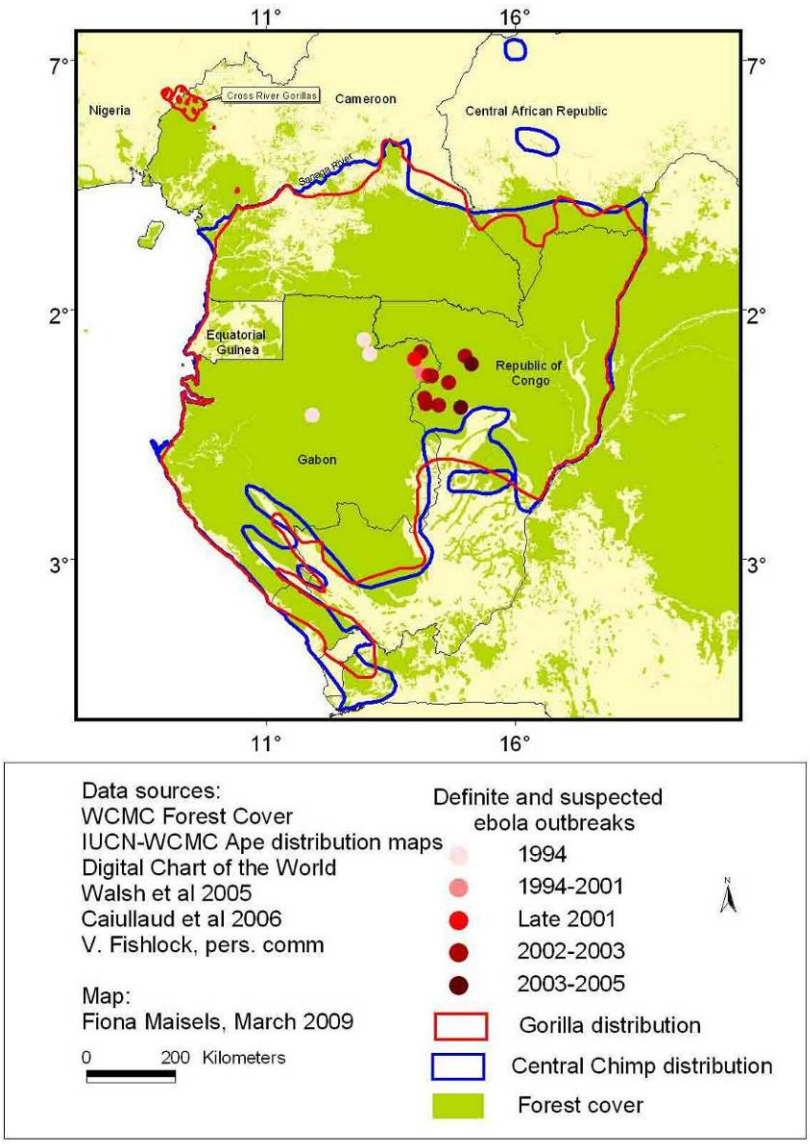

Figure 1. Gorilla and central chimpanzee distribution, and sites of Ebola haemorrhagic fever outbreaks, 1994-2005

Elephants

African forest elephants are thought to be a separate species (*Loxodonta cyclotis)* from the bush elephant *Loxodonta africana*[2] and the most recent IUCN assessment lists the Central African elephant population as Endangered (Blanc 2008). The main threat to elephants is very high poaching pressure for ivory, which has had a devastating effect on their populations throughout much of Africa, especially Central, West, and East Africa (Beyers et al 2011, Bouche et al 2011, 2012, CITES 2013, 2014, 2015; Maisels et al. 2013; UNEP et al. 2013, Wittemyer et al 2014) (Fig. 2).

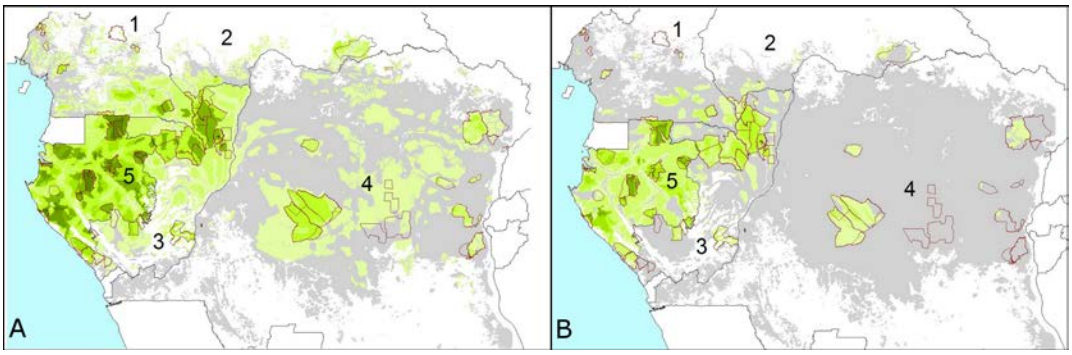

Figure 2. Forest elephant abundance and range decline, (A) 2002 (B) 2011[3]

Elephant (and other) hunting has been greatly facilitated by the rapidly growing, extensive road network throughout Central Africa (Blake et al. 2008; Vanthomme et al. 2013; Yackulic et al. 2011) but the driver of ivory poaching has been the increase in demand –and thus price - in the Far East, especially China (Martin and Vigne 2011; Underwood et al 2013, Vigne and Martin 2014; Wittemyer et al. 2011) coupled with poor governance in much of elephant range (Bennett 2014). The increase in poaching has in fact now been shown to be strongly correlated with trends in consumer demand in the Far East (CITES 2013).

Wildlife surveys in the northern Republic of Congo

Wildlife surveys in Northern Congo have been ongoing since the late 1980s, and particularly since 2002 (Fig. 3). The data collected has resulted in the creation of two National Parks (Nouabalé-Ndoki and Ntokou-Pikounda), a Community Reserve (Lac Tele), and the extension of the existing Odzala National Park. Between 2003 and 2014, much of Northern Congo was surveyed using line transects placed systematically over the Parks and the adjoining logging concessions[4]. Results showed that the whole area was of great importance for large mammal populations and that the management system using a combination of the protected areas (with real and effective protection from poachers and damage) and surrounding logging concessions with strictly enforced rules on hunting and access was a successful model for conservation. About 60% of the world population of western lowland gorillas are in Congo; over 25% are in this single large area (Strindberg et al 2013 and in prep). In addition it is likely that perhaps 20% or more of all central chimpanzees *Pan troglodytes*

[2] Brandt et al. 2012; Ishida et al. 2011a,b; Ishida et al. 2012; Rohland et al. 2010
[3] http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0059469
[4] Blake 2006; Iyenguet et al. 2012; Maisels et al. 2012, 2013; Malonga 2008; Malonga et al. 2009; MIKE 2005; Rainey et al. 2010; Stokes et al. 2010

troglodytes live in Congo (this time including the Conkouati-Douli National Park in southern Congo) with most of the rest of both the world's gorillas and central chimpanzees living in neighbouring Gabon and southeastern Cameroon. Finally, it is possible that about a fifth of the worlds' forest elephant population lives in Congo (Blanc et al. 2007), with the population heavily skewed to the north (Maisels et al. 2013).

Methods

There is a five-step process from simply surveying an area through to assuring its conservation. The first is to train staff, the second is to design and implement surveys, the third is to analyse and report on the results, the fourth is to ensure results are fed back into effective conservation management and the fifth is to use the results to establish regular cycles of monitoring for adaptive management. Since about 2000, large mammal surveys in large forested areas in Central Africa have used distance sampling along line transects (Buckland et al. 2001) and reconnaissance walks known as "recces" (Walsh et al. 2001). The most commonly used program for both survey design and data analysis is the DISTANCE software (Thomas et al. 2010). Use of these methods ensure that data are comparable across time and space, and standard texts have been produced for guidance in sampling design, training, and field protocol[5]. To date, the survey results across the region (Fig. 3) have been used in advising on landscape planning[6] and on assessing Red List status of great apes (Oates et al. 2007b; Walsh et al. 2008) and elephant (IUCN/African elephant range States 2010) and IUCN ape action plans[7].

The enormous landscape of the Ngombe-Ntokou-Pikounda forest lies in the northern Republic of Congo and covers 17,745km^2. The area comprises two logging concessions (Ngombe and Northern Pikounda) and the newly gazetted Ntokou-Pikounda National Park (4,252 km^2) (Fig. 4). The Ngombe concession is divided by the main Ouesso-Brazzaville road. In 1999-2000, an initial exploration was made through the southern part of the landscape which identified it as of high importance for wildlife (Fay 2005), largely because of its impenetrable (to hunters) understorey of Marantaceae. In 2007, a landscape-wide survey used distance methods (Fig. 5) to assess wildlife abundance and distribution, and human pressure, across the whole area, concentrating on great apes and elephants (Malonga 2008). The results revealed a very large gorilla population – over 70,000 individuals- and around 15,000 forest elephants.

This report details the second (2014) survey of the site. The goal of the survey was principally to assess elephant and ape population and distribution, other wildlife (especially duiker) abundance, and human pressure, and whether it had changed since the last cycle. The results from 2007 provided the baseline for survey design for this site.

[5] Buckland et al. 2001; Hedges 2012; Hedges and Lawson 2006; Hedges et al. 2012; Kühl et al. 2008; Maisels 2010; Maisels and Aba'a 2010; Maisels et al. 2008a; Maisels et al. 2008b; Strindberg 2012; Strindberg et al. 2004
[6] Blake et al. 2008; Rainey et al. 2010; Stokes et al. 2010; Yackulic et al. 2011
[7] Dunn et al 2014, IUCN and ICCN 2012; IUCN 2014, Morgan et al. 2011; Oates et al. 2007a; Plumptre et al. 2010; Tutin et al. 2005).

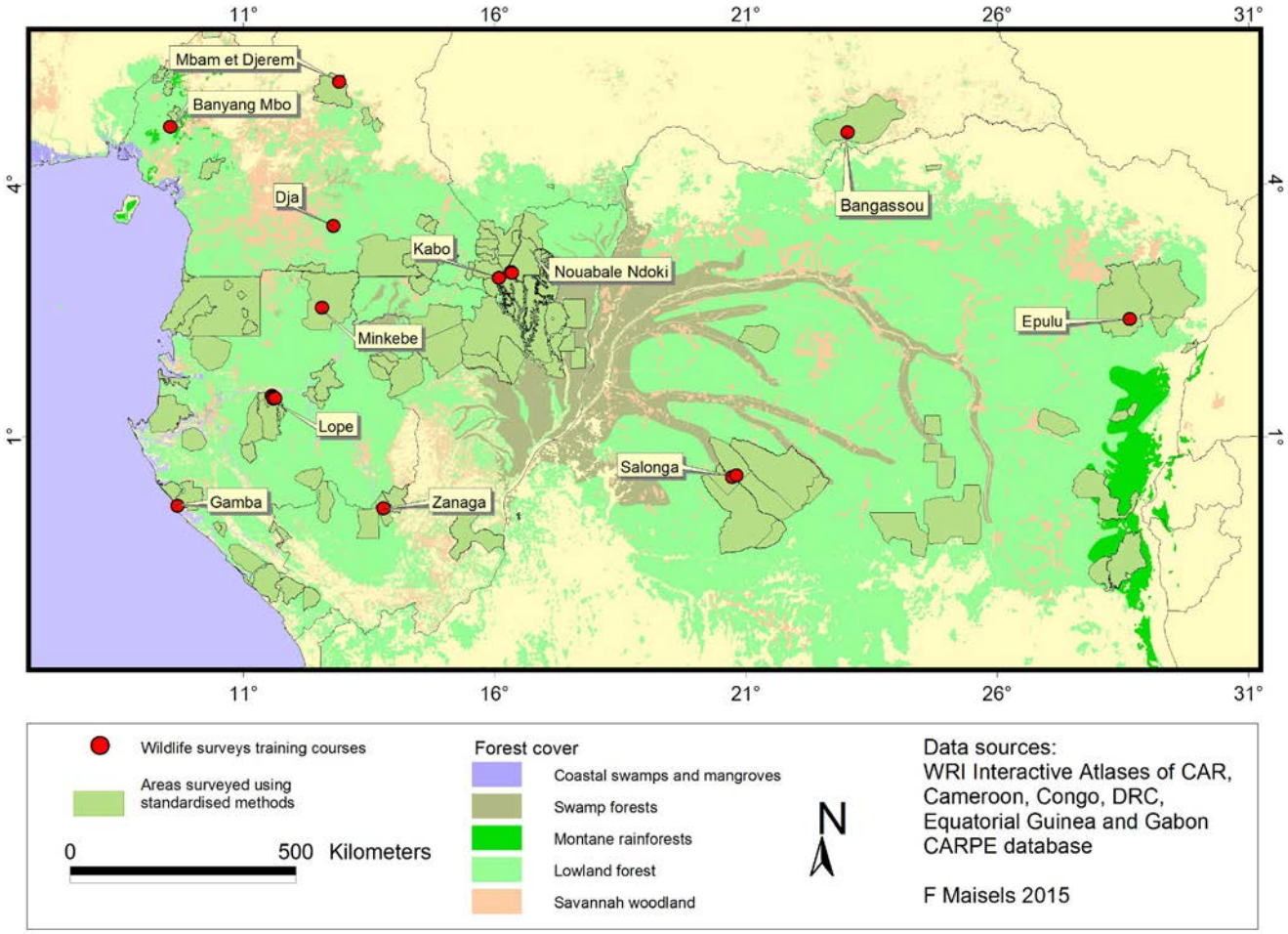

Figure 3. Standardised surveys (2002-2014) and methods training courses (1997-2014) of wildlife and human impact in Central Africa.

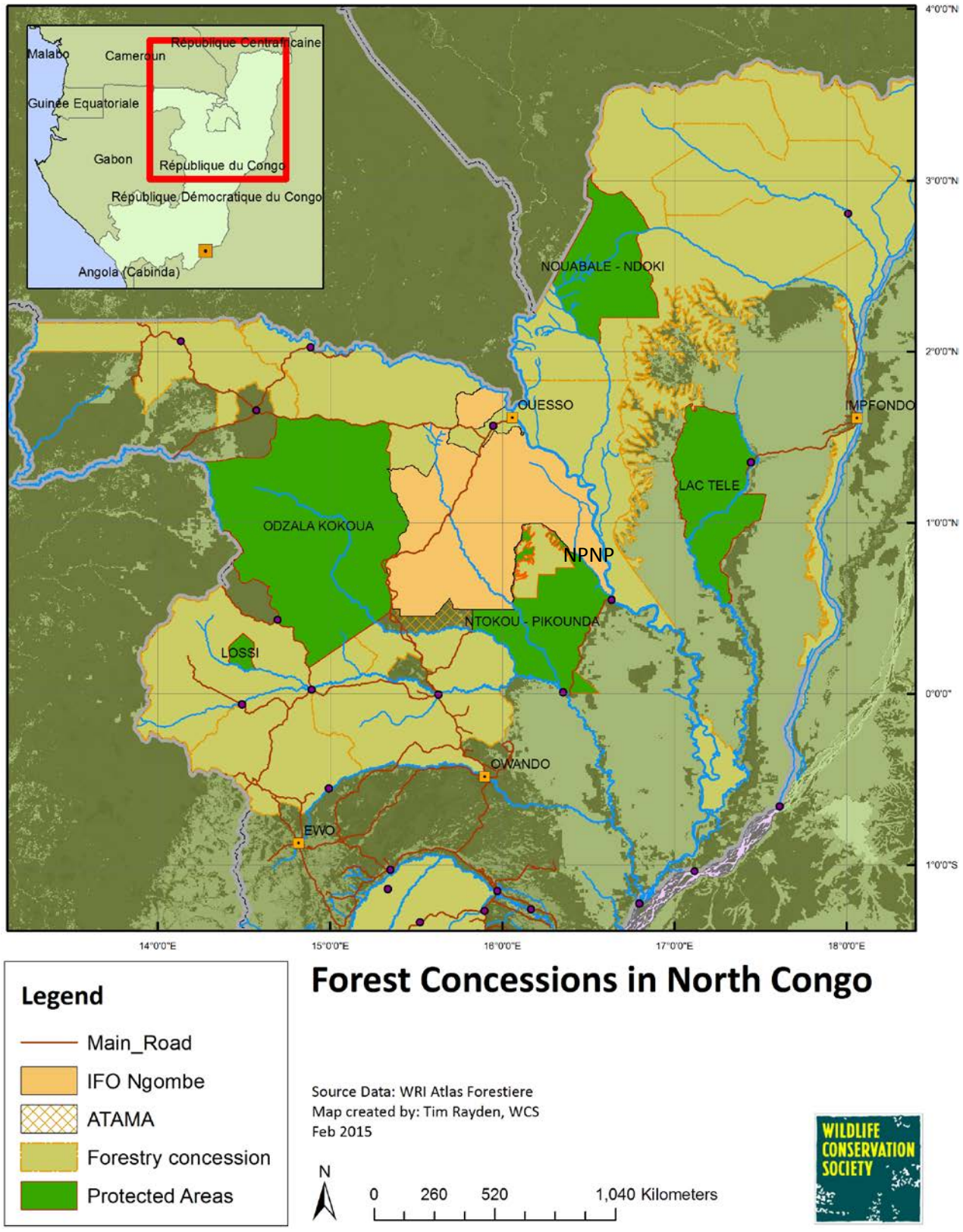

Figure 4 Location of the Ntokou-Pikounda National Park (NPNP) and the Ngombe Concession in northern Republic of Congo.

Survey design

The sampling design was completed (Fig. 6) using the results from the survey of 2007 to guide the intensity of sampling for this cycle. The original strata design was based on the three logging concessions then existing (Ngombe, Ntokou and Pikounda), but without prior knowledge of the abundance or distribution of wildlife in each stratum. In 2014, and at the logging company's request, we subdivided the strata into areas with assumed low, medium and high hunting levels; and depending on whether the areas were slated for logging, already logged, or were part of the new Ntokou-Pikounda National Park (created in 2012). Stratification based on known or expected wildlife density reduces heterogeneity and improves precision. In addition, to further improve precision, the number of replicates (transects) in each strata was set at a minimum of 20, and preferably at least 30. Target CV for great ape nests was set at 15%; for elephant dung it was 20%.

A total of 193 transects in the various strata were drawn up (Fig 6). In 2007, transects were one kilometre long. Because of the logistics of setting up and implementing transects, only one transect can be walked in a day. In order to maximise the probability of encountering wildlife sign on transects (rather than on the recce walks between them), we increased the effort (length) per transect. Our target CV was 15-20%, which meant that the required effort in each stratum, transects could be either 2 or 2.5 km long (2km in areas less likely to be hunted and more likely to hold higher densities of elephants or great apes) (Table 1). Effort (total number of kilometres) was thus (depending on the stratum) between 40 and 80 km per stratum.

Table 1. Transects planned and completed in each stratum, 2014.

Stratum	Area (km2)	No. of transects	Length of each transect	Planned Effort (km)	Final effort (km)	Reason for stratum
Ngombe NW	902.8	22	2.0	44	43.7	Medium hunting pressure; unlogged; part of concession
Ngombe Road corridor	3777.9	30	2.5	75	74.9	High hunting pressure; logged; part of concession
Ngombe Sangha E	2147.7	32	2.5	80	77.7	Medium hunting pressure; logged; part of concession
Ngombe south-centre	2523.7	32	2.0	64	63.1	Medium hunting pressure; logged; part of concession
Ngombe SW	1624.0	33	2.5	82.5	82.1	Low hunting pressure; unlogged; part of concession
Ntokou-Pikounda+Pikounda N	5213.7	43	2.0	88	85.9	Low to medium hunting pressure; unlogged; national park and small concession
Total	**16189.8**	**192**		**433.5**	**427.3**	

Survey implementation

The surveys were carried out between 15 February through to 3 October 2014. All but one of the planned transects were completed.

Each team comprised: a team leader; an assistant team leader; a compass bearer and a transect cutter, and a small group of porters (locally recruited).

The data collected was then cleaned and verified, and backed up. For great apes, the next step was to assign each nest to species (chimp or gorilla). A logistic regression model using all the data from both recces and transects was used to separate the species (Strindberg 2014: Annex 1). The parameters used by Sanz *et al*

(2007) were included: Nest Type, Nest Height, Slope, Ground Cover Type, Ground Cover under the Nest, Habitat Type (see Annex I for the analysis details). Encounter rate and density of sign per species or species group were then estimated. Using the standard multipliers (deposition and decay rate of elephant dung and great ape nests), density and number of elephants and great apes were estimated for each stratum.

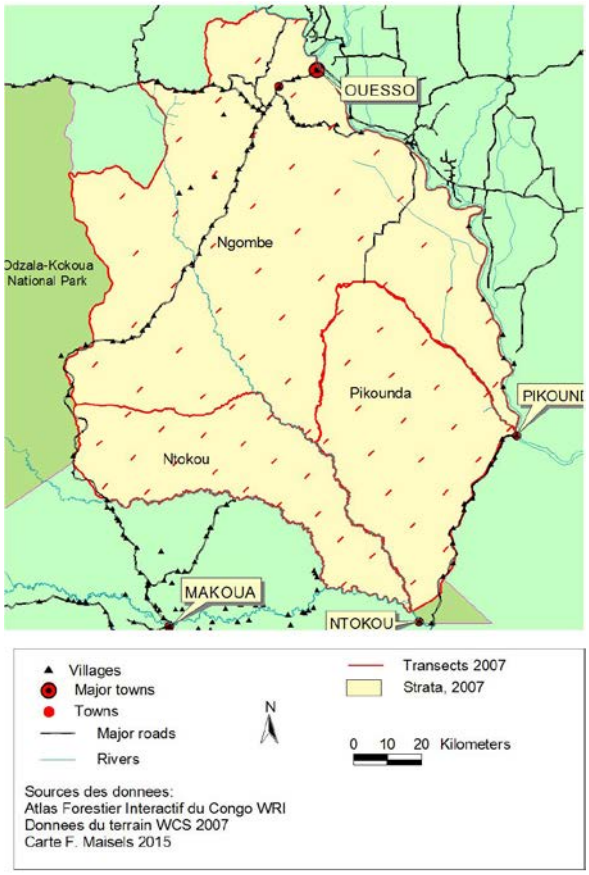

Figure 5. Survey design 2007, showing the strata and the transect locations.

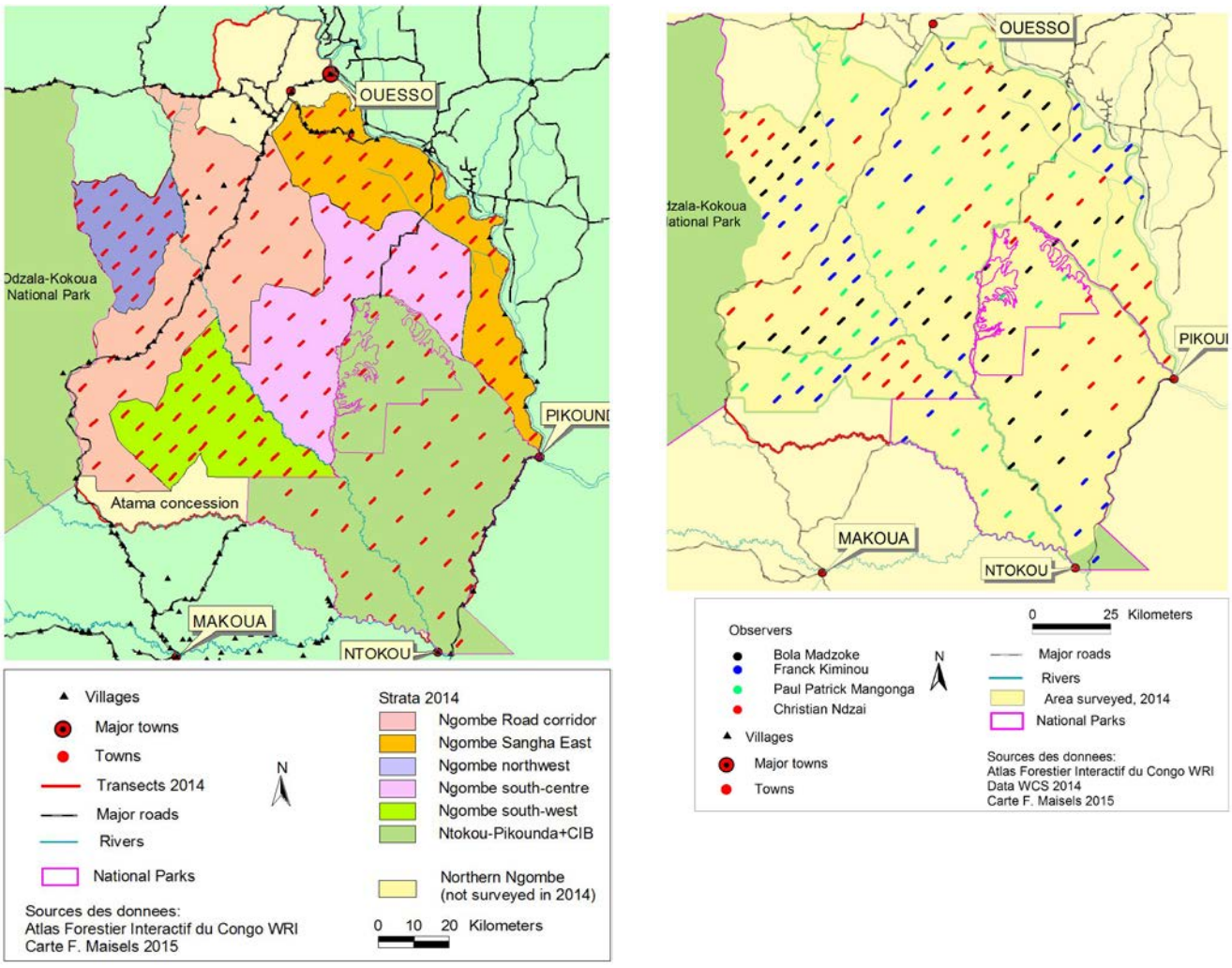

Figure 6. Survey design 2014. Left: the strata and the transect locations. Right: transects carried out by each individual observer

Data analysis: great apes

Gorillas make nests both in trees and on the ground, but chimps in Central Africa only nest in trees. Nests in trees, therefore, can only be assigned correctly to species in the field if there is an unmistakable sign of one or other of the two ape species under (or in) the nest; this is normally dung under the nest. Chimp and gorilla dung are easy to distinguish in the field (Arandjelovic et al. 2010) and fresh and recent tree nests normally still have dung underneath. To distinguish the remaining older nests that had no dung, we used the methodology of Sanz et al (2007), who showed that with the right covariates, even old nests can be assigned to species. Useful covariates had been shown to be height of the nest, species of tree in which the nest had been constructed, and whether the ground cover under the nest was closed or open. Data was accordingly collected on these variables, plus the general habitat type, for each nest (Appendix 1).

After nest density is calculated (using the DISTANCE programme) then multipliers must be used to estimate animal density. To compare directly between the 2007 and 2014 surveys, we used the same nest production rate throughout (1); decay rates were set for both species at 90.

The standard formula for transforming nest density to animal density is (White and Edwards 2000)

G or C = N / (r* D)

Where G or C = gorilla of chimp density, N = nest density (calculated using DISTANCE), r = decay rate (in days), and D = nest production rate (per day).

Data analysis: elephants

Elephant dung was classified according to the standard methodology of Barnes & Jensen (1987), adapted later by the MIKE program, where the final class "E" is flattened fibres on the ground, with no faecal matter remaining. Class "E" is also known as Class S4 and S5 (Hedges & Lawson 2006) in the MIKE dung classification system. This class is not usually included in the estimation of density, because the probability of detecting E dung is unlikely at 2m or more in the undergrowth (Barnes & Jensen 1987). The other classes (A/B through D) all have equal likelihood of being spotted (Barnes et al 1988) and are all included in the analysis.

Estimating elephant density from dung density:

The standard formula for transforming dung density to animal density is very similar to that for great ape nests (Barnes and Jensen 1987):

$$E = Y / (r^* D)$$

Where E = elephant density, Y = dung pile density (calculated using DISTANCE), r = decay rate (in days), and D = dung production rate (per day).

The same multipliers for dung production and dung decay used in 2007 were used here to provide comparable results of animal density and number. There has been no locally estimated deposition rate, so we used 19 for production and 90 for decay, as did the MIKE program throughout the region in its first iteration (MIKE 2005).

Data analysis: Ungulates

Recent DNA-based work has shown that distinguishing the pellet-shaped dung of the ungulate species living in the Central African rainforests to species was not as clear-cut as it seemed (Ntie et al. 2010). There are three main classes of ungulates (the small blue duiker *Philantomba monticola*, the medium-sized "red" duikers *Cephalophus callipygus, leucogaster, nigrifrons, ogilbyi* and *dorsalis*, and the largest one *Cephalophus silvicultor*) It seemed reasonable to suppose that their dung fell into three clear classes (small, medium and large) according to their size. However, there is confusion where juveniles are concerned, and also, it has been shown, where other ungulates are concerned (water chevrotain *Hyemoschus aquaticus* and the medium sized *Tragelaphus spekei (*sitatunga*)* and bushbuck *T. scriptus*).

Therefore we are obliged to code dung as follows: u1, u2 and u3, respectively).

U1 is "Small" and comprises all *Philantomba monticola* dung plus that produced by the juveniles of the medium-sized duiker species *C. leucogaster, C. dorsalis, C. callipygus, C. nigrifrons* and *C. Ogilbyi,* and water chevrotain.

U2 is "Medium" and is produced by the medium sized duikers and water chevrotain, *plus* that produced by juvenile *C. Silvicultor,* sitatunga, and bushbuck.

U3 is "Large" and is that produced by adult *C. Silvicultor*, bushbuck, and sitatunga.

Bongo *Tragelaphus eurycerus* and buffalo *Syncerus caffer nanus* dung, and those of the two pig species red river hog *Potamochoerus porcus* and giant forest hog *Hylochoerus meinertzhageni* are unmistakable and can be classified to species.

Data analysis: comparing the results of this survey with the previous cycle

In 2007, the area comprised three logging concessions: Ngombe, Pikounda and Ntokou. Since then, there have been three changes:

- The Atama palm oil concession was carved out of the Ntokou concession (Fig. 6);
- The Ntokou-Pikounda National Park was carved out of the old Pikounda concession and the eastern sector of the old Ntokou concession;
- The Pikounda North concession was created of the remains of what had been the Pikounda concession;
- The remains of the Ngombe and Ntokou concessions were combined to form one large concession (Ngombe).

In order to be able to directly compare the results from 2007 with those of 2014, we assigned the transects of both years to two areas: (i) the Ngombe logging concession (2014 boundaries) and (ii) the Ntokou-Pikounda National Park plus the Pikounda North concession. Seven transects from 2007 were outside the area surveyed in 2014 (four in what is now the Atama palm oil concession in the south, and three close to the town of Ouesso in the north) (Fig 7). We then estimated dung and nest density for both the 2007 and 2014 survey cycles. We used the method described in Buckland et al (2001: section 3.6.5) to compare datasets between years. We used the equation 3.102 to obtain the z value. We used an alpha of 0.05 for our decision criterion of significance.

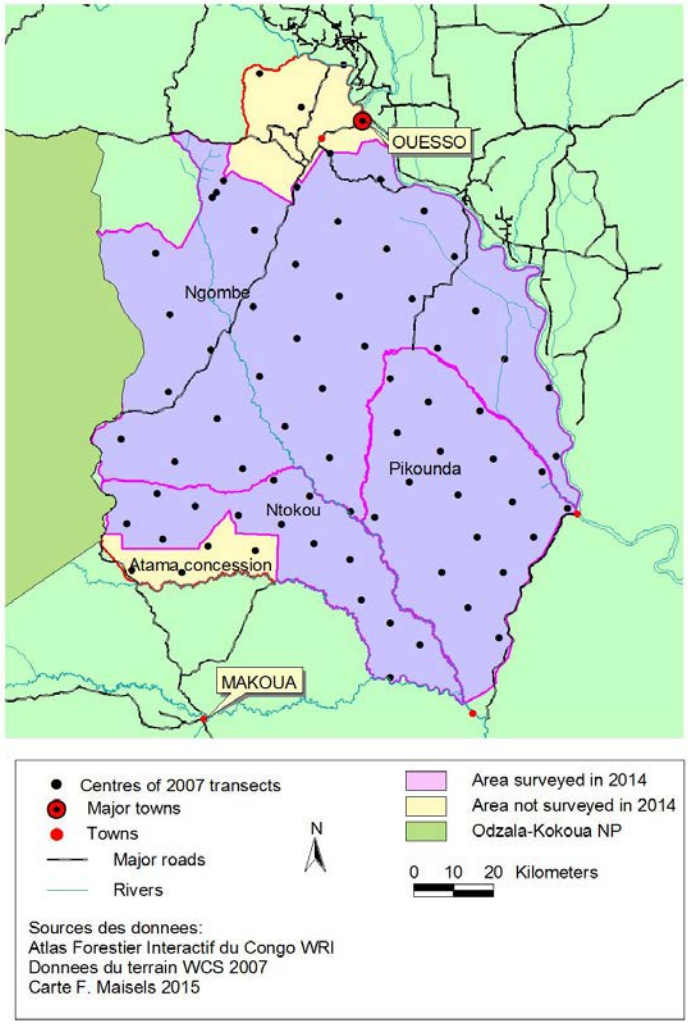

Figure 7. 2007 transect locations, area surveyed in 2014, and area surveyed in 2007 and not in 2014.

Results

Great apes

A total of 2838 great ape nests were recorded on transects in 2014, of which just under half were not assigned to either chimpanzee or gorilla. These were classified as "Great ape" nests; i.e. in a tree, with no corroborating evidence (dung, urine) as to whether it was a chimp or gorilla nest. A logistic regression model using all the data from both recces and transects (total 3540 nests) was used to separate the species (Strindberg 2014: see Annex 1). A model with Nest Height, Slope and Habitat Type over 99% of the nests were correctly attributed. Even with Nest Type alone, almost 99% of nests were correctly classified. After this procedure, 2113 nests from the 2014 dataset (74%) were found to be gorilla nests and the other 725 were chimp nests (Table 2).

Table 2. Number of great ape nests recorded on transects during the 2014 survey after logistic regression was used to separate them by species.

	Ngombe northwest	Ngombe Road corridor	Ngombe Sangha East	Ngombe south-centre	Ngombe south-west	Ntokou-Pikounda+Pikounda N
Gorilla nests: 2014	38	728	348	405	431	163
Chimp nests: 2014	12	159	74	156	178	146
Great ape nests: 2014	**50**	**887**	**422**	**561**	**609**	**309**

Great ape density

In 2014, ape density was high and typical of this area (Table 3). The whole landscape contained 5.07 great apes/ km^2 (95% c.l. 4.14-6.22; CV 10.27%), 4.86 gorillas/ km^2 (95% c.l. 3.80-6.23; CV 12.49%), and 0.59 chimpanzees/ km^2 (95% c.l. 0.43-0.82; CV 16.44%). This translates to 82,618 great apes (95% c.l. 67,033-100,720) of which the majority are gorillas (78,753 individuals; 95% c.l. 61,514-100,820).

Great ape distribution

As in 2014, ape density was low near Ouesso and to the west of the river Lengoue south of the Ouesso-Sembe –Souanke road (the Ngombe northwest stratum). Although, as seen above, great ape abundance was not statistically significantly different over the whole area 2007-2014, the density of ape nests was lower in 2014 - specifically along the road linking the villages of Pikounda and Ntokou, after which the National Park is named, and indeed throughout much of the south of the new Park (Fig. 8). To further explore distribution of great apes in the new National Park, we mapped all other ape sign (ape dung, ape feeding sign, apes seen or heard, and signs of passage) throughout the landscape (Fig. 9). All but seven (of the 30) transects within the Park had some kind of ape sign. However, the two areas identified by the lack of ape nests (south of Ouesso and the Ngombe northwest stratum) were also visibly lacking in any ape sign at all.

There does not appear to be any relationship between the pattern of ape distribution and the spatial distribution of where individual observers collected data (Figs. 6, 8).

Table 3. Great apes: data from 2014. Encounter rates of nests, density of great ape nests, and density and number of animals in the different strata, after truncation and after DISTANCE was run on the results. Also shown are percent coefficient of variation (% cv) and 95% confidence intervals (95% c.l).

2014	Encounter rate of nests (95% c.l)	%cv	Nest density/ km^2 (95% c.l)	Animal density (95% c.l)	N animals (95% c.l)
Gorillas: Ngombe NW	0.80 (0.34-1.90)	43.74	77 (34-175)	0.86 (0.36-2.04)	773 (324-1844)
Gorillas: Ngombe Road corridor	8.71 (5.73-13.23)	21.3	838 (555-1266)	9.31 (6.07-14.29)	35174 (22913-53995)
Gorillas: Ngombe Sangha E	3.94 (2.35-6.61)	26.33	379 (230-626)	4.21 (2.49-7.13)	9044 (5343-15309)
Gorillas: Ngombe south-centre	5.72 (3.99-8.20)	18.55	550 (384-789)	6.12 (4.21-8.88)	15434 (10629-22409)
Gorillas: Ngombe SW	4.87 (3.34-7.10)	19.34	469 (322-682)	5.21 (3.53-7.68)	8459 (5737-12473)
Gorillas: Ntokou-Pikounda+Pikounda N	1.77 (0.90-3.49)	35.05	170 (87-332)	1.89 (0.95-3.76)	9869 (4969-19598)
All gorillas		**12.49**	**438 (342-560)**	**4.86 (3.80-6.23)**	**78753 (61514-100820)**
Chimps: Ngombe NW	0.21 (0.07-0.62)	57.25	6.77 (2.39-19.17)	0.08 (0.02-0.23)	68 (22-205)
Chimps: Ngombe Road corridor	1.94 (1.02-3.67)	32.13	63.66 (34.50-117.46)	0.71 (0.37-1.34)	2672 (1408-5070)
Chimps: Ngombe Sangha E	0.89 (0.37-2.14)	45.22	29.19 (12.52-68.09)	0.32 (0.13-0.78)	697 (289-1678)
Chimps: Ngombe south-centre	1.98 (0.98-4.02)	35.93	65.10 (33.03-128.32)	0.72 (0.36-1.47)	1825 (897-3714)
Chimps: Ngombe SW	1.97 (0.81-4.79)	45.84	64.86 (27.68-151.96)	0.72 (0.30-1.75)	1170 (481-2847)
Chimps: Ntokou-Pikounda+Pikounda N	1.65 (0.93-2.95)	29.48	54.36 (30.88-95.69)	0.60 (0.34-1.08)	3149 (1759-5637)
All chimps		**16.44**	**53.26 (38.60-73.50)**	**0.59 (0.43-0.82)**	**9581 (6937-13234)**
All apes: Ngombe NW	0.96 (0.41-2.27)	43.35	71 (32-160)	0.79 (0.33-1.88)	715 (302-1694)
All apes: Ngombe Road corridor	10.84 (7.44-15.80)	18.85	804 (558-1159)	8.94 (6.10-13.08)	33758 (23060-49420)
All apes: Ngombe Sangha E	4.90 (3.10-7.76)	23.04	364 (234-566)	4.04 (2.54-6.42)	8678 (5461-13791)
All apes: Ngombe south-centre	7.84 (5.58-11.02)	17.09	582 (418-810)	6.46 (4.58-9.12)	16309 (11550-23028)
All apes: Ngombe SW	6.65 (4.71-9.38)	17.33	493 (352-690)	5.48 (3.86-7.77)	8898 (6274-12621)
All apes: Ntokou-Pikounda+Pikounda N	3.21 (1.99-5.20)	24.37	238 (149-382)	2.65 (1.63-4.30)	13810 (8508-22414)
All great apes		**10.27**	**457 (373-560)**	**5.07 (4.14-6.22)**	**82618 (67033-100720)**

*Nest production rate used=1; nest decay rate used= 90 days.

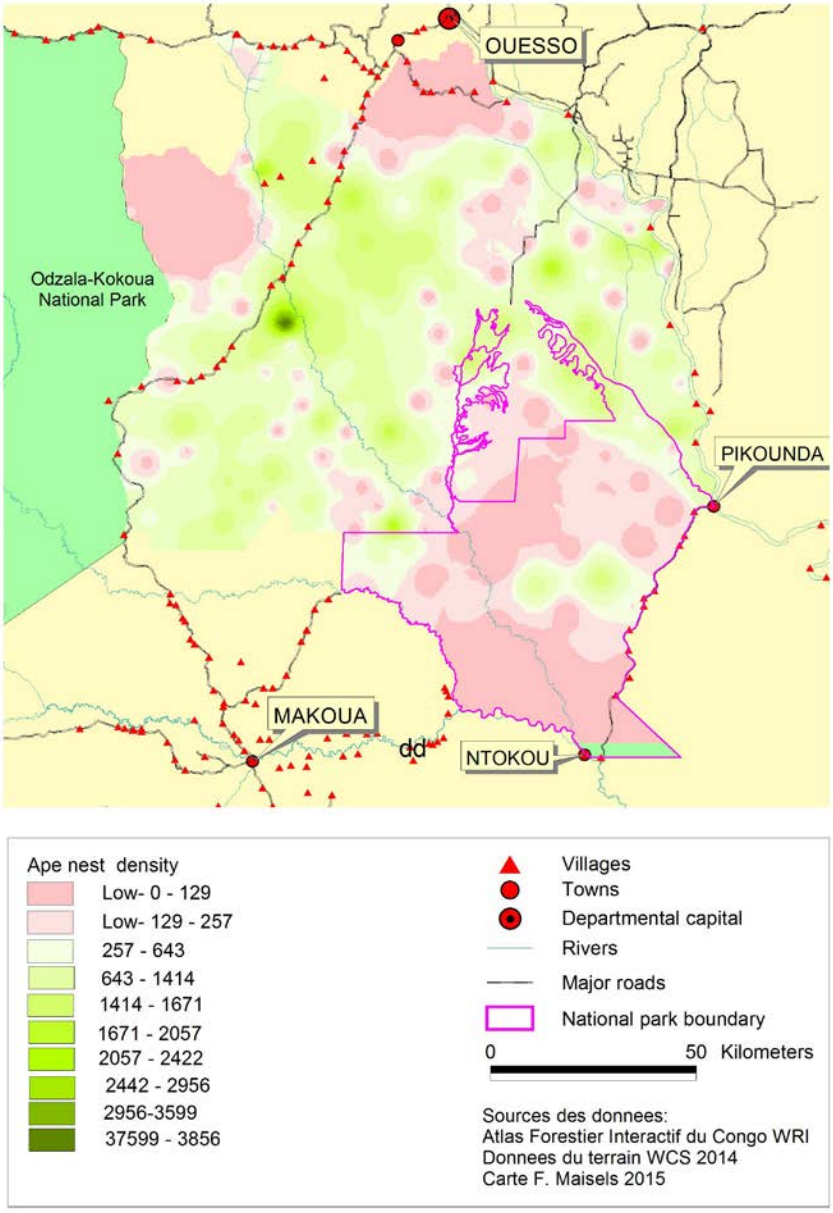

Figure 8. Great ape density and distribution 2014. Darker green colours indicate higher density; the two lowest density classes are pink.

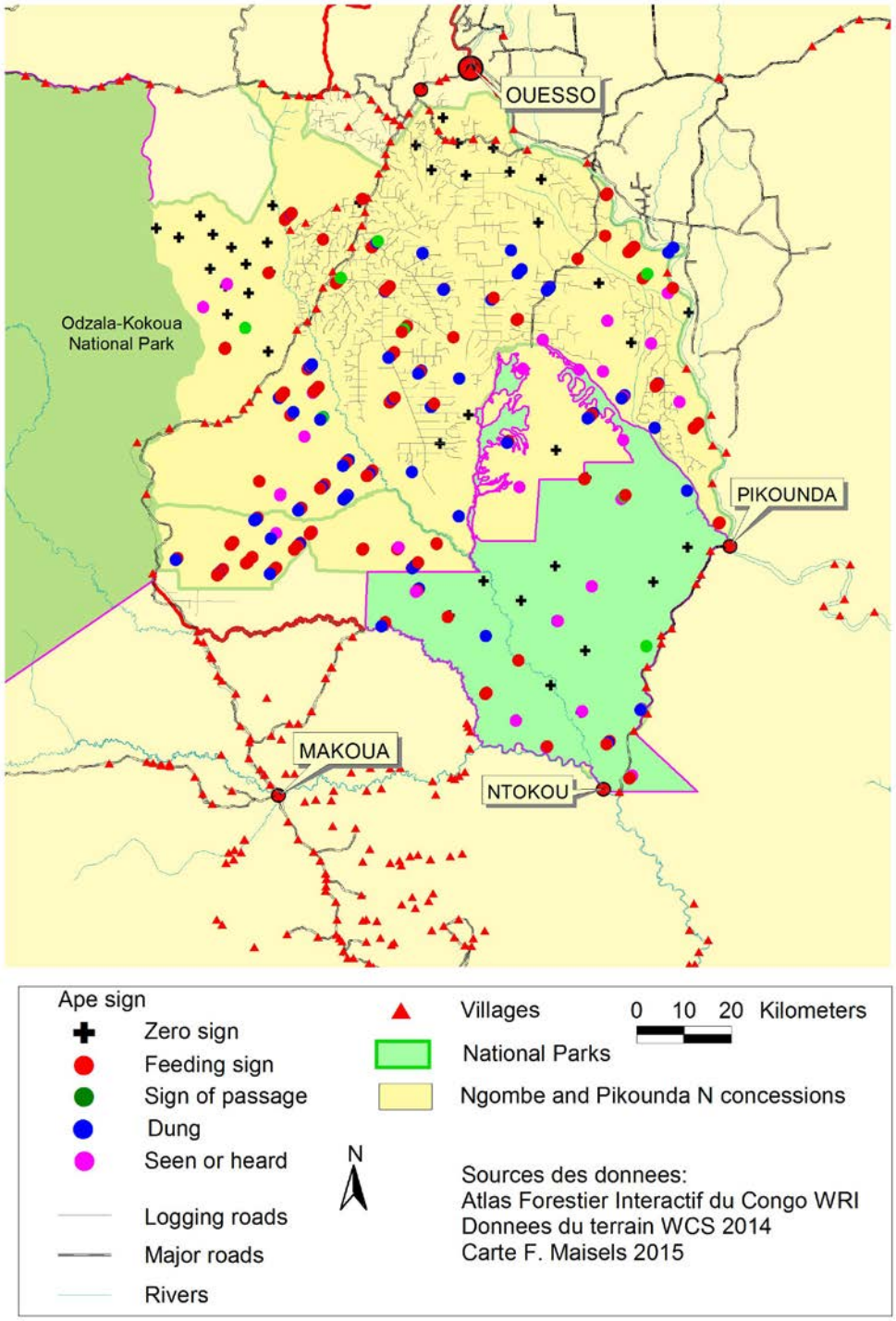

Figure 9. Great ape signs other than nests, 2014.

Elephants

A total of 1426 elephant dung were recorded in 2014 (Table 4) of which 987 were "non E" dung. All analyses were carried out after excluding the "E" dung from the dataset (Hedges & Lawson 2006; Hedges et al 2012).

Table 4. Elephants: Number of dungpiles recorded by stratum during the 2014 survey.

	Ngombe northwest	Ngombe Road corridor	Ngombe Sangha East	Ngombe south-centre	Ngombe south-west	Ntokou-Pikounda+Pikounda N
2014	129	216	25	97	362	158

Elephant density

In 2014, elephant dung density was 437/ km^2 (95% c.l. 316-605); CV 16.28%; elephant density 0.26/ km^2 (95% c.l. 0.19-0.35) and overall elephant number 4,142 (2,994-5,731) (Table 5).

Table **5. Elephants:** Encounter rates and density of elephant dung and density and number of animals* in 2014 by stratum, after truncation and after DISTANCE had been run on the results. Also shown are percent coefficient of variation (% cv) and 95% confidence intervals (95% c.l).

	Encounter rate of dung (95% c.l)	%cv	dung density/ km^2 (95% c.l)	Animal density (95% c.l)	N animals (95% c.l)
Ngombe NW	2.77 (1.94-3.94)	17.27	622 436-888)	0.36 0.25-0.52)	329 (230-469)
Ngombe Road corridor	2.62 (1.09-6.27)	44.80	588 245-1410)	0.34 0.14-0.82)	1299 (542-3116)
Ngombe Sangha E	0.28 (0.11-0.76)	51.12	64 24-170)	0.04 0.01-0.10)	80 (30-213)
Ngombe south-centre	1.38 (0.75-2.52)	30.35	310 169-567)	0.18 0.10-0.33)	457 (250-837)
Ngombe SW	3.92 (2.80-5.50)	16.87	881 627-1239)	0.52 0.37-0.72)	837 (595-1176)
Ntokou-Pikounda+Pikounda N	1.66 (1.07-2.59)	22.24	374 240-583)	0.22 0.14-0.34)	1141 (732-1777)
Whole area		**16.28**	**437 (316-605)**	**0.26 (0.19-0.35)**	**4142 (2994-5731)**

*The same parameters were used for deposition and decay rate for all years: 19 for deposition and 90 for decay rate, to maintain conformity with the report of 2007.

Elephant Distribution

Elephant distribution seems strongly to reflect aspects of current and recent timber harvesting activity (Fig. 10). Elephant density was very low in the areas currently being exploited and higher in the areas not yet harvested.

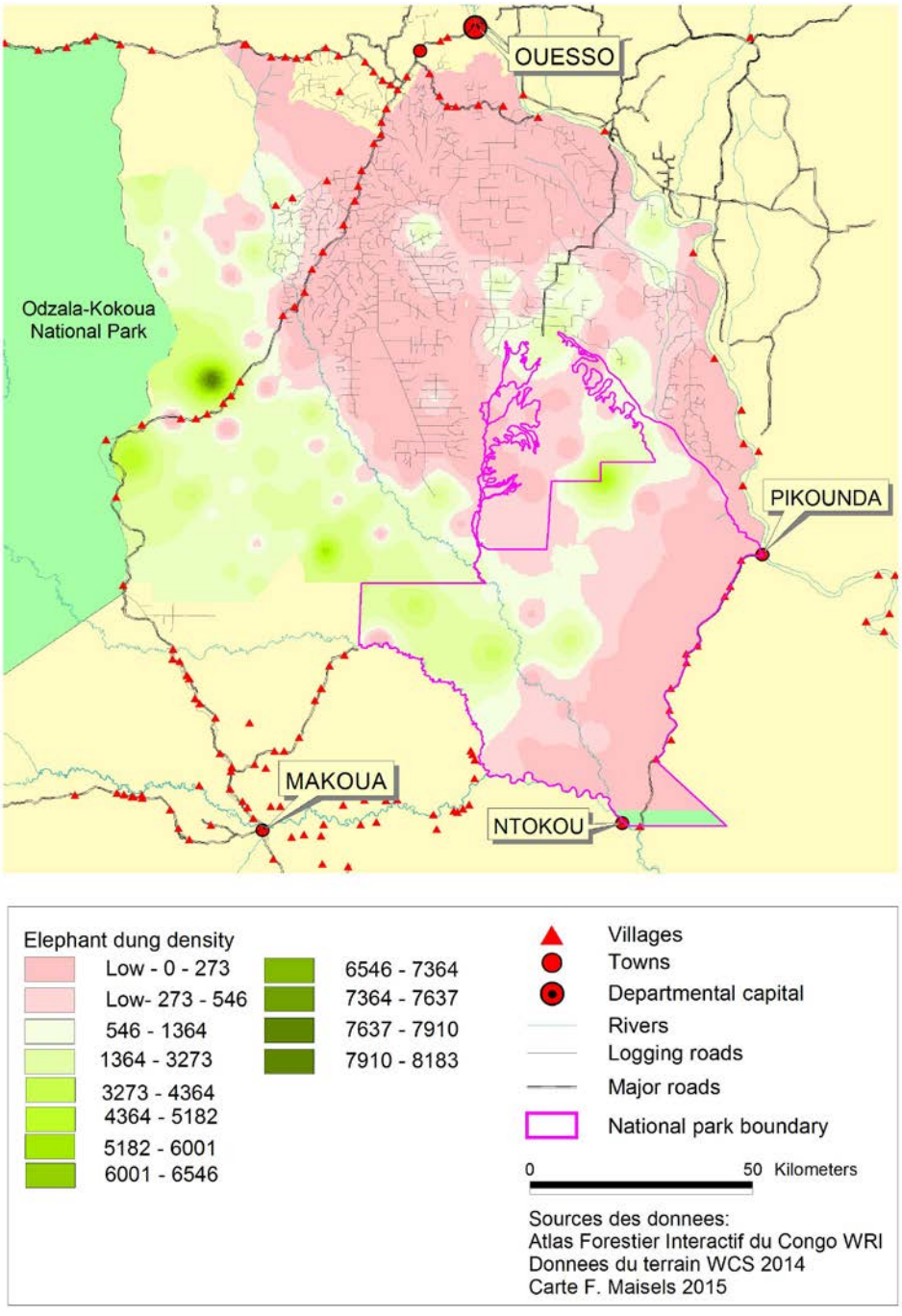

Figure 10. Elephant distribution, 2014.

Ungulates

Relative ungulate abundance

In 2014 dung density could be estimated for all three pellet dung classes (U1, U2, U3) for the pooled dataset, but estimates where individual strata held less than 60 dungpiles gave poor precision (Table 6, Table 7, Fig. 11).

Table 6. Number of ungulate dung in 2014 by stratum.

Stratum	Effort (km)	*Syncerus caffer nanus*	*Potamochoerus porcus*	U1	U2	U3
Ngombe northwest	43.7	1	0	4	22	16
Ngombe Road corridor	74.9	2	0	38	122	16
Ngombe Sangha East	77.7	0	16	47	105	44
Ngombe south-centre	63.1	0	0	56	143	49
Ngombe south-west	82.1	2	6	23	89	20
Ntokou-Pikounda+Pikounda N	85.9	1	8	40	72	32
All strata	**427.3**	**6**	**30**	**208**	**553**	**177**

Table 7. Density of ungulate dung 2014. Encounter rates and density of dung by stratum, after truncation and after DISTANCE had been run on the results. Also shown are percent coefficient of variation (% cv) and 95% confidence intervals (95% c.l).

	Encounter rate (95% c.l.)	Dung density/ km2 (95% c.l)	%cv
Small ungulate pellet dung			
Ngombe North West	0.09 (0.03-0.28)	33 (11-104)	59.27
Ngombe Road corridor	0.48 (0.29-0.78)	175 (105-292)	25.62
Ngombe Sangha E	0.51 (0.23-1.17)	188 (82-431)	42.68
Ngombe south-centre	0.86 (0.54-1.37)	312 (191-510)	24.67
Ngombe South West	0.26 (0.11-0.59)	93 (40-217)	43.36
Ntokou-Pikounda+Pikounda N	0.38 (0.21-0.72)	140 (74-267)	32.83
Whole landscape		**171 (125-234)**	**16.08**
Medium sized ungulate pellet dung			
Ngombe North West	0.46 (0.25-0.85)	127 (68-237)	30.96
Ngombe Road corridor	1.55 (0.96-2.49)	429 (265-695)	23.96
Ngombe Sangha E	1.09 (0.66-1.80)	303 (183-502)	25.23
Ngombe south-centre	2.06 (1.19-3.56)	570 (328-991)	27.63
Ngombe South West	1.00 (0.48-2.08)	277 (132-578)	37.43
Ntokou-Pikounda+Pikounda N	0.76 (0.43-1.34)	210 (118-374)	29.31
Whole landscape		**332 (255-431)**	**13.31**
Large sized ungulate pellet dung			
Ngombe North West	0.37 (0.18-0.73)	115 (57-231)	34.99
Ngombe Road corridor	0.20 (0.11-0.36)	63 (35-113)	29.70
Ngombe Sangha E	0.49 (0.18-1.32)	153 (56-416)	52.22
Ngombe south-centre	0.71 (0.46-1.09)	223 (142-350)	22.60
Ngombe South West	0.24 (0.14-0.43)	76 (42-137)	29.65
Ntokou-Pikounda+Pikounda N	0.29 (0.17-0.49)	91 (54-155)	26.89
Whole landscape		**113 (83-155)**	**16.00**
All ungulate pellet dung			
Ngombe North West	0.92 (0.58-1.45)	271 (171-429)	22.53
Ngombe Road corridor	2.26 (1.52-3.36)	667 (446-999)	19.96
Ngombe Sangha E	2.10 (1.13-3.90)	620 (332-1158)	31.39
Ngombe south-centre	3.61 (2.31-5.66)	1068 (678-1682)	22.60
Ngombe South West	1.49 (0.79-2.78)	439 (234-824)	31.66
Ntokou-Pikounda+Pikounda N	1.43 (0.88-2.34)	424 (258-694)	24.90
Whole landscape		**600 (478-753)**	**11.54**

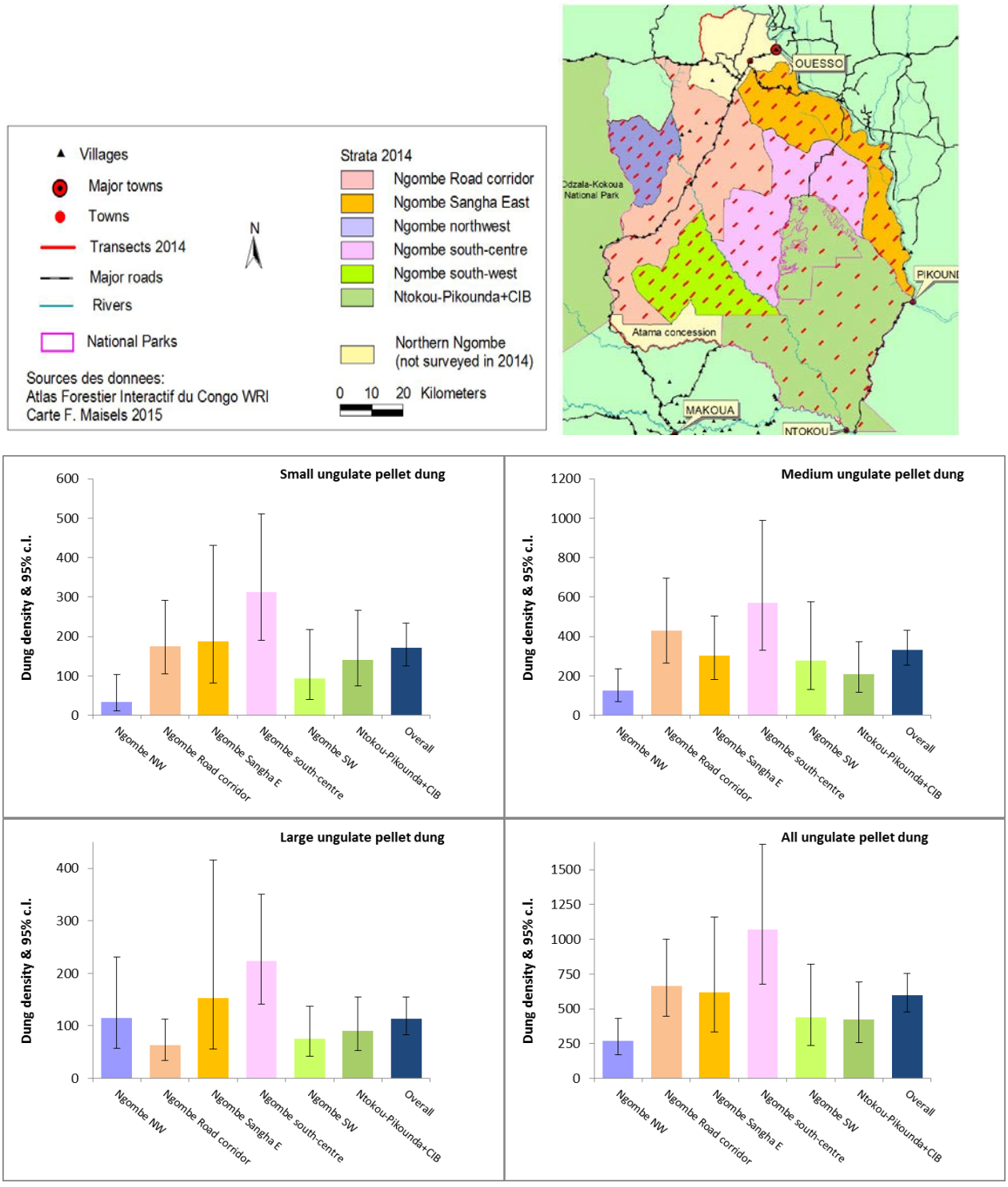

Figure 11. Density of ungulate pellet dung in 2014 in the different strata; colours correspond to those on the map.

Ungulate distribution

Ungulate dung was most abundant in the centre of the large Ngombe concession, north of the northern limit of the Ntokou-Pikounda National Park, and including the area between the Park and the Sangha River. South of Ouesso and the Ouesso-Sembe/Sounake road had low dung density, as did the areas north of the Atama concession and most of the Ntokou-Pikounda National Park (Fig. 12).

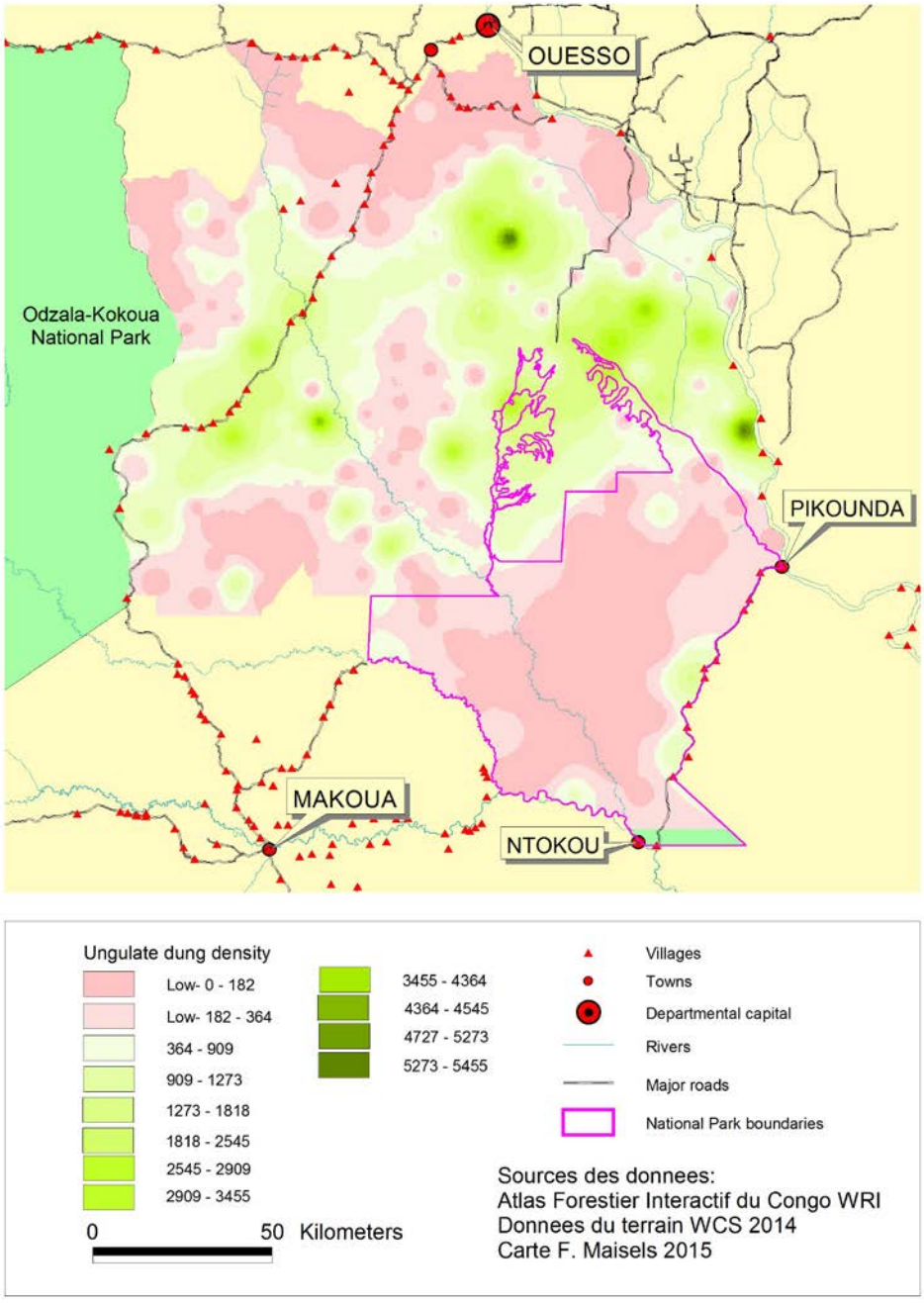

Figure 12. Distribution of ungulate pellet dung in 2014

Human activity

General signs of hunting and other activities seen on transects

Here we present only signs seen on the transects themselves, as this provides comparable effort in each sector. The different types of human sign (Fig 13) included specific hunting sign (gunshots, snares, hunting camps, shotgun shells) and more general sign (machete cuts, signs of passage and paths), and non-timber forest product extraction signs such as palm wine and honey. It is clear that incursions are very active in the south of the Ntokou-Pikounda National park area, including one camp. Most of the hunting signs are in the logging concession, however, especially nearer the roads and the Sangha River, and in 2014 there are many signs in the area that was unexploited in 2007, as expected (Fig. 14). Hunting signs are aligned along the national public road, but also in much of the northern part of the Ngombe concession, along the Sangha River, and in the south-west of the Ngombe concession between the road and the Atama palm oil concession.

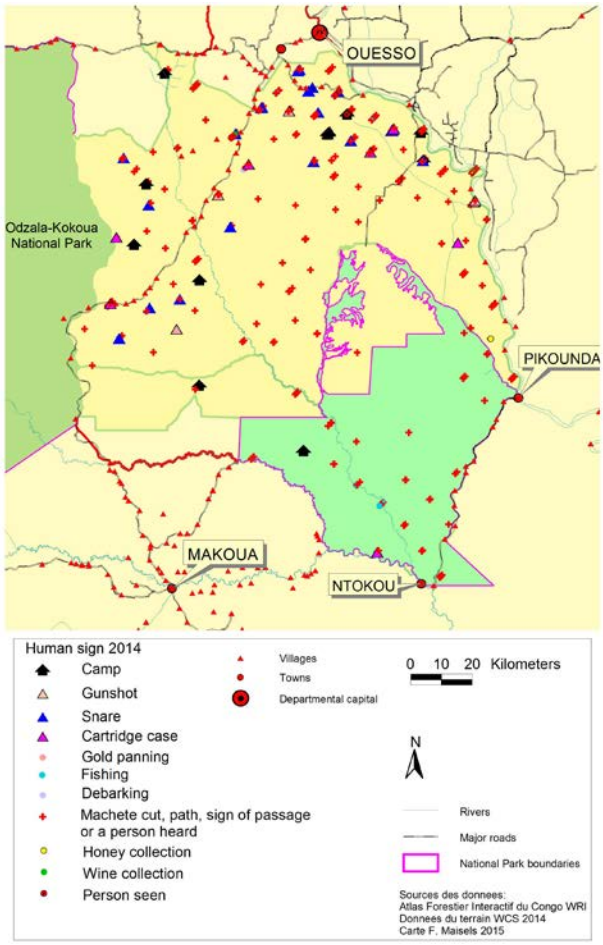

Figure 13. All human sign seen on transects in 2014. Triangles are hunting signs. Camps are hunting camps.

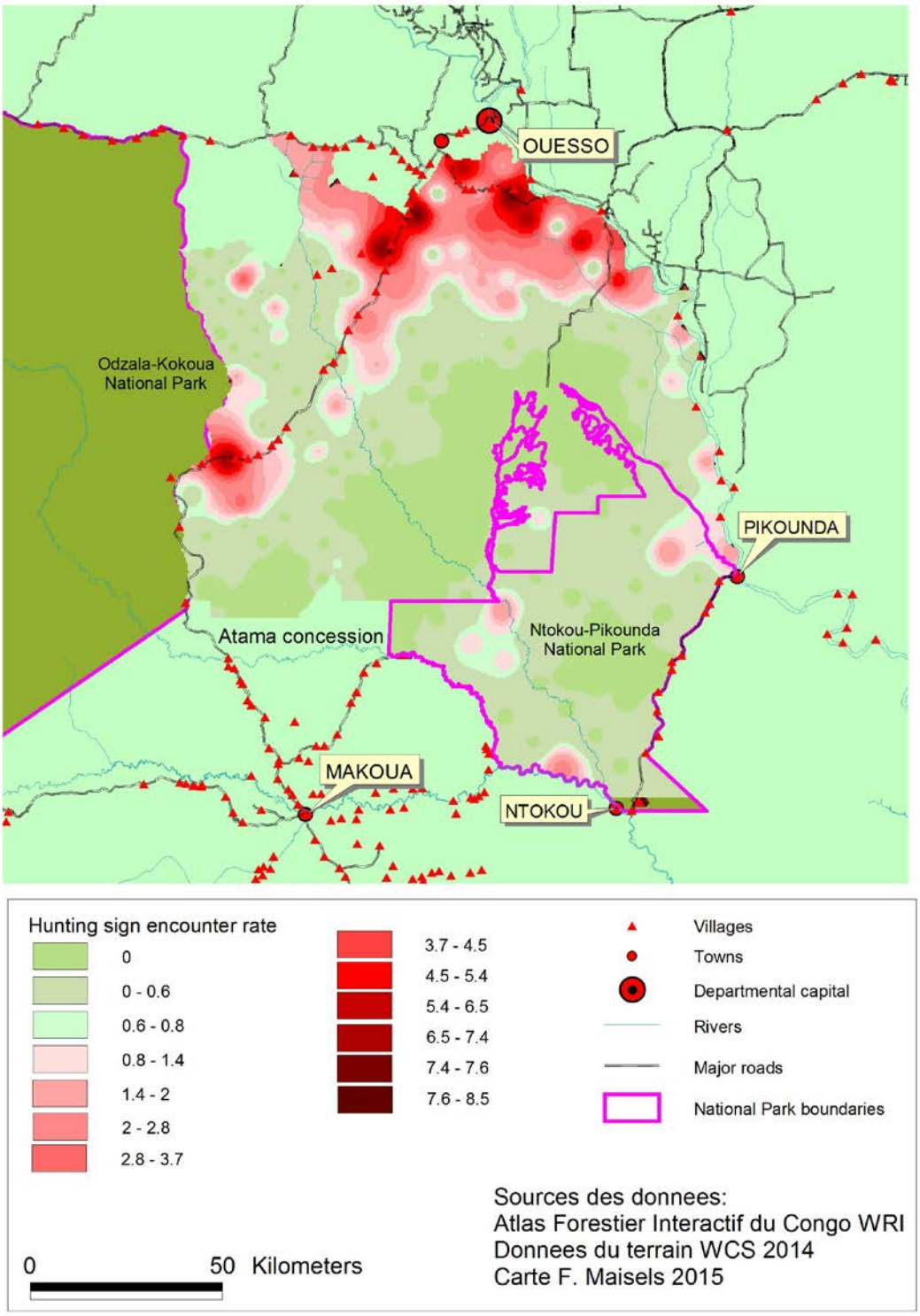

Figure 14. Interpolation map of the encounter rate of hunter sign on transects, 2014.

Elephant carcasses

We collated data from all three survey types- transects, guided recces and recce-voyages. Nine elephant carcasses were discovered by the teams (of a total of 11 of various species). Three elephant carcasses were on the transects, five on the recce-voyages, and one on a guided recce (Fig. 15). Three elephants were definitely killed by poachers (this appears in the "notes" section of the datasheet: Table 8) and likely most of the rest as well. Because of the very low numbers of carcasses typically found on surveys, quantitative comparison of encounter rates can be highly misleading, but the spatial pattern of elephant carcasses found on this survey is informative- two in the National Park and most of the rest in the southwest parts of the concession. In 2007 one elephant carcass was found in the south of what is now the National park, just to the west of the Lengoue river, on a transect.

Table 8. All elephant carcasses discovered in the survey. Definite signs of poaching indicated in yellow; the rest are likely also poached.

Stratum	Method	Observateur 1	Lat	Long	Date	Age	Species	Notes
Ntokou-Pikounda+CIB	Transect	Bola Madzoke	0.6877	16.1725	27 March 2014	V	Elephant	
Ntokou-Pikounda+CIB	Transect	Bola Madzoke	0.6293	16.2418	29 March 2014	V	Chimpanzee	
Ntokou-Pikounda+CIB	Transect	NDZAI Christian	0.5839	16.3237	31 March 2014	V	Elephant	Poached
Ntokou-Pikounda+CIB	RV	KIMINOU Franck	0.4362	15.922976	03 April 2014	V	Elephant	Poached
Ngombe south-west	RV	Bola Madzoke	0.7773	15.751258	27 April 2014	TV	Elephant	
Ngombe south-west	RV	MANGONGA Paul Patrick	0.5977	15.638922	02 May 2014		Elephant	
Ngombe south-west	Transect	Bola Madzoke	0.6589	15.6262	04 May 2014	V	Elephant	Poached
UFA Ngombe	RV	Bola Madzoke	0.6907	15.8972	30 May 2014	TV	Elephant	Mandible
Ngombe northwest	RV	KIMINOU Franck	1.0206	15.536277	18 September 2014	TV	Elephant	
UFA Ngombe	RG	Bola Madzoke	1.2743	15.5808	01 October 2014	TV	Elephant	
Ngombe northwest	Transect	Bola Madzoke	1.3125	15.6194	03 October 2014	V	Bay duiker	

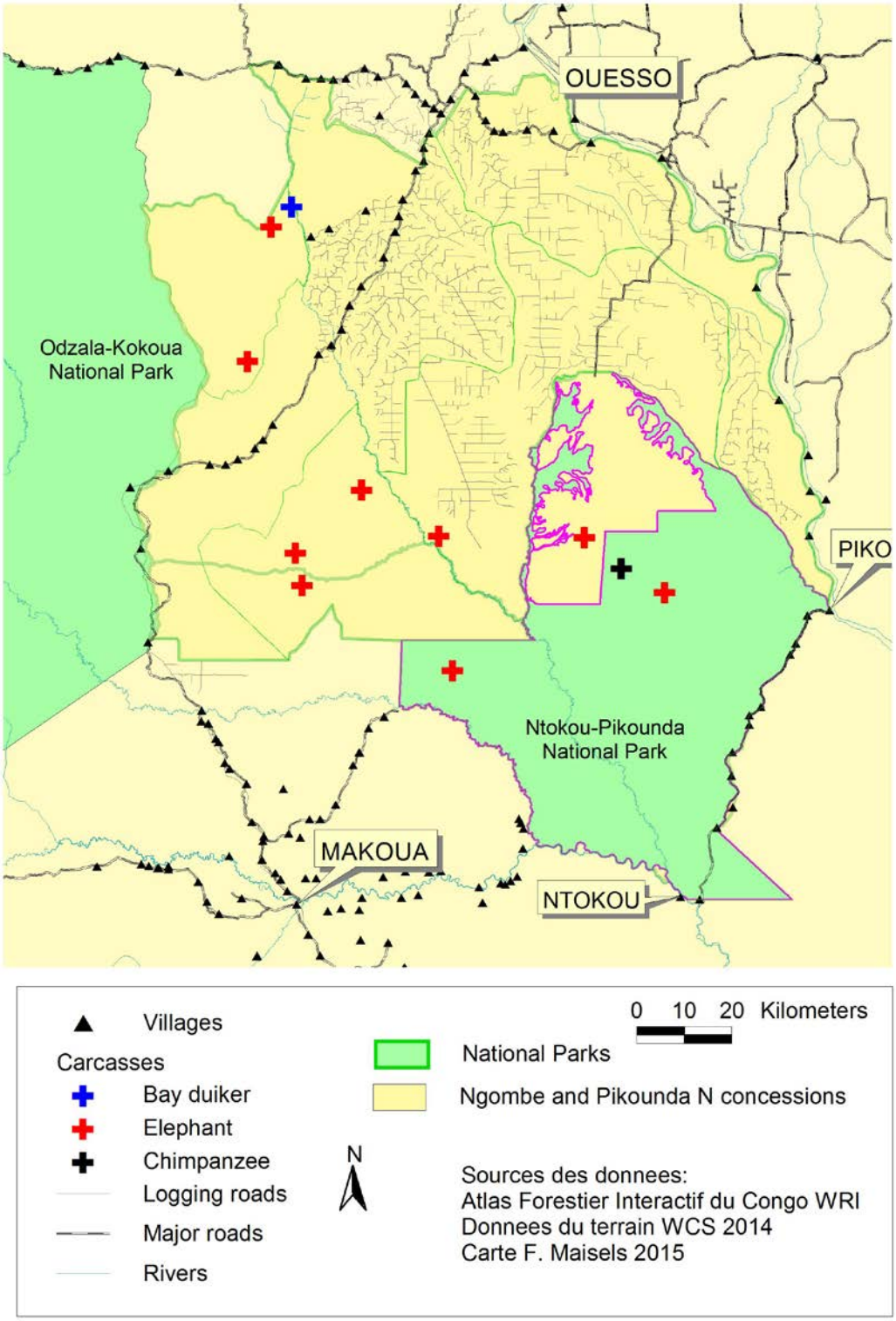

Figure 15. Carcasses (all species) discovered by the survey teams, 2014

Comparison of 2007 and 2014

Great apes

In 2014, the majority (89%) of all nests were in the Ngombe logging concession and just 11% in the National Park plus the small Pikounda N concession area). The nests on the 2007 transects that fell within the same area surveyed in 2014 were subjected to a logistic regression analysis to separate out nests made by gorillas from nests made by chimps (Table 9). In 2007, as in 2014, there were more gorilla nests than chimp nests (68%); the Park plus Pikounda N held 38% of the total ape nests.

Table 9. Number of great ape nests recorded during the 2007 surveys (N=995) within the same area as 2014, after logistic regression was used to separate them by species. Strata are the Ngombe 2014 concession areas and the Ntokou-Pikounda NP+CIB.

	Whole Ngombe concession	Ntokou-Pikounda+Pikounda N
Gorilla nests: 2007	414	267
Chimp nests: 2007	199	115
Great ape nests: 2007	613	382

In 2007, using the same area that was surveyed in 2014, ape densities were 5.79 great apes/ km^2 (95% c.l. 4.05-8.27; CV 18.2%) (Table 10), corresponding to 93,697 (95% c.l. 65,549-133,930) individuals of which 81,793 (95% c.l. 54,399-122,980); CV 20.72%) were gorillas.

The reanalysis of the 2007 data, using the Ngombe concession and the Park plus Pikounda N (Table 10, Figs 15, 16), showed that the Ngombe concession had a density of 6.54 (95% c.l. 5.23-8.18) apes and 6.12 (95% c.l. 4.72-7.94) gorillas in 2014; which translates to 71,793 (95% c.l. 57,414-89,774) individual apes and 67,196 (95% c.l. 51,810-87,152) gorillas. Chimpanzee density within the Ngombe concession in 2014 was 0.67 (95% c.l. 0.43-1.02) which translates to 7,312 (95% c.l. 4,767-11,215) individuals. The Park plus Pikounda N held 9,869 (95% c.l. 4,969-19,598) gorillas and 3,149 (95% c.l. 1,759-5,637) chimpanzees, or a total of 13,810 (95% c.l. 8,508-22,414) great apes in 2007.

Table 10. Great apes: All nests from 2007 and 2014 where transects were assigned to the 2014 Ngombe concession area or the National Park plus Pikounda N. Density of nests and density and number of animals* by stratum, after truncation and after DISTANCE had been run on the results. Also shown are percent coefficient of variation (% cv) and 95% confidence intervals (95% c.I).

Stratum	Species, year	%cv	nest density/ km2 (95% c.I)	Animal density (95% c.I)	N animals (95% c.I)	Difference 2007-2014? (Z statistic, P-value)
Ngombe	Gorillas 2007	25.42	449 (275-733)	4.99 (3.02-8.25)	54,751 (33,119-90,515)	
Ngombe	Gorillas 2014	13.08	551 (425-715)	6.12 (4.72-7.94)	67,196 (51,810-87,152)	z=-0.7556; P=0.2236
Ngombe	Chimps 2007	27.57	54 (31-93)	0.60 (0.35-1.04)	6,590 (3,818-11,374)	
Ngombe	Chimps 2014	21.90	60 (39-92)	0.67 (0.43-1.02)	7,312 (4,767-11,215)	z=-0.3022; P=0.3821
Ngombe	All apes 2007	21.28	506 (332-772)	5.62 (3.69-8.57)	61,746 (40,517-94,097)	
Ngombe	All apes 2014	11.22	589 (471-736)	6.54 (5.23-8.18)	71,793 (57,414-89,774)	z=-0.6570; P=0.2546
NPNP+Pik N	Gorillas 2007	32.44	467 (251-867)	5.19 (2.71-9.94)	27,042 (14,109-51,828)	
NPNP+Pik N	Gorillas 2014	35.05	170 (87-332)	1.89 (0.95-3.76)	9,869 (4,969-19,598)	**z=1.8244; P=0.0344**
NPNP+Pik N	Chimps 2007	26.57	57 (33-97)	0.63 (0.37-1.08)	3,283 (1,916-5,626)	
NPNP+Pik N	Chimps 2014	29.48	54 (31-96)	0.60 (0.34-1.08)	3,149 (1,759-5,637)	z=0.1365; P=0.4443
NPNP+Pik N	All apes 2007	23.43	562 (351-900)	6.25 (3.91-10.0)	32,583 (20,366-52,128)	
NPNP+Pik N	All apes 2014	24.37	238 (149-382)	2.65 (1.63-4.30)	13,810 (8,508-22,414)	**z=2.2518; P=0.0122**
Whole landscape	**All gorillas 2007**	**20.72**	**455 (302-683)**	**5.05 (3.36-7.60)**	**81,793 (54,399-122,980)**	
Whole landscape	**All gorillas 2014**	**12.49**	**438 (342-560)**	**4.86 (3.80-6.23)**	**78,753 (61,514-100,820)**	z=1560; P=0.4404
Whole landscape	**All chimps 2007**	**20.65**	**55 (36-83)**	**0.61 (0.40-0.92)**	**9.873 (6,563-14,852)**	
Whole landscape	**All chimps 2014**	**16.44**	**53 (39-73)**	**0.59 (0.43-0.82)**	**9,581 (6,937-13,234)**	z=1397; P=0.4443
Whole landscape	**All apes 2007**	**18.2**	**524 (375-734)**	**5.79 (4.05-8.27)**	**93,697 (65,549-133,930)**	
Whole landscape	**All apes 2014**	**10.27**	**457 (373-560)**	**5.07 (4.14-6.22)**	**82,618 (67,033-100,720)**	z=0.6303; P=0.2643

The total number of apes in the area as a whole is still extremely high in 2014, as it was in 2007. There was no significant difference in nest density for the landscape or a whole or for the Ngombe concession (Table 10). However, within Ntokou-Pikounda plus Pikounda N, there had been a significant decline in nest density from 2007 (P= 0.012) (Fig. 18) which was essentially due to a lower gorilla nest density in the area (P= 0.034). Precision was low in this stratum in both years (32% and 35%, respectively for gorillas) but it appeared that gorilla nest density had dropped from 467 nests/ km2 to 170 (Table 10; Fig. 17). Twelve of the transects in the park had zero nests on them (28% of the transects) compared to just one transect in 2007 (5% of the transects).

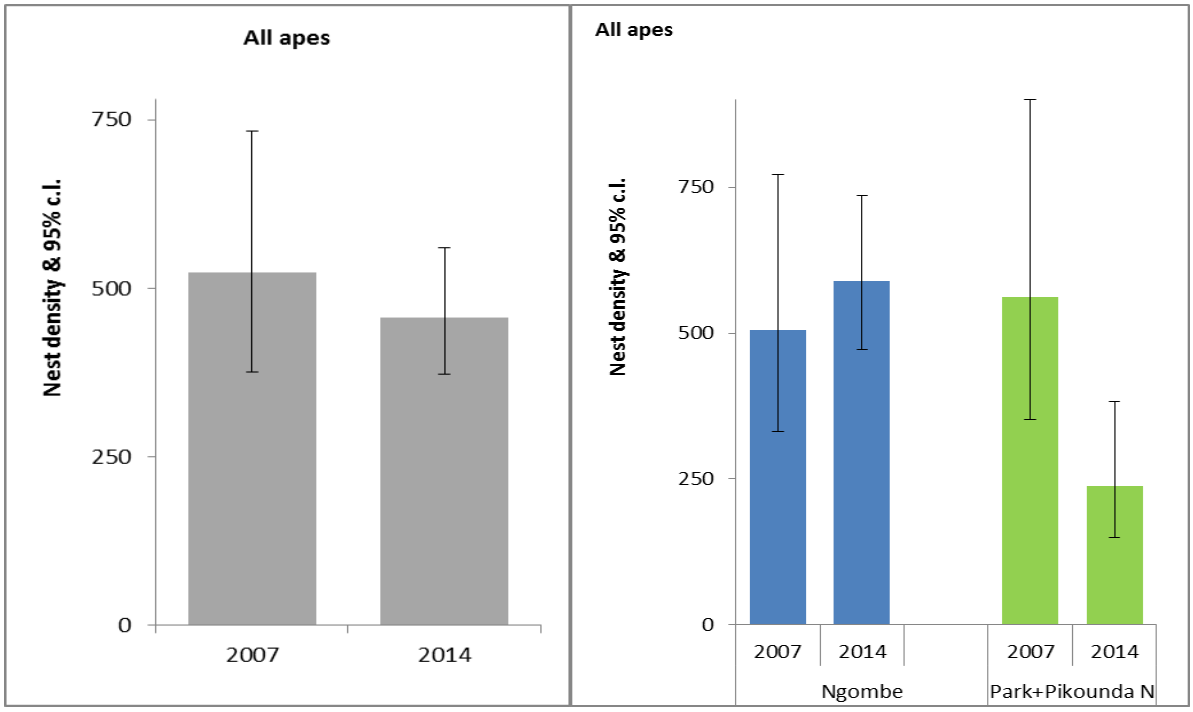

Figure 16. Density of great ape nests 2007-2014. Same surface area used in 2007 and 2014.

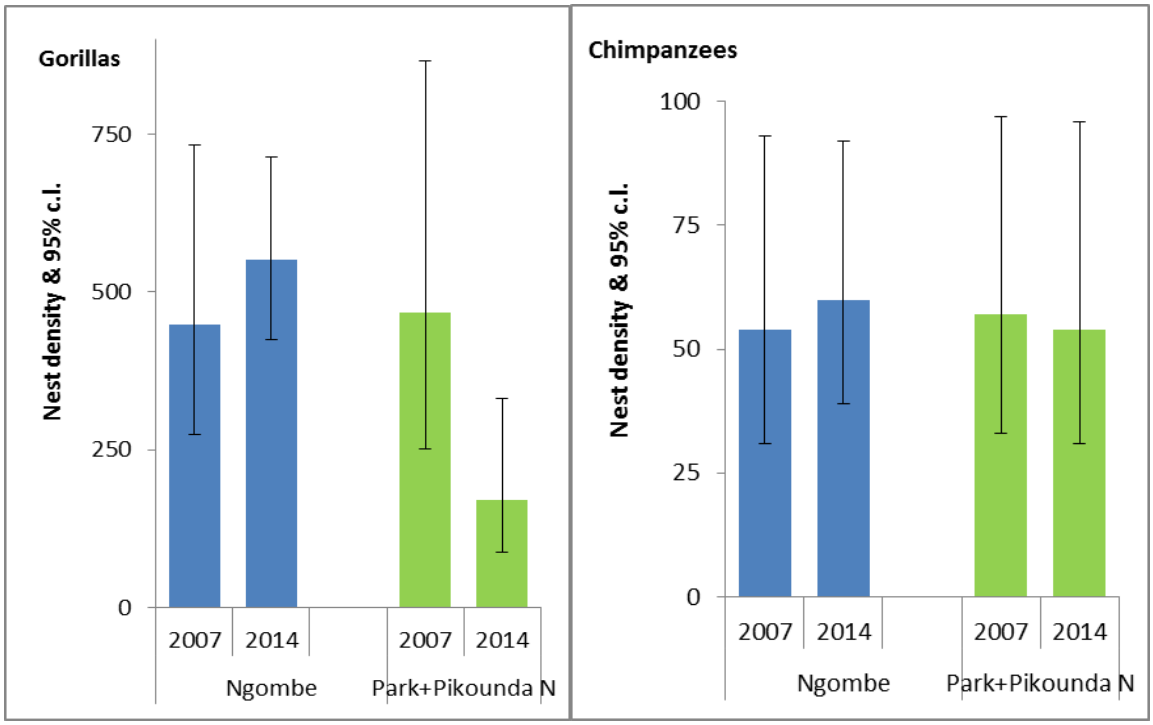

Figure 17. Density of gorilla and chimpanzee nests 2007-2014. Same surface area used in 2007 and 2014.

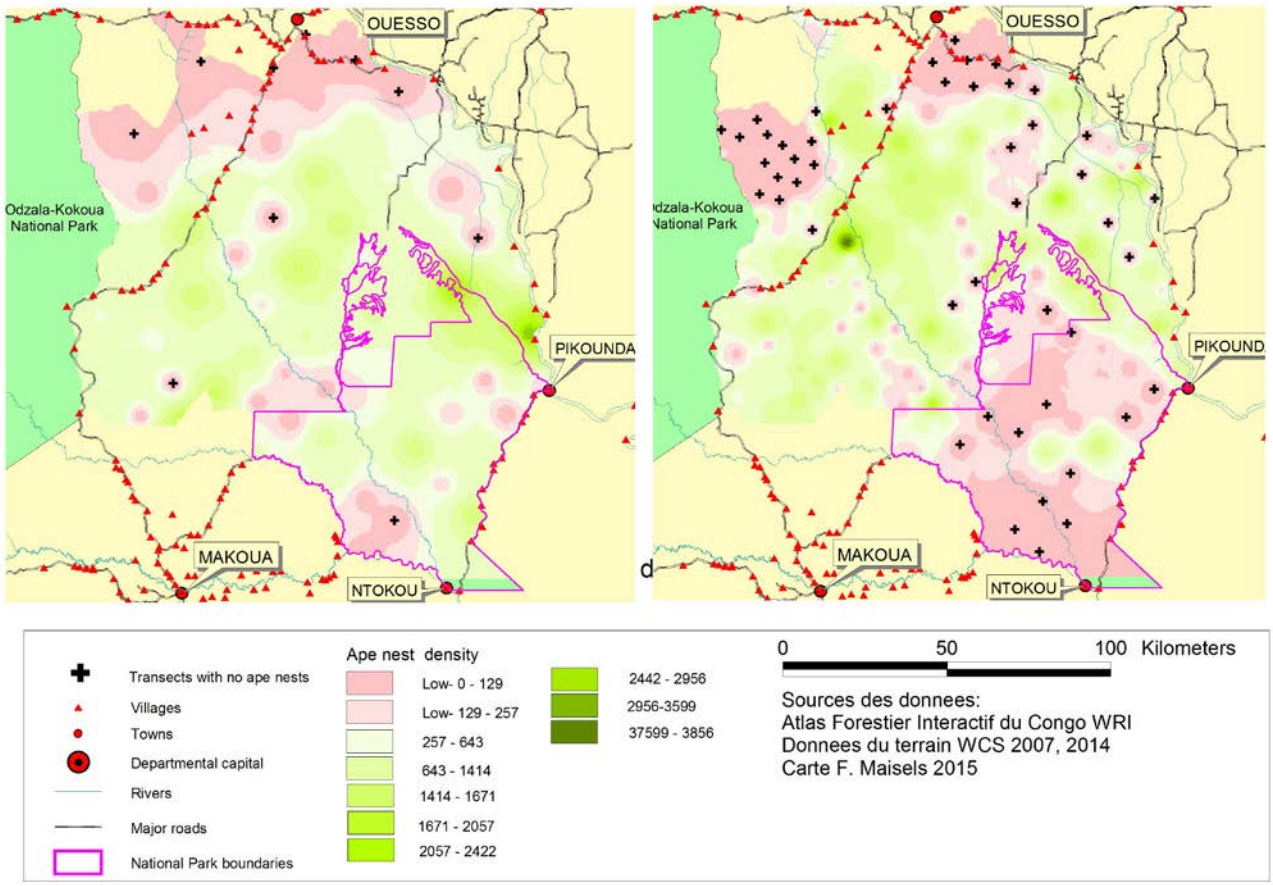

Figure 18. Great ape density and distribution 2007-2014. Darker green colours indicate higher density; the two the two lowest density classes are pink. Transects with zero nests are indicated as black crosses.

Elephants

In 2007, in the same area as that surveyed in 2014, there were 770 dungpiles total, with 455 classified as "non E" (Table 11).

Table 11. Elephants: Number of dungpiles recorded by stratum during the 2007 and 2014 surveys when dung is assigned to the Ngombe 2014 concession area and the Ntokou-Pikounda NP+ Pikounda N.

	Ngombe concession	Ntokou-Pikounda+Pikounda N
2007	287	168
2014	829	158

The elephant dung on transects were assigned, as for the great ape nests, to either the Ngombe concession (2014 limits) or to the Ntokou-Pikounda National Park plus the Pikounda North area, for a comparison within the same areas 2007-2014.

Taking the two areas separately, dung density in the concession was 460/ km^2 (95% c.l. 304-698); CV 20.750%; elephant density 0.27/ km^2 (95% c.l. 0.18-0.41) and corresponding elephant number 2956 (1951-4479) (Table

12). In the National Park- Pikounda North area, dung density in the concession was 374/ km^2 (95% c.l. 240-583); CV 22.24%; elephant density was 0.22/ km^2 (95% c.l. 0.14-0.34) and overall elephant number was 1141 (95% c.l. 732-1777). The overall results for 2007 were: dung density 527/ km^2 (95% c.l. 337-824; CV 22.71); elephant density was 0.31/ km^2 (95% c.l. 0.20-0.48; which corresponded to 4,992 individuals (95% c.l. 3,192-7,806).

Over the seven years between the two surveys, there was a trend for dung density to fall in the area as a whole (Fig. 19) but this was not significant at the 5% level.

Elephant density has been consistently highest between the Lengoue River and the western limit of the Odzala–Kokoua national park (Fig. 20) on both survey cycles. In 2007 it was already clear that elephants were avoiding the Sangha River, the Pikounda road and villages between Pikounda and Ntokou villages, and the area nearest Ouesso. This pattern has become more exaggerated in 2014, with only small pockets of higher elephant density between the Lengoue and the Sangha.

Table 12. Elephants: All dung from 2007 and 2014 using the 2014 Ngombe concession area and the Park plus the Pikounda North area. Density of elephant dung and density and number of animals* by stratum, after truncation and after DISTANCE had been run on the results. Also shown are percent coefficient of variation (% cv) and 95% confidence intervals (95% c.l).

	%cv	dung density/ km^2 (95% c.l)	Animal density (95% c.l)	N animals (95% c.l)	Difference 2007-2014? (Z statistic, P-value)
Ngombe 2007	28.37	514 (293-900)	0.30 (0.17-0.53)	3299 (1883-5780)	
Ngombe 2014	20.75	460 (304-698)	0.27 (0.18-0.41)	2956 (1951-4479)	Z=0.7245; p=0.2358
Park + Pikounda N 2007	36.19	555 (269-1144)	0.32 (0.16-0.67)	1692 (821-3490)	
Park Pikounda N 2014	22.24	374 (240-583)	0.22 (0.14-0.34)	1141 (732-1777)	Z=0.8326; p=0.2033
Whole area 2007	**22.71**	**527 (337-824)**	**0.31 (0.20-0.48)**	**4992 (3192-7806)**	
Whole area 2014	**16.28**	**437 (316-605)**	**0.26 (0.19-0.35)**	**4142 (2994-5731)**	**Z=0.646; p=0.2266**

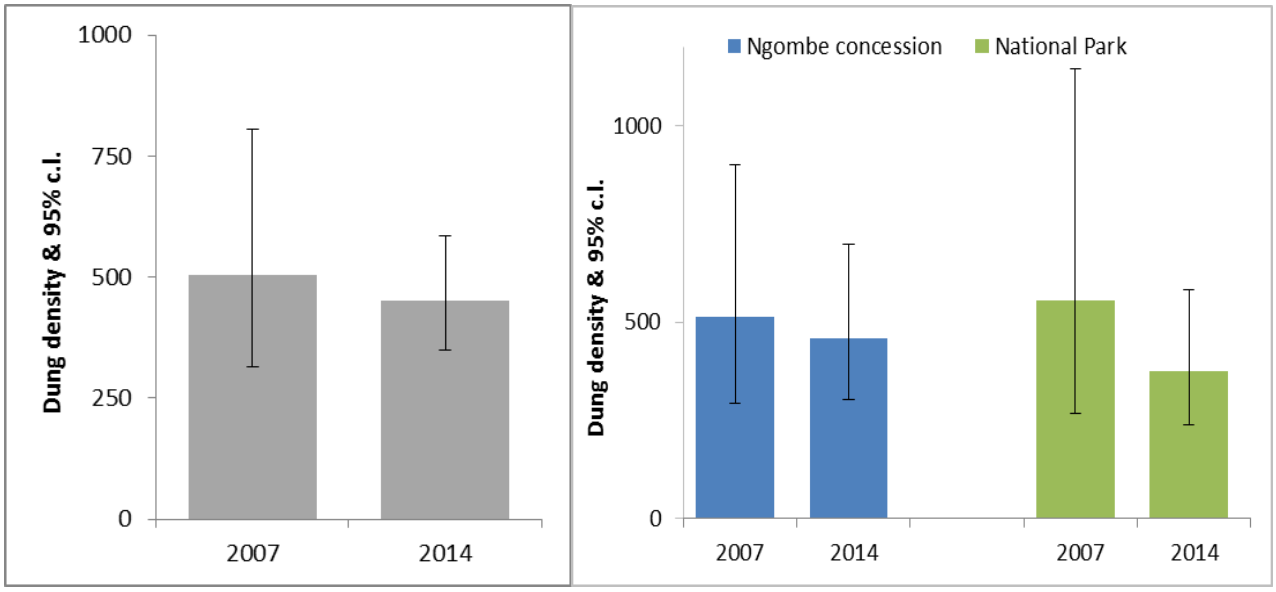

Figure 19. Elephant dung density in the whole area (left), and in Ngombe and the National Park in 2007 and 2014 (right).

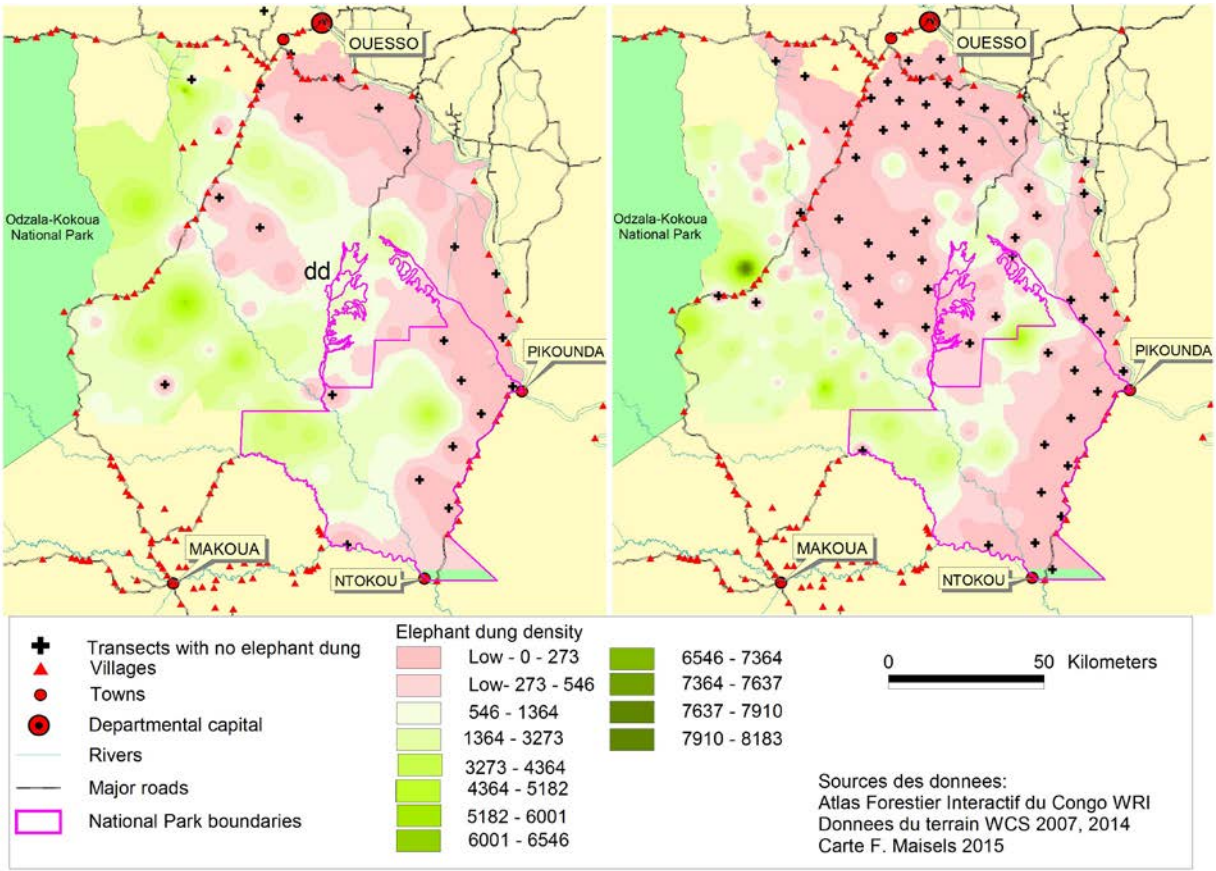

Figure 20. Elephant distribution, 2007-2014. Scale is the same for both maps. Black crosses indicate transects where no elephant dung were recorded.

Ungulates

Enough dung was recorded in the whole area in 2007 (Table 13) for a dung density estimation of the small, medium and large sized ungulates producing pellets (essentially mostly duikers, although a very few water chevrotain and sitatunga dung are also in this group) although the number of dung for the U3 class was at the lower limit for density estimation.

When the survey results from 2007 in the present Ngombe concession area and the Ntokou-Pikounda National park + Pikounda N areas were compared to 2014, there had been a significant increase in the NPNP + Pikounda N in dung density of the smallest sized ungulates ("U1"), which would have been mostly blue duiker *Philantomba monticola*. Otherwise there were no significant differences between years for either the medium or large sized dung or for all dung taken as a whole (Table 14; Fig. 21).

The pattern of change in abundance of ungulate pellet dung, which is almost all produced by the various forest duikers, is most striking near the town of Ouesso in the north, and the roads running south of it (Fig. 22). Dung was most abundant in the centre of the large Ngombe concession in both surveys, and, unlike elephants, there was not a progressive decline west of the whole length of the Sangha River.

Table 13. Numbers of ungulate dung in 2007 and 2014 by stratum.

Year	Stratum	Effort (km)	*Tragelaphus eurycerus*	*Syncerus caffer nanus*	*Potamochoerus porcus*	U1	U2	U3
2007	Ngombe	76	5	7	0	82	158	28
2007	Ntokou	33.8	2	5	7	4	26	17
2007	Pikounda	35.5	0	0	7	9	32	3
2007	**All strata**	**145.7**	**7**	**12**	**14**	**95**	**216**	**48**
2014	Ngombe northwest	43.7	0	1	0	4	22	16
2014	Ngombe Road corridor	74.9	0	2	0	38	122	16
2014	Ngombe Sangha East	77.7	0	0	16	47	105	44
2014	Ngombe south-centre	63.1	0	0	0	56	143	49
2014	Ngombe south-west	82.1	0	2	6	23	89	20
2014	Ntokou-Pikounda+Pikounda N	85.9	0	1	8	40	72	32
2014	**All strata**	**427.3**	**0**	**6**	**30**	**208**	**553**	**177**

Table 14. Ungulates: All dung from 2007 and 2014 using the 2014 Ngombe concession area. Density of dung by stratum, after truncation and after DISTANCE had been run on the results. Also shown are percent coefficient of variation (% cv) and 95% confidence intervals (95% c.l).

Stratum	Species, year	dung density/ km^2 (95% c.l)	%cv	Difference 2007-2014? (Z statistic, P-value)
Ngombe	Small ungulate pellet dung 2007	239 (102-561)	40.0	
Ngombe	Small ungulate pellet dung 2014	177 (129-241)	16.1	Z=0.621; p=0.27
Ngombe	Medium ungulate pellet dung 2007	410 (244-688)	23.9	
Ngombe	Medium ungulate pellet dung 2014	331 (255-431)	13.3	Z=0.735; p=0.23
Ngombe	Large ungulate pellet dung 2007	174 (69-442)	52.8	
Ngombe	Large ungulate pellet dung 2014	113 (83-154)	15.9	Z=0.652; p=0.26
Ngombe	**All ungulate pellet dung 2007**	**747 (441-1263)**	**23.4**	
Ngombe	**All ungulate pellet dung 2014**	**684 (531-881)**	**12.8**	Z=-0.322; p=0.37
NPNP+Pik N	Small ungulate pellet dung 2007	62 (30-139)	36.9	
NPNP+Pik N	Small ungulate pellet dung 2014	140 (74-267)	32.83	**Z=-1.682; p=0.0465**
NPNP+Pik N	Medium ungulate pellet dung 2007	183 (75-445)	45.3	
NPNP+Pik N	Medium ungulate pellet dung 2014	210 (118-374)	29.31	Z=-0.258; p=0.397
NPNP+Pik N	Large ungulate pellet dung 2007	36 (8-161)	85	
NPNP+Pik N	Large ungulate pellet dung 2014	91 (54-155)	26.89	Z=--1.404; p=0.081
NPNP+Pik N	**All ungulate pellet dung 2007**	**267 (127-562)**	**24.9**	
NPNP+Pik N	**All ungulate pellet dung 2014**	**424 (258-694)**	**24.90**	Z=-1.080; p=0.140

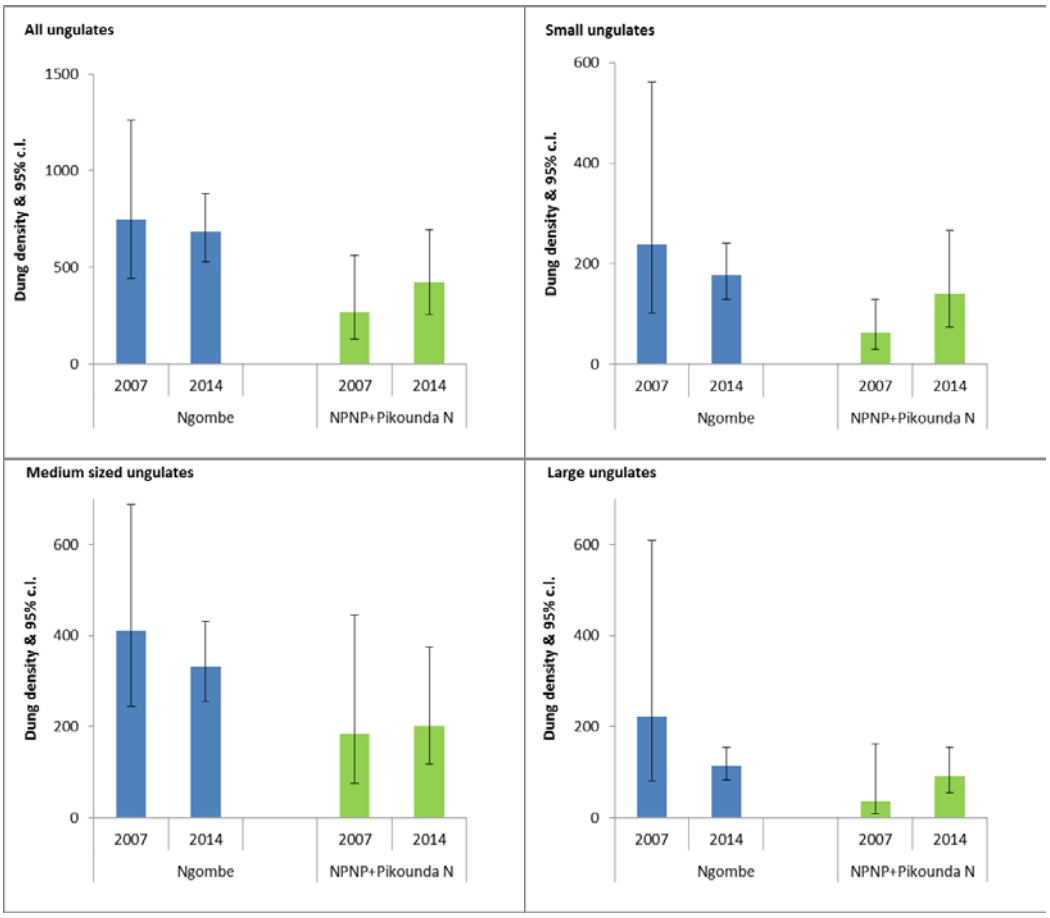

Figure 21. Density of all ungulate dung in the Ngombe concession and Ntokou-Pikounda NP + Pikounda N, 2007 and 2014.

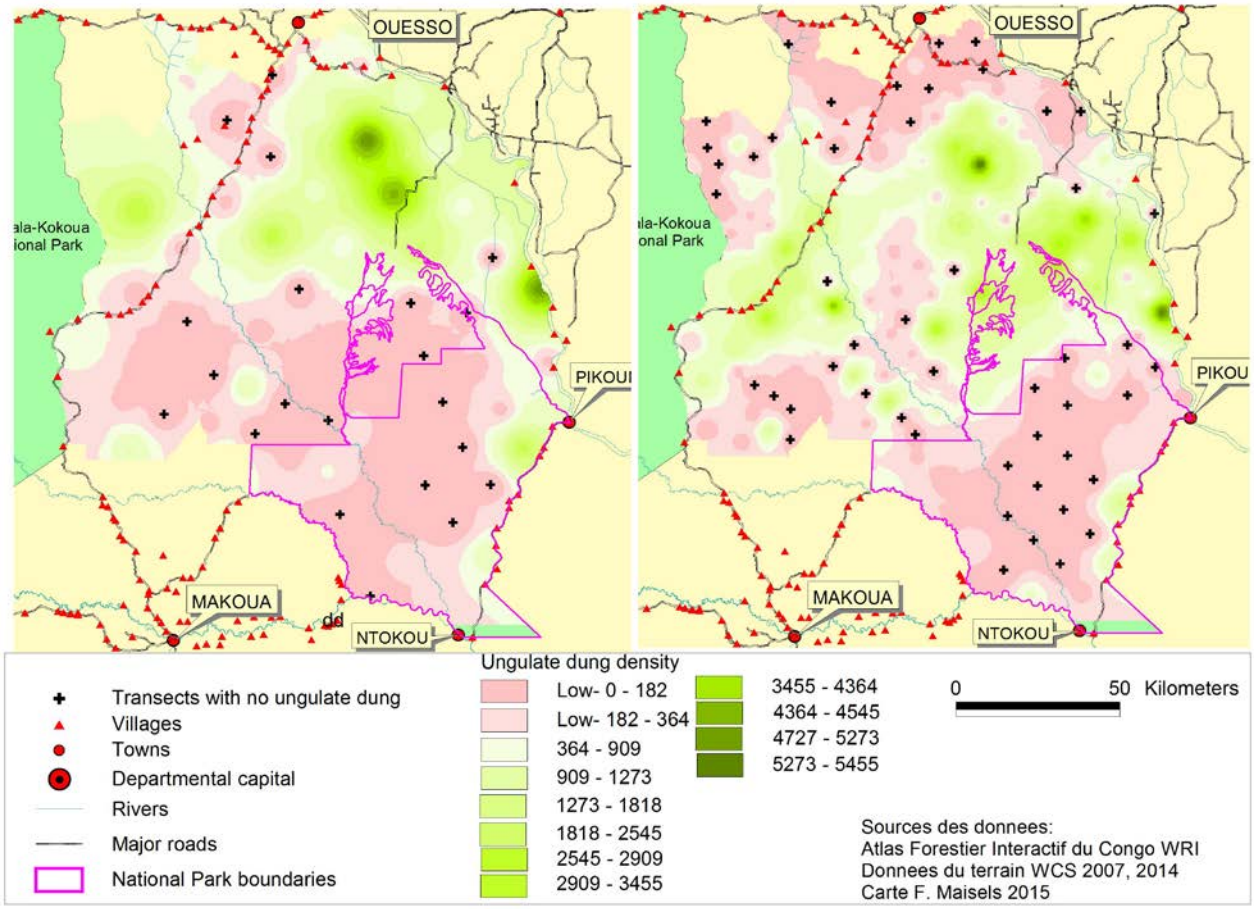

Figure 22. Distribution of ungulate pellet dung in 2007 (left) and 2014 (right).

Human sign

Hunting signs in 2007 and 2014 were are aligned along the national public road, but also in much of the northern part of the Ngombe concession, along the Sangha river, and in the south-west of the Ngombe concession between the road and the Atama palm oil concession. By 2014 there was more hunting along the Ouesso-Brazzaville road, with a scattering of sign along the Sangha between Pokola and Pikounda, and on the Lengoue river on the northern limit of the Ntokou-Pikounda National Park (Fig. 23).

An interpolation map of hunting signs only (Fig. 24) clearly shows the change since 2007. In both 2007 and 2014 hunting was concentrated in the area south of Ouesso and along the Sangha opposite Pokola, with some sign near the villages of Pikounda and Ntokou.

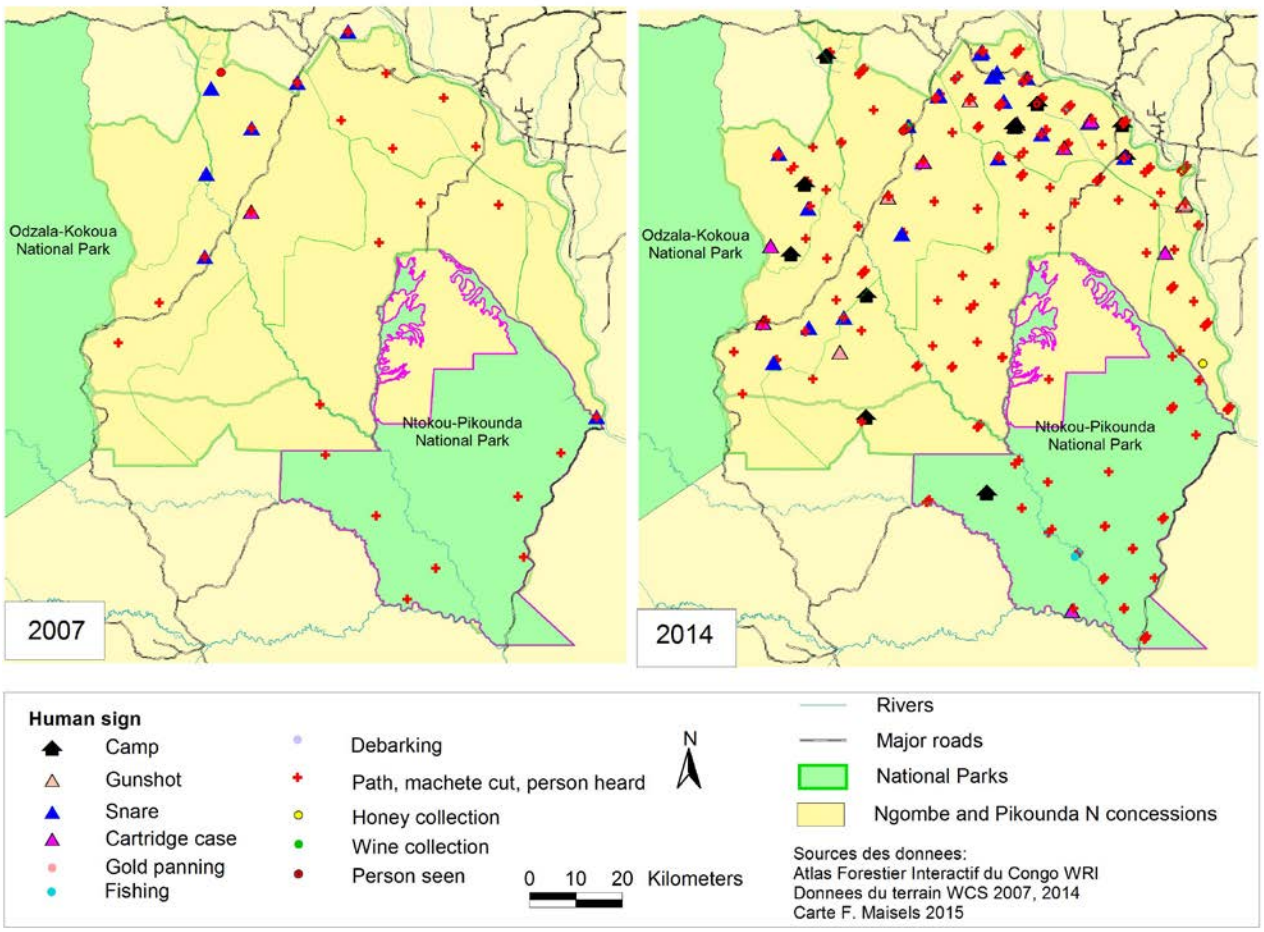

Figure 23. All human sign seen on transects 2007-2014. Triangles are hunting signs. Camps are hunting camps.

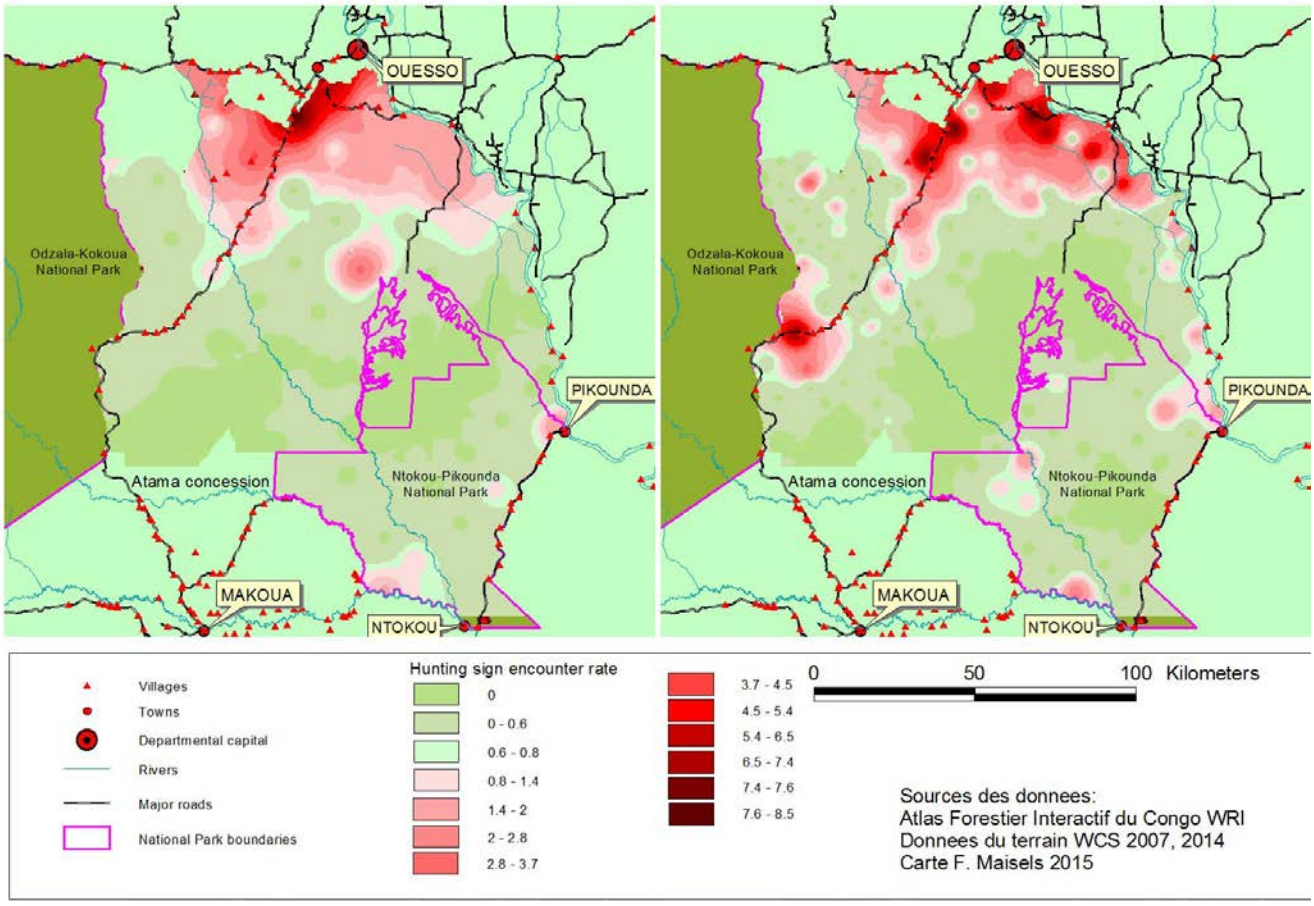

Figure 24. Distribution and encounter rate of hunter sign on transects in 2007 and 2014.

Conclusions

A complete large mammal survey was carried out between February and October 2014 across the landscape of the IFO Ngombé concession and the Ntokou-Pikounda National Park. The survey area was divided into different strata to examine the effects of logging and human pressure on wildlife abundance. This was a repeat survey of the area surveyed in 2007. The two surveys used identical methods to enable comparison between the baseline survey and the current situation. Due to an increased survey effort, the precision of estimates of animal density was greatly improved in the second survey. The results show the following:

Apes:

The overall ape population, calculated from nest density, is relatively stable across the Ngombe logging concession – even along the main Ouesso-Brazzaville road. This is reassuring. However, gorilla nest density in the Ntokou-Pikounda area has declined significantly since the area was first surveyed in 2007. The cause is most likely to be hunting. The map of great ape sign across the area shows that even where there were no nests found on transects, there were ape signs (including vocalisations and direct encounters) throughout most of the area, so apes are clearly still reasonably well distributed within the Park. More hunting signs were detected in Ntokou-Pikounda in 2014 than in 2007, and access to the area is much easier than it was. The road from Pikounda to Ntokou (along which there are 13 villages) has been newly reopened and the Lengoue river was also cleared to allow the transport of heavy goods to Liouesso. The area just to the East of Odzala-Kokoua National Park, between the two busy roads links from Ouesso (the Ouesso- Sembe-Souanke road and the Ouesso- Brazzaville road: the Ngombe northwest stratum) had no ape nests and few ape sign. This, too, had hunting sign within it- two camps, snares and signs of shotgun hunting; sign which was mostly absent in 2007. Nevertheless, Ebola outbreaks cannot be ruled out, as this has influenced ape densities in the landscape in the past. No case of this disease has been recorded since 2005, and there has been no mention of unusual mortality among humans or animals in the area since then. A significant recommendation is that disease surveillance work (that is currently on-going along the Ouesso-Brazzaville road, and along the Sangha between Pokola and Pikounda village: Olson et al. 2011; Olson et al. 2012, Reed et al 2014) be extended to include the villages along the Ntokou-Pikounda road and the villages between Makoua and the Western border of the Ntokou-Pikounda National Park.

Elephants:

There was a trend for elephant numbers to fall across the landscape. There was a small decline in the concession area and a larger decline in the national park area. However, in neither case was this difference statistically significant, due in part to the large coefficient of variation of the data from the original survey in 2007.

The distribution of elephant signs shows a reduction in range of the elephant population away from the north and east of the concessions and the Ntokou-Pikounda National Park, with relatively abundant elephant sign in the south and west of the concession (to the West of the Lengoue River up to the eastern limit of the Odzala-Kokoua National Park). There was no elephant dung at all for about 45km radius around Ouesso, none for

about 20-25km from the Ntokou-Pikounda road or the southern Sangha, and almost none in the area undergoing timber harvest at the time of the survey. In general, the distribution of elephants is a mirror image of the distribution of human signs.

Ungulates

The results for ungulates were mixed. There was a trend for a declining in ungulate abundance in the concession, and a slight increase in the National Park. However, as with the results for elephants, these differences were not statistically significant for all ungulates taken as a group. Apart from the area around Ouesso, where there was a clear 20-30 radius within which ungulate dung was absent in 2014 (which was not the case in 2007), ungulate distribution remained relatively consistent between the two surveys, suggesting that the distribution is linked to underlying ecological factors as well as human hunting pressure.

The comparison between the strata used for the 2014 survey suggests that certain areas support higher densities of ungulates regardless of logging history.

Human signs and hunting pressure

Many more signs of human activity were detected during the 2014 survey than in 2007. Human signs are classified into different categories to distinguish between signs of general activity, (such as machete cuts, which may be linked to timber inventories) and direct evidence of hunting (such as snares, camps, and shotgun cartridges). Based on this data, it is apparent that there has been an increase in hunting activity along the main Ouesso-Brazzaville road, along the Sangha and Lengoue Rivers, and in the new National Park.

The increased penetration of hunting activity in the south west of the concession, and into the national park are of great concern. Improvements to road and river access means that greater efforts need to be made to patrol these areas and their known points of access. One such route is the Lengoue river, which represents an important axis for hunting and fishing activity between the concession and the national park area. A significant recommendation arising is that anti-poaching strategies should be revised to reflect this reality, with more emphasis placed on river patrol missions and patrols in the south west of the concession, and an increase in intelligence gathering, especially related to ivory poaching.

Although the park was formally gazetted in December 2012, there is to date no effective protection for this area. A functional eco-guard force should be created for the national park as soon as possible. The forest ministry and its technical partners should review as rapidly as possible all available options for the effective protection of the park.

Recommendations

Long term monitoring data can be used to inform company practices and increase the effectiveness of anti-poaching efforts. In light of these results, we recommend the following:

- An increase in the extent and intensity of anti-poaching activities carried out by the PROGEPP ecoguards to enable increased surveillance of the south of the concession and the Lengoue river corridor.

- The antipoaching intelligence network should include the area around the Ntokou-Pikounda National Park.
- The immediate establishment of an effective protection force dedicated to the Ntokou-Pikounda National Park.
- Maintenance of the ongoing great apes disease surveillance program, and the expansion of effective surveillance of the Ntokou-Pikounda area, including the villages east of Makoua and the villages along the Ntokou-Pikounda road.
- Planning for a repeat survey using comparable methods to be executed in 2018/19

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Annexes

Annex 1. Logistic regression model to separate gorillas from chimps

Analysis to predict ape species for ape nest data collected in the Ngombe Landscape in 2014

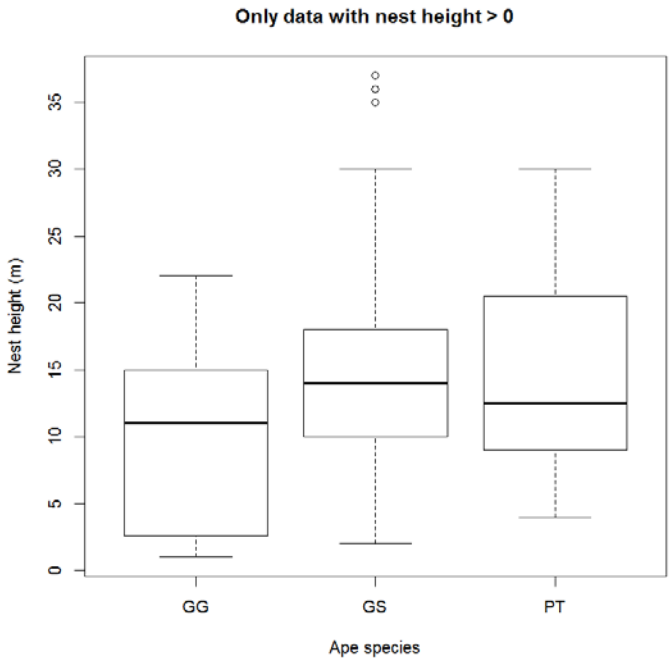
Samantha Strindberg – December 2014

For the 2014 Ngombe Landscape survey 3,540 ape nests were recorded on transects and recces. Of these, 2,444 were attributed to a particular ape species, namely chimpanzee (PT *Pan troglodytes*) or gorilla (GG *Gorilla gorilla gorilla*). A logistic regression model was used to predict the ape species for those nests not attributed to either chimpanzee or gorilla. The recce data were included to increase the number of chimpanzee nests attributed with certainty to this species to 96.

Explanatory variables considered included:

Nest Type: Predominantly H - Herbaceous and approximately half the number A - Arboreal, and a very small number of LIG - branches from shrubs on the ground, MIX - Mixed, P - Palm, AA - tree limbs on the ground. The types were consolidated into simply A and H by recoding the LIG, MIX, P, and AA as H, as all were attributed to gorilla for those nest identified to ape species.

Nest Height: in meters from 0-37m with boxplots by species and great ape nests attributed to species (GS) for nests >0m shown on the right.



Slope: Categories ranging from 0 to 3.

Tree Species: this variable was not used due to insufficient sample sizes with only Marantaceae having a good sample size for non-GS entries.

Ground Cover Type (Understorey): Classified as herbaceous (H), shrubs (A), or lianes (L). The single L entry was reclassed as missing.

Visibility on the Ground and **Ground Cover under the nest**: Classified as very open (TO), open (O), closed (F), completely closed (TF). The first of these variables was dropped, because it was not useful in distinguishing between the ape species (most of the values were missing, particularly for chimpanzee). For ground cover under the nest the very open category was consolidated with the open category, as there were no ape nests attributed to species in the TO category (3 zeroes were reclassed as O).

Canopy Cover: 0 - savanna or up to 25% canopy cover, 1- 26-50% canopy cover (quite light on the ground), 2 - 51-75% canopy cover, 3 - over 75% canopy cover (so dark and gloomy). This variable was removed from the analysis due to the large number of missing values.

Habitat Type: Categories included Mixed forest with closed understory (FMSF); Mixed forest with open understory (FMSO); Marantace Forest (FM); Monodominant forest (FMONO); Marsh Forest (MC) and Marsh Forest with lianas (MCL); Liana Forest (FLR) and Mixed Forest with Liana understory (FMSFL – combined with FMSF); Flooded Forest (FI); Old Secondary Forest (FSV); Treefalls (TR) and Raphia (RAP). The values FLR, FSV, RAP, skidder trail, TR were all set to missing value due to small sample size in each category.

Habitat Type Simplified: The simplified habitat consolidates some categories and refines others. If the habitat type was FM but the ground cover was herbaceous, or lianes, then it was reclassed as FMSF, and with shrubs it was reclassed as FMSO. If ground visibility was very open or open, then FM was reclassed as FMSO (for this reason some FMSO with closed visibility and herbaceous ground cover were reclassed as FMSF). The Flooded forest (FI) was combined with Monodominant forest (FMONO). FMSFL was combined with FMSF, as was FSV and FMSFM (except 2 entries with shrubby understorey classed as FMSO). Marsh forest with lianas was combined with MC. The values FLR, FSV, RAP, and TR were all set to missing value due to small sample size in each category.

The logistic regression analysis was conducted using the R software. Chimpanzees (PT) were coded as one and gorillas (GG) as zero, and a binomial distribution with a “probit” link (the “logit” and "cloglog" links generally did not perform as well when AIC was considered probably due to the large number of identified gorilla compared to chimpanzee nests). The variables Nest Height and Nest Type were never included in the same model due to their collinearity (Nest Type is a categorical simplified version of Nest Height). For similar reasons Habitat Type and simplified Habitat Type were never included in the same model. To avoid further numerical problems only a single interaction term was considered at any one time and these included two-way interactions between Habitat Type, Nest Height and Ground Cover.

Not surprisingly, given that chimpanzees tend to build higher nests, the value for predicted ape species increased for increasing Nest Height across all models considered, and not surprisingly, for Nest Type there was a big decrease in the value for predicted ape species for herbaceous nests that are only built by gorillas. The value for predicted ape species increased for increasing Slope, which makes sense given that chimpanzees nest in trees where slope is of little concern. Given the general preference of chimpanzees for no Ground Cover under the nest and of gorillas for more, the results for this variable are also as expected with the value for predicted ape species increasing significantly for open versus closed, and no significant difference for closed versus completely closed. There was not always a significant increase in predicted ape species value

when the Ground Cover was herbaceous rather than shrubby. When compared to the FM Habitat Type the value for predicted ape species decreased for FMONO, FMSF, FMSO, but only for FMSFM, MC and MCL was there a significant increase in the predicted value. For the simplified Habitat type only for the consolidated MC category was there an indication of a significant increase in predicted species value compared to the FM reference value.

The proportion of ape nests correctly attributed to the species identified during the survey as the builder of the nest is detailed in Table 1. The model with Nest Height, Slope and Habitat Type correctly attributed upward of 99% of the nests. However, a large percentage of the nests were correctly attributed to ape species using other variables and even simpler models. For example, with only the Nest Type variable, almost 99% of the nests were correctly attributed. Adding the two-way interaction term did not improve the predictive power. The model with Nest Height, Slope and Habitat Type was used to predict ape species whenever the values for this model's variables were not missing. In these instances the models with Nest Type and then the models with Nest Height and Slope and then the simple model with only Nest Height were used to predict any entries where the ape species was not yet predicted.

Table 1: Key models with details of the variables, the percent of ape nests correctly classified by each, as well as a breakdown by ape species of those nests not correctly classified by each model.

No	Model	% Correctly Classified Overall	%GG Incorrect	%PT Incorrect
1	Nest Height + Slope + Habitat Type	99.18	30	70
2	Nest Type	98.94	100	0
3	Nest Height + Slope + Habitat Simplified	97.83	24.53	75.47
4	Nest Height + Slope	97.67	29.82	70.18
5	Nest Height	97.55	28.33	71.67
6	Nest Type + Ground Cover Type + Ground Cover Under Nest + Slope + Habitat Simplified	96.81	3.85	96.15
7	Nest Type + Ground Cover Type + Ground Cover Under Nest + Slope + Habitat Type	96.81	1.28	98.72
8	Nest Type + Ground Cover Type + Ground Cover Under Nest + Slope	96.77	2.53	97.47
9	Nest Height+ Ground Cover Type + Ground Cover Under Nest + Slope	96.69	4.94	95.06
10	Nest Height+ Ground Cover Type + Ground Cover Under Nest + Slope + Habitat Simplified	96.64	4.88	95.12
11	Nest Height+ Ground Cover Type + Ground Cover Under Nest + Slope + Habitat Type	96.60	3.61	96.39
12	Slope	96.07	0	100
13	Habitat Type	96.07	0	100
14	Habitat Simplified	96.07	0	100
15	Ground Cover Type	96.07	0	100
16	Ground Cover Under Nest	96.07	0	100

Annex 2. Waypoints for each transect, 2014

Stratum	Transect	Way point	X-UTM	Y-UTM	Lat-dd	Long-dd	Lat-degs	Lat-mins	Long-degs	Min Long
Ngombe NW	1	1	538851.0	138305.6	1.25127	15.34922	1	15.076	15	20.953
Ngombe NW	1	2	540265.2	139719.8	1.26406	15.36194	1	15.844	15	21.716
Ngombe NW	2	3	544154.3	143608.9	1.29924	15.3969	1	17.954	15	23.814
Ngombe NW	2	4	545568.5	145023.1	1.31203	15.40962	1	18.722	15	24.577
Ngombe NW	3	5	551155.5	142832.0	1.2922	15.45983	1	17.532	15	27.590
Ngombe NW	3	6	549741.3	141417.8	1.27941	15.44712	1	16.765	15	26.827
Ngombe NW	4	7	545852.2	137528.7	1.24423	15.41216	1	14.654	15	24.730
Ngombe NW	4	8	544438.0	136114.5	1.23144	15.39944	1	13.886	15	23.966
Ngombe NW	5	9	540984.5	132661.0	1.2002	15.3684	1	12.012	15	22.104
Ngombe NW	5	10	539570.3	131246.8	1.18741	15.35568	1	11.245	15	21.341
Ngombe NW	6	11	554337.4	138235.7	1.25061	15.48843	1	15.037	15	29.306
Ngombe NW	6	12	552923.2	136821.5	1.23782	15.47571	1	14.269	15	28.543
Ngombe NW	7	13	549034.1	132932.4	1.20264	15.44075	1	12.158	15	26.445
Ngombe NW	7	14	547619.9	131518.2	1.18985	15.42804	1	11.391	15	25.682
Ngombe NW	8	15	569257.2	145377.3	1.31519	15.62255	1	18.911	15	37.353
Ngombe NW	8	16	567842.9	143963.1	1.3024	15.60983	1	18.144	15	36.590
Ngombe NW	9	17	564246.9	140367.0	1.26988	15.5775	1	16.193	15	34.650
Ngombe NW	9	18	562832.7	138952.8	1.25709	15.56479	1	15.425	15	33.887
Ngombe NW	10	19	558943.6	135063.7	1.22191	15.52982	1	13.315	15	31.789
Ngombe NW	10	20	557529.4	133649.5	1.20912	15.51711	1	12.547	15	31.027
Ngombe NW	11	21	553640.3	129760.4	1.17394	15.48215	1	10.436	15	28.929
Ngombe NW	11	22	552226.1	128346.2	1.16115	15.46943	1	9.669	15	28.166
Ngombe NW	12	23	548337.0	124457.1	1.12597	15.43447	1	7.558	15	26.068
Ngombe NW	12	24	546922.8	123042.9	1.11318	15.42176	1	6.791	15	25.306
Ngombe NW	13	25	550554.5	118896.5	1.07566	15.4544	1	4.540	15	27.264
Ngombe NW	13	26	551968.8	120310.7	1.08845	15.46711	1	5.307	15	28.027
Ngombe NW	14	27	555857.8	124199.8	1.12363	15.50207	1	7.418	15	30.124
Ngombe NW	14	28	557272.1	125614.0	1.13642	15.51478	1	8.185	15	30.887
Ngombe NW	15	29	561161.1	129503.1	1.1716	15.54975	1	10.296	15	32.985
Ngombe NW	15	30	562575.4	130917.3	1.18439	15.56246	1	11.063	15	33.748
Ngombe NW	16	31	566464.4	134806.4	1.21957	15.59742	1	13.174	15	35.845
Ngombe NW	16	32	567878.6	136220.6	1.23236	15.61014	1	13.942	15	36.608
Ngombe NW	17	33	551250.9	111814.6	1.01159	15.46065	1	0.695	15	27.639
Ngombe NW	17	34	552665.1	113228.8	1.02438	15.47336	1	1.463	15	28.402
Ngombe NW	18	35	556554.2	117117.9	1.05956	15.50832	1	3.574	15	30.499
Ngombe NW	18	36	557968.4	118532.1	1.07235	15.52103	1	4.341	15	31.262
Ngombe NW	19	37	561857.5	122421.2	1.10753	15.55599	1	6.452	15	33.359
Ngombe NW	19	38	563271.7	123835.4	1.12032	15.56871	1	7.219	15	34.123
Ngombe NW	20	39	567160.8	127724.5	1.1555	15.60367	1	9.330	15	36.220
Ngombe NW	20	40	568575.0	129138.8	1.16829	15.61638	1	10.097	15	36.983
Ngombe NW	21	41	562968.8	115754.4	1.04721	15.56597	1	2.833	15	33.958
Ngombe NW	21	42	561554.6	114340.2	1.03442	15.55326	1	2.065	15	33.196
Ngombe NW	22	43	557665.5	110451.1	0.99924	15.5183	0	59.954	15	31.098
Ngombe NW	22	44	556251.3	109036.9	0.98645	15.50558	0	59.187	15	30.335
Ngombe SW	23	45	553079.5	73208.3	0.66232	15.47704	0	39.739	15	28.622

Ngombe SW	23	46	554847.3	74976.1	0.67831	15.49293	0	40.699	15	29.576
Ngombe SW	24	47	572231.0	92359.8	0.83555	15.64918	0	50.133	15	38.951
Ngombe SW	24	48	573998.8	94127.6	0.85154	15.66507	0	51.092	15	39.904
Ngombe SW	25	49	578241.4	98370.2	0.88992	15.7032	0	53.395	15	42.192
Ngombe SW	25	50	580009.2	100138.0	0.90591	15.71909	0	54.355	15	43.145
Ngombe SW	26	51	583433.6	95077.1	0.86012	15.74986	0	51.607	15	44.992
Ngombe SW	26	52	581665.8	93309.3	0.84413	15.73397	0	50.648	15	44.038
Ngombe SW	27	53	577423.1	89066.6	0.80575	15.69583	0	48.345	15	41.750
Ngombe SW	27	54	575655.4	87298.9	0.78976	15.67994	0	47.386	15	40.796
Ngombe SW	28	55	571412.8	83056.2	0.75139	15.64181	0	45.083	15	38.509
Ngombe SW	28	56	569644.9	81288.5	0.7354	15.62592	0	44.124	15	37.555
Ngombe SW	29	57	565402.3	77045.8	0.69702	15.58779	0	41.821	15	35.267
Ngombe SW	29	58	563634.6	75278.1	0.68103	15.5719	0	40.862	15	34.314
Ngombe SW	30	59	559391.9	71035.4	0.64265	15.53377	0	38.559	15	32.026
Ngombe SW	30	60	557624.1	69267.7	0.62666	15.51788	0	37.600	15	31.073
Ngombe SW	31	61	557433.8	60592.1	0.54817	15.51616	0	32.890	15	30.970
Ngombe SW	31	62	559201.6	62359.8	0.56416	15.53205	0	33.850	15	31.923
Ngombe SW	32	63	563072.9	66231.1	0.59918	15.56684	0	35.951	15	34.010
Ngombe SW	32	64	564840.7	67998.9	0.61518	15.58273	0	36.911	15	34.964
Ngombe SW	33	65	569083.3	72241.5	0.65355	15.62086	0	39.213	15	37.252
Ngombe SW	33	66	570851.1	74009.3	0.66954	15.63675	0	40.172	15	38.205
Ngombe SW	34	67	575093.8	78251.9	0.70792	15.67488	0	42.475	15	40.493
Ngombe SW	34	68	576861.5	80019.7	0.72391	15.69077	0	43.435	15	41.446
Ngombe SW	35	69	581104.1	84262.4	0.76229	15.72891	0	45.737	15	43.735
Ngombe SW	35	70	582871.9	86030.1	0.77827	15.7448	0	46.696	15	44.688
Ngombe SW	36	71	561842.0	56515.0	0.51128	15.55577	0	30.677	15	33.346
Ngombe SW	36	72	563609.8	58282.7	0.52728	15.57166	0	31.637	15	34.300
Ngombe SW	37	73	567852.4	62525.4	0.56565	15.60979	0	33.939	15	36.587
Ngombe SW	37	74	569620.2	64293.1	0.58164	15.62568	0	34.898	15	37.541
Ngombe SW	38	75	573862.8	68535.8	0.62002	15.66381	0	37.201	15	39.829
Ngombe SW	38	76	575630.6	70303.5	0.63601	15.6797	0	38.161	15	40.782
Ngombe SW	39	77	579873.3	74546.2	0.67439	15.71783	0	40.463	15	43.070
Ngombe SW	39	78	581641.0	76314.0	0.69038	15.73372	0	41.423	15	44.023
Ngombe SW	40	79	585883.6	80556.6	0.72875	15.77185	0	43.725	15	46.311
Ngombe SW	40	80	587651.4	82324.4	0.74474	15.78774	0	44.684	15	47.264
Ngombe SW	41	81	567775.0	53962.7	0.48819	15.60909	0	29.291	15	36.545
Ngombe SW	41	82	569542.8	55730.4	0.50418	15.62498	0	30.251	15	37.499
Ngombe SW	42	83	573785.4	59973.1	0.54256	15.66311	0	32.554	15	39.787
Ngombe SW	42	84	575553.2	61740.8	0.55855	15.67899	0	33.513	15	40.739
Ngombe SW	43	85	579795.8	65983.5	0.59693	15.71712	0	35.816	15	43.027
Ngombe SW	43	86	581563.6	67751.2	0.61292	15.73301	0	36.775	15	43.981
Ngombe SW	44	87	585806.3	71993.9	0.65129	15.77115	0	39.077	15	46.269
Ngombe SW	44	88	587574.0	73761.7	0.66728	15.78703	0	40.037	15	47.222
Ngombe SW	45	89	591816.6	78004.3	0.70566	15.82517	0	42.340	15	49.510
Ngombe SW	45	90	593584.4	79772.1	0.72164	15.84106	0	43.298	15	50.464
Ngombe SW	46	91	583125.6	60828.0	0.55028	15.74704	0	33.017	15	44.822
Ngombe SW	46	92	584893.4	62595.8	0.56627	15.76293	0	33.976	15	45.776
Ngombe SW	47	93	589136.1	66838.4	0.60465	15.80106	0	36.279	15	48.064
Ngombe SW	47	94	590903.8	68606.2	0.62064	15.81695	0	37.238	15	49.017
Ngombe SW	48	95	595146.4	72848.8	0.65901	15.85508	0	39.541	15	51.305

Ngombe SW	48	96	596914.2	74616.6	0.675	15.87097	0	40.500	15	52.258
Ngombe SW	49	97	589362.8	58579.9	0.52994	15.80309	0	31.796	15	48.185
Ngombe SW	49	98	591130.5	60347.6	0.54593	15.81898	0	32.756	15	49.139
Ngombe SW	50	99	595373.2	64590.3	0.5843	15.85711	0	35.058	15	51.427
Ngombe SW	50	100	597140.9	66358.0	0.60029	15.87299	0	36.017	15	52.379
Ngombe SW	51	101	593863.8	54595.6	0.49389	15.84353	0	29.633	15	50.612
Ngombe SW	51	102	595631.6	56363.4	0.50988	15.85942	0	30.593	15	51.565
Ngombe SW	52	103	599333.1	60064.9	0.54336	15.89269	0	32.602	15	53.561
Ngombe SW	52	104	601100.8	61832.7	0.55935	15.90857	0	33.561	15	54.514
Ngombe SW	53	105	610903.6	63150.1	0.57125	15.99666	0	34.275	15	59.800
Ngombe SW	53	106	609135.8	61382.3	0.55526	15.98077	0	33.316	15	58.846
Ngombe SW	54	107	604893.2	57139.7	0.51689	15.94264	0	31.013	15	56.558
Ngombe SW	54	108	603125.4	55371.9	0.5009	15.92676	0	30.054	15	55.606
Ngombe SW	55	109	612604.4	56365.7	0.50988	16.01193	0	30.593	16	0.716
Ngombe SW	55	110	610836.7	54597.9	0.49389	15.99605	0	29.633	15	59.763
Ngombe Sangha E	56	111	611644.5	167092.3	1.5115	16.00362	1	30.690	16	0.217
Ngombe Sangha E	56	112	609876.8	165324.5	1.49552	15.98772	1	29.731	15	59.263
Ngombe Sangha E	57	113	604927.0	160374.7	1.45076	15.94321	1	27.046	15	56.593
Ngombe Sangha E	57	114	603159.2	158607.0	1.43478	15.92731	1	26.087	15	55.639
Ngombe Sangha E	58	115	606819.8	152368.0	1.37832	15.96019	1	22.699	15	57.611
Ngombe Sangha E	58	116	608587.6	154135.8	1.39431	15.97609	1	23.659	15	58.565
Ngombe Sangha E	59	117	613537.3	159085.5	1.43906	16.0206	1	26.344	16	1.236
Ngombe Sangha E	59	118	615305.1	160853.3	1.45505	16.03649	1	27.303	16	2.189
Ngombe Sangha E	60	119	620254.8	165803.1	1.4998	16.081	1	29.988	16	4.860
Ngombe Sangha E	60	120	622022.6	167570.8	1.51578	16.0969	1	30.947	16	5.814
Ngombe Sangha E	61	121	624084.5	159733.3	1.44488	16.1154	1	26.693	16	6.924
Ngombe Sangha E	61	122	622316.8	157965.5	1.4289	16.0995	1	25.734	16	5.970
Ngombe Sangha E	62	123	617367.0	153015.8	1.38414	16.05499	1	23.048	16	3.299
Ngombe Sangha E	62	124	615599.3	151248.0	1.36816	16.0391	1	22.090	16	2.346
Ngombe Sangha E	63	125	610649.5	146298.2	1.3234	15.99459	1	19.404	15	59.675
Ngombe Sangha E	63	126	608881.7	144530.5	1.30742	15.9787	1	18.445	15	58.722
Ngombe Sangha E	64	127	619739.1	145488.4	1.31604	16.07628	1	18.962	16	4.577
Ngombe Sangha E	64	128	621506.9	147256.2	1.33203	16.09218	1	19.922	16	5.531
Ngombe Sangha E	65	129	626456.6	152205.9	1.37678	16.13668	1	22.607	16	8.201
Ngombe Sangha E	65	130	628224.4	153973.7	1.39276	16.15258	1	23.566	16	9.155
Ngombe Sangha E	66	131	621192.4	137042.2	1.23964	16.08931	1	14.378	16	5.359
Ngombe Sangha E	66	132	622960.2	138810.0	1.25562	16.10521	1	15.337	16	6.313
Ngombe Sangha E	67	133	627554.6	143404.4	1.29716	16.14652	1	17.830	16	8.791
Ngombe Sangha E	67	134	629322.4	145172.2	1.31314	16.16241	1	18.788	16	9.745
Ngombe Sangha E	68	135	634272.1	150121.9	1.35789	16.20692	1	21.473	16	12.415
Ngombe Sangha E	68	136	636039.9	151889.7	1.37388	16.22281	1	22.433	16	13.369
Ngombe Sangha E	69	137	626928.9	132879.2	1.20196	16.14085	1	12.118	16	8.451
Ngombe Sangha E	69	138	628696.7	134647.0	1.21794	16.15675	1	13.076	16	9.405
Ngombe Sangha E	70	139	633646.4	139596.7	1.26269	16.20125	1	15.761	16	12.075
Ngombe Sangha E	70	140	635414.2	141364.5	1.27868	16.21714	1	16.721	16	13.028
Ngombe Sangha E	71	141	640363.9	146314.2	1.32343	16.26165	1	19.406	16	15.699
Ngombe Sangha E	71	142	642131.7	148082.0	1.33941	16.27754	1	20.365	16	16.652
Ngombe Sangha E	72	143	651948.6	147999.3	1.33861	16.36576	1	20.317	16	21.946
Ngombe Sangha E	72	144	650180.8	146231.6	1.32263	16.34987	1	19.358	16	20.992
Ngombe Sangha E	73	145	645453.1	141503.8	1.27989	16.30736	1	16.793	16	18.442

Ngombe Sangha E	73	146	643685.3	139736.1	1.26391	16.29147	1	15.835	16	17.488
Ngombe Sangha E	74	147	652036.6	138187.9	1.24987	16.36651	1	14.992	16	21.991
Ngombe Sangha E	74	148	650268.8	136420.1	1.23389	16.35061	1	14.033	16	21.037
Ngombe Sangha E	75	149	654486.2	130738.0	1.18248	16.38849	1	10.949	16	23.309
Ngombe Sangha E	75	150	656253.9	132505.7	1.19846	16.40438	1	11.908	16	24.263
Ngombe Sangha E	76	151	660416.3	126768.6	1.14655	16.44175	1	8.793	16	26.505
Ngombe Sangha E	76	152	662184.1	128536.4	1.16253	16.45765	1	9.752	16	27.459
Ngombe Sangha E	77	153	666741.5	133093.8	1.20373	16.49862	1	12.224	16	29.917
Ngombe Sangha E	77	154	668509.3	134861.6	1.2197	16.51451	1	13.182	16	30.871
Ngombe Sangha E	78	155	665948.6	122401.3	1.10702	16.49145	1	6.421	16	29.487
Ngombe Sangha E	78	156	667716.3	124169.1	1.123	16.50734	1	7.380	16	30.440
Ngombe Sangha E	79	157	663796.2	110349.5	0.99803	16.47205	0	59.882	16	28.323
Ngombe Sangha E	79	158	665563.9	112117.3	1.01402	16.48794	1	0.841	16	29.276
Ngombe Sangha E	80	159	670272.1	116825.4	1.05658	16.53027	1	3.395	16	31.816
Ngombe Sangha E	80	160	672039.9	118593.2	1.07256	16.54616	1	4.354	16	32.770
Ngombe Sangha E	81	161	664789.9	101443.8	0.91748	16.48095	0	55.049	16	28.857
Ngombe Sangha E	81	162	663022.2	99676.0	0.9015	16.46506	0	54.090	16	27.904
Ngombe Sangha E	82	163	662153.8	88908.1	0.80412	16.45722	0	48.247	16	27.433
Ngombe Sangha E	82	164	663921.6	90675.9	0.8201	16.47311	0	49.206	16	28.387
Ngombe Sangha E	83	165	668626.1	95380.4	0.86263	16.51539	0	51.758	16	30.923
Ngombe Sangha E	83	166	670393.8	97148.1	0.87861	16.53128	0	52.717	16	31.877
Ngombe Sangha E	84	167	674644.5	91499.3	0.82751	16.56945	0	49.651	16	34.167
Ngombe Sangha E	84	168	672876.8	89731.6	0.81153	16.55356	0	48.692	16	33.214
Ngombe Sangha E	85	169	667946.5	84801.3	0.76696	16.50925	0	46.018	16	30.555
Ngombe Sangha E	85	170	666178.8	83033.6	0.75097	16.49336	0	45.058	16	29.602
Ngombe Sangha E	86	171	673352.8	80308.1	0.7263	16.55781	0	43.578	16	33.469
Ngombe Sangha E	86	172	671585.0	78540.3	0.71032	16.54192	0	42.619	16	32.515
Ngombe Sangha E	87	173	679029.6	66185.9	0.59857	16.60877	0	35.914	16	36.526
Ngombe Sangha E	87	174	680797.3	67953.7	0.61455	16.62465	0	36.873	16	37.479
Ngombe Road corridor	88	175	568981.8	166893.2	1.50984	15.62012	1	30.590	15	37.207
Ngombe Road corridor	88	176	567214.0	165125.4	1.49385	15.60423	1	29.631	15	36.254
Ngombe Road corridor	89	177	576573.9	160343.2	1.45057	15.68835	1	27.034	15	41.301
Ngombe Road corridor	89	178	578341.7	162111.0	1.46655	15.70425	1	27.993	15	42.255
Ngombe Road corridor	90	179	581017.1	150644.3	1.36281	15.72827	1	21.769	15	43.696
Ngombe Road corridor	90	180	579249.4	148876.5	1.34683	15.71237	1	20.810	15	42.742
Ngombe Road corridor	91	181	572936.5	142563.6	1.28973	15.65561	1	17.384	15	39.337
Ngombe Road corridor	91	182	571168.7	140795.9	1.27374	15.63972	1	16.424	15	38.383
Ngombe Road corridor	92	183	599669.1	155154.1	1.40355	15.89593	1	24.213	15	53.756
Ngombe Road corridor	92	184	597901.3	153386.4	1.38757	15.88004	1	23.254	15	52.802
Ngombe Road corridor	93	185	590830.3	146315.3	1.32362	15.81646	1	19.417	15	48.988
Ngombe Road corridor	93	186	589062.5	144547.5	1.30764	15.80056	1	18.458	15	48.034
Ngombe Road corridor	94	187	581991.4	137476.5	1.24369	15.73699	1	14.621	15	44.219
Ngombe Road corridor	94	188	580223.7	135708.7	1.2277	15.7211	1	13.662	15	43.266
Ngombe Road corridor	95	189	573152.6	128637.6	1.16375	15.65752	1	9.825	15	39.451
Ngombe Road corridor	95	190	571384.8	126869.9	1.14776	15.64163	1	8.866	15	38.498
Ngombe Road corridor	96	191	603609.4	144952.3	1.31125	15.93131	1	18.675	15	55.879
Ngombe Road corridor	96	192	601841.6	143184.5	1.29527	15.91542	1	17.716	15	54.925
Ngombe Road corridor	97	193	594770.6	136113.4	1.23132	15.85184	1	13.879	15	51.110
Ngombe Road corridor	97	194	593002.8	134345.7	1.21534	15.83595	1	12.920	15	50.157
Ngombe Road corridor	98	195	585931.8	127274.6	1.15139	15.77238	1	9.083	15	46.343

Ngombe Road corridor	98	196	584163.9	125506.8	1.1354	15.75649	1	8.124	15	45.389
Ngombe Road corridor	99	197	577092.9	118435.8	1.07145	15.69292	1	4.287	15	41.575
Ngombe Road corridor	99	198	575325.1	116668.0	1.05546	15.67703	1	3.328	15	40.622
Ngombe Road corridor	100	199	568254.1	109596.9	0.9915	15.61346	0	59.490	15	36.808
Ngombe Road corridor	100	200	566486.3	107829.2	0.97551	15.59757	0	58.531	15	35.854
Ngombe Road corridor	101	201	559415.2	100758.1	0.91155	15.53401	0	54.693	15	32.041
Ngombe Road corridor	101	202	557647.4	98990.3	0.89556	15.51812	0	53.734	15	31.087
Ngombe Road corridor	102	203	550576.4	91919.3	0.8316	15.45456	0	49.896	15	27.274
Ngombe Road corridor	102	204	548808.6	90151.5	0.8156	15.43867	0	48.936	15	26.320
Ngombe Road corridor	103	205	541737.6	83080.4	0.75164	15.37511	0	45.098	15	22.507
Ngombe Road corridor	103	206	539969.8	81312.7	0.73565	15.35923	0	44.139	15	21.554
Ngombe Road corridor	104	207	606970.3	134171.1	1.21371	15.96148	1	12.823	15	57.689
Ngombe Road corridor	104	208	605202.6	132403.3	1.19773	15.94559	1	11.864	15	56.735
Ngombe Road corridor	105	209	598131.5	125332.2	1.13378	15.88202	1	8.027	15	52.921
Ngombe Road corridor	105	210	596363.7	123564.5	1.1178	15.86613	1	7.068	15	51.968
Ngombe Road corridor	106	211	589292.6	116493.4	1.05385	15.80256	1	3.231	15	48.154
Ngombe Road corridor	106	212	587524.9	114725.6	1.03786	15.78667	1	2.272	15	47.200
Ngombe Road corridor	107	213	580453.8	107654.6	0.97391	15.7231	0	58.435	15	43.386
Ngombe Road corridor	107	214	578686.1	105886.8	0.95792	15.70721	0	57.475	15	42.433
Ngombe Road corridor	108	215	571615.0	98815.7	0.89396	15.64365	0	53.638	15	38.619
Ngombe Road corridor	108	216	569847.2	97048.0	0.87797	15.62776	0	52.678	15	37.666
Ngombe Road corridor	109	217	562776.1	89976.9	0.81401	15.5642	0	48.841	15	33.852
Ngombe Road corridor	109	218	561008.4	88209.1	0.79802	15.54831	0	47.881	15	32.899
Ngombe Road corridor	110	219	553937.3	81138.1	0.73405	15.48475	0	44.043	15	29.085
Ngombe Road corridor	110	220	552169.6	79370.3	0.71806	15.46887	0	43.084	15	28.132
Ngombe Road corridor	111	221	545098.4	72299.2	0.6541	15.40531	0	39.246	15	24.319
Ngombe Road corridor	111	222	543330.7	70531.5	0.63811	15.38942	0	38.287	15	23.365
Ngombe Road corridor	112	223	544205.8	57264.4	0.51808	15.39728	0	31.085	15	23.837
Ngombe Road corridor	112	224	545973.6	59032.2	0.53407	15.41317	0	32.044	15	24.790
Ngombe Road corridor	113	225	584686.1	97744.7	0.88425	15.76112	0	53.055	15	45.667
Ngombe Road corridor	113	226	586453.8	99512.5	0.90024	15.77701	0	54.014	15	46.621
Ngombe Road corridor	114	227	600474.8	113533.4	1.02704	15.90305	1	1.622	15	54.183
Ngombe Road corridor	114	228	602242.6	115301.2	1.04303	15.91894	1	2.582	15	55.136
Ngombe Road corridor	115	229	609313.6	122372.2	1.10697	15.98251	1	6.418	15	58.951
Ngombe Road corridor	115	230	611081.4	124140.0	1.12296	15.9984	1	7.378	15	59.904
Ngombe Road corridor	116	231	556386.5	55303.0	0.50032	15.50674	0	30.019	15	30.404
Ngombe Road corridor	116	232	554618.8	53535.2	0.48433	15.49086	0	29.060	15	29.452
Ngombe Road corridor	117	233	613586.7	112503.2	1.01769	16.02088	1	1.061	16	1.253
Ngombe Road corridor	117	234	611818.9	110735.4	1.0017	16.00499	1	0.102	16	0.299
Ngombe south-centre	118	235	614847.5	136123.7	1.23135	16.03229	1	13.881	16	1.937
Ngombe south-centre	118	236	616261.7	137537.9	1.24414	16.045	1	14.648	16	2.700
Ngombe south-centre	119	237	598651.9	108614.3	0.98255	15.88665	0	58.953	15	53.199
Ngombe south-centre	119	238	597237.6	107200.1	0.96976	15.87394	0	58.186	15	52.436
Ngombe south-centre	120	239	623107.6	133070.0	1.2037	16.10651	1	12.222	16	6.391
Ngombe south-centre	120	240	621693.3	131655.8	1.19091	16.09379	1	11.455	16	5.627
Ngombe south-centre	121	241	588990.1	87638.9	0.79282	15.79978	0	47.569	15	47.987
Ngombe south-centre	121	242	590404.3	89053.1	0.80561	15.81249	0	48.337	15	48.749
Ngombe south-centre	122	243	597493.4	96142.2	0.86973	15.87621	0	52.184	15	52.573
Ngombe south-centre	122	244	598907.6	97556.4	0.88252	15.88893	0	52.951	15	53.336
Ngombe south-centre	123	245	604564.4	103213.2	0.93367	15.93978	0	56.020	15	56.387

Ngombe south-centre	123	246	605978.7	104627.5	0.94647	15.95249	0	56.788	15	57.149
Ngombe south-centre	124	247	615218.4	113867.2	1.03002	16.03555	1	1.801	16	2.133
Ngombe south-centre	124	248	616632.6	115281.4	1.04281	16.04826	1	2.569	16	2.896
Ngombe south-centre	125	249	622074.9	120723.8	1.09202	16.09719	1	5.521	16	5.831
Ngombe south-centre	125	250	623489.2	122138.0	1.10481	16.1099	1	6.289	16	6.594
Ngombe south-centre	126	251	629146.1	127794.8	1.15596	16.16076	1	9.358	16	9.646
Ngombe south-centre	126	252	630560.3	129209.0	1.16875	16.17347	1	10.125	16	10.408
Ngombe south-centre	127	253	593489.3	80824.4	0.73116	15.8402	0	43.870	15	50.412
Ngombe south-centre	127	254	594903.6	82238.6	0.74396	15.85291	0	44.638	15	51.175
Ngombe south-centre	128	255	600560.4	87895.5	0.79512	15.90376	0	47.707	15	54.226
Ngombe south-centre	128	256	601974.6	89309.7	0.80791	15.91647	0	48.475	15	54.988
Ngombe south-centre	129	257	607631.5	94966.6	0.85907	15.96732	0	51.544	15	58.039
Ngombe south-centre	129	258	609045.7	96380.8	0.87186	15.98003	0	52.312	15	58.802
Ngombe south-centre	130	259	614702.6	102037.6	0.92301	16.03088	0	55.381	16	1.853
Ngombe south-centre	130	260	616116.8	103451.8	0.9358	16.04359	0	56.148	16	2.615
Ngombe south-centre	131	261	621773.6	109108.7	0.98696	16.09444	0	59.218	16	5.666
Ngombe south-centre	131	262	623187.8	110522.9	0.99975	16.10716	0	59.985	16	6.430
Ngombe south-centre	132	263	628844.7	116179.8	1.0509	16.15801	1	3.054	16	9.481
Ngombe south-centre	132	264	630258.9	117594.0	1.06369	16.17072	1	3.821	16	10.243
Ngombe south-centre	133	265	635915.8	123250.8	1.11483	16.22158	1	6.890	16	13.295
Ngombe south-centre	133	266	637329.9	124665.0	1.12762	16.23429	1	7.657	16	14.057
Ngombe south-centre	134	267	642986.8	130321.9	1.17876	16.28515	1	10.726	16	17.109
Ngombe south-centre	134	268	644401.0	131736.1	1.19155	16.29786	1	11.493	16	17.872
Ngombe south-centre	135	269	602258.7	78280.1	0.70813	15.919	0	42.488	15	55.140
Ngombe south-centre	135	270	603672.9	79694.3	0.72092	15.93171	0	43.255	15	55.903
Ngombe south-centre	136	271	609329.8	85351.1	0.77208	15.98256	0	46.325	15	58.954
Ngombe south-centre	136	272	610743.9	86765.3	0.78487	15.99527	0	47.092	15	59.716
Ngombe south-centre	137	273	616400.8	92422.2	0.83603	16.04612	0	50.162	16	2.767
Ngombe south-centre	137	274	617815.0	93836.4	0.84882	16.05883	0	50.929	16	3.530
Ngombe south-centre	138	275	634653.3	110674.6	1.00108	16.21019	1	0.065	16	12.611
Ngombe south-centre	138	276	636067.4	112088.8	1.01387	16.2229	1	0.832	16	13.374
Ngombe south-centre	139	277	641724.3	117745.7	1.06502	16.27375	1	3.901	16	16.425
Ngombe south-centre	139	278	643138.5	119159.9	1.0778	16.28647	1	4.668	16	17.188
Ngombe south-centre	140	279	648795.4	124816.7	1.12894	16.33732	1	7.736	16	20.239
Ngombe south-centre	140	280	650209.6	126230.9	1.14173	16.35004	1	8.504	16	21.002
Ngombe south-centre	141	281	617026.2	81733.9	0.73935	16.05171	0	44.361	16	3.103
Ngombe south-centre	141	282	615612.0	80319.7	0.72656	16.039	0	43.594	16	2.340
Ngombe south-centre	142	283	609955.1	74662.8	0.6754	15.98816	0	40.524	15	59.290
Ngombe south-centre	142	284	608540.9	73248.6	0.66261	15.97545	0	39.757	15	58.527
Ngombe south-centre	143	285	659888.8	124596.4	1.1269	16.437	1	7.614	16	26.220
Ngombe south-centre	143	286	658474.6	123182.2	1.11412	16.42429	1	6.847	16	25.457
Ngombe south-centre	144	287	652817.7	117525.4	1.06298	16.37344	1	3.779	16	22.406
Ngombe south-centre	144	288	651403.5	116111.1	1.05019	16.36072	1	3.011	16	21.643
Ngombe south-centre	145	289	645746.6	110454.3	0.99905	16.30987	0	59.943	16	18.592
Ngombe south-centre	145	290	644332.4	109040.1	0.98626	16.29716	0	59.176	16	17.830
Ngombe south-centre	146	291	615094.3	68488.3	0.61953	16.03433	0	37.172	16	2.060
Ngombe south-centre	146	292	613680.1	67074.1	0.60674	16.02162	0	36.404	16	1.297
Ngombe south-centre	147	293	658250.8	111644.7	1.00977	16.42223	1	0.586	16	25.334
Ngombe south-centre	147	294	656836.5	110230.5	0.99699	16.40952	0	59.819	16	24.571
Ngombe south-centre	148	295	651179.7	104573.6	0.94584	16.35867	0	56.750	16	21.520

Ngombe south-centre	148	296	649765.4	103159.4	0.93306	16.34596	0	55.984	16	20.758
Ngombe south-centre	149	297	656297.4	98377.6	0.88978	16.40463	0	53.387	16	24.278
Ngombe south-centre	149	298	654883.2	96963.4	0.877	16.39192	0	52.620	16	23.515
Ntokou-Pikounda+Pikounda N	150	299	631528.4	105365.9	0.95307	16.18209	0	57.184	16	10.925
Ntokou-Pikounda+Pikounda N	150	300	630114.2	103951.7	0.94029	16.16938	0	56.417	16	10.163
Ntokou-Pikounda+Pikounda N	151	301	623043.1	96880.6	0.87634	16.10582	0	52.580	16	6.349
Ntokou-Pikounda+Pikounda N	151	302	621628.9	95466.4	0.86356	16.0931	0	51.814	16	5.586
Ntokou-Pikounda+Pikounda N	152	303	644911.8	104607.1	0.94617	16.30235	0	56.770	16	18.141
Ntokou-Pikounda+Pikounda N	152	304	643497.6	103192.9	0.93338	16.28964	0	56.003	16	17.378
Ntokou-Pikounda+Pikounda N	153	305	636426.5	96121.9	0.86944	16.22608	0	52.166	16	13.565
Ntokou-Pikounda+Pikounda N	153	306	635012.3	94707.7	0.85666	16.21336	0	51.400	16	12.802
Ntokou-Pikounda+Pikounda N	154	307	627941.2	87636.6	0.79271	16.14981	0	47.563	16	8.989
Ntokou-Pikounda+Pikounda N	154	308	626527.0	86222.4	0.77993	16.1371	0	46.796	16	8.226
Ntokou-Pikounda+Pikounda N	155	309	595393.0	40946.2	0.37041	15.85726	0	22.225	15	51.436
Ntokou-Pikounda+Pikounda N	155	310	596807.3	42360.5	0.3832	15.86997	0	22.992	15	52.198
Ntokou-Pikounda+Pikounda N	156	311	603687.9	49241.2	0.44544	15.9318	0	26.726	15	55.908
Ntokou-Pikounda+Pikounda N	156	312	605102.2	50655.4	0.45823	15.94451	0	27.494	15	56.671
Ntokou-Pikounda+Pikounda N	157	313	621223.1	66776.3	0.60404	16.0894	0	36.242	16	5.364
Ntokou-Pikounda+Pikounda N	157	314	622637.3	68190.5	0.61683	16.10211	0	37.010	16	6.127
Ntokou-Pikounda+Pikounda N	158	315	629708.3	75261.6	0.68077	16.16566	0	40.846	16	9.940
Ntokou-Pikounda+Pikounda N	158	316	631122.6	76675.8	0.69356	16.17837	0	41.614	16	10.702
Ntokou-Pikounda+Pikounda N	159	317	638193.6	83746.9	0.7575	16.24192	0	45.450	16	14.515
Ntokou-Pikounda+Pikounda N	159	318	639607.8	85161.1	0.77029	16.25463	0	46.217	16	15.278
Ntokou-Pikounda+Pikounda N	160	319	646678.9	92232.1	0.83423	16.31819	0	50.054	16	19.091
Ntokou-Pikounda+Pikounda N	160	320	648093.1	93646.3	0.84702	16.3309	0	50.821	16	19.854
Ntokou-Pikounda+Pikounda N	161	321	655523.4	86934.5	0.78629	16.39764	0	47.177	16	23.858
Ntokou-Pikounda+Pikounda N	161	322	654109.1	85520.2	0.7735	16.38493	0	46.410	16	23.096
Ntokou-Pikounda+Pikounda N	162	323	647038.1	78449.2	0.70956	16.32138	0	42.574	16	19.283
Ntokou-Pikounda+Pikounda N	162	324	645623.9	77035.0	0.69678	16.30867	0	41.807	16	18.520
Ntokou-Pikounda+Pikounda N	163	325	638552.8	69963.9	0.63283	16.24512	0	37.970	16	14.707
Ntokou-Pikounda+Pikounda N	163	326	637138.6	68549.7	0.62005	16.23241	0	37.203	16	13.945
Ntokou-Pikounda+Pikounda N	164	327	630067.5	61478.6	0.5561	16.16886	0	33.366	16	10.132
Ntokou-Pikounda+Pikounda N	164	328	628653.3	60064.4	0.54331	16.15615	0	32.599	16	9.369
Ntokou-Pikounda+Pikounda N	165	329	621582.3	52993.3	0.47936	16.0926	0	28.762	16	5.556
Ntokou-Pikounda+Pikounda N	165	330	620168.0	51579.1	0.46657	16.07989	0	27.994	16	4.793
Ntokou-Pikounda+Pikounda N	166	331	613096.9	44508.1	0.40261	16.01634	0	24.157	16	0.980
Ntokou-Pikounda+Pikounda N	166	332	611682.8	43093.8	0.38982	16.00364	0	23.389	16	0.218
Ntokou-Pikounda+Pikounda N	167	333	664861.8	82130.8	0.74281	16.48153	0	44.569	16	28.892
Ntokou-Pikounda+Pikounda N	167	334	663447.6	80716.6	0.73003	16.46882	0	43.802	16	28.129
Ntokou-Pikounda+Pikounda N	168	335	656376.5	73645.5	0.66609	16.40527	0	39.965	16	24.316
Ntokou-Pikounda+Pikounda N	168	336	654962.3	72231.3	0.6533	16.39256	0	39.198	16	23.554
Ntokou-Pikounda+Pikounda N	169	337	647891.3	65160.2	0.58936	16.32901	0	35.362	16	19.741
Ntokou-Pikounda+Pikounda N	169	338	646477.0	63746.0	0.57658	16.3163	0	34.595	16	18.978
Ntokou-Pikounda+Pikounda N	170	339	639405.9	56674.9	0.51263	16.25275	0	30.758	16	15.165
Ntokou-Pikounda+Pikounda N	170	340	637991.8	55260.7	0.49984	16.24005	0	29.990	16	14.403
Ntokou-Pikounda+Pikounda N	171	341	630920.7	48189.6	0.43589	16.1765	0	26.153	16	10.590
Ntokou-Pikounda+Pikounda N	171	342	629506.4	46775.4	0.4231	16.16379	0	25.386	16	9.827
Ntokou-Pikounda+Pikounda N	172	343	622435.4	39704.4	0.35915	16.10025	0	21.549	16	6.015
Ntokou-Pikounda+Pikounda N	172	344	621021.2	38290.1	0.34636	16.08754	0	20.782	16	5.252
Ntokou-Pikounda+Pikounda N	173	345	672760.8	75887.6	0.68632	16.55248	0	41.179	16	33.149

Ntokou-Pikounda+Pikounda N	173	346	671346.5	74473.3	0.67354	16.53977	0	40.412	16	32.386
Ntokou-Pikounda+Pikounda N	174	347	664858.0	67984.8	0.61487	16.48146	0	36.892	16	28.888
Ntokou-Pikounda+Pikounda N	174	348	663443.8	66570.6	0.60209	16.46875	0	36.125	16	28.125
Ntokou-Pikounda+Pikounda N	175	349	656372.8	59499.6	0.53815	16.4052	0	32.289	16	24.312
Ntokou-Pikounda+Pikounda N	175	350	654958.5	58085.3	0.52536	16.39249	0	31.522	16	23.549
Ntokou-Pikounda+Pikounda N	176	351	647887.4	51014.3	0.46142	16.32895	0	27.685	16	19.737
Ntokou-Pikounda+Pikounda N	176	352	646473.3	49600.1	0.44863	16.31624	0	26.918	16	18.974
Ntokou-Pikounda+Pikounda N	177	353	639402.2	42529.0	0.38468	16.2527	0	23.081	16	15.162
Ntokou-Pikounda+Pikounda N	177	354	637987.9	41114.8	0.37189	16.23999	0	22.313	16	14.399
Ntokou-Pikounda+Pikounda N	178	355	630916.9	34043.7	0.30794	16.17645	0	18.476	16	10.587
Ntokou-Pikounda+Pikounda N	178	356	629502.7	32629.5	0.29515	16.16374	0	17.709	16	9.824
Ntokou-Pikounda+Pikounda N	179	357	622431.6	25558.4	0.23119	16.1002	0	13.871	16	6.012
Ntokou-Pikounda+Pikounda N	179	358	621017.4	24144.2	0.2184	16.08749	0	13.104	16	5.249
Ntokou-Pikounda+Pikounda N	180	359	672247.1	61231.8	0.55378	16.54782	0	33.227	16	32.869
Ntokou-Pikounda+Pikounda N	180	360	670832.9	59817.6	0.54099	16.53512	0	32.459	16	32.107
Ntokou-Pikounda+Pikounda N	181	361	663761.8	52746.5	0.47706	16.47157	0	28.624	16	28.294
Ntokou-Pikounda+Pikounda N	181	362	662347.6	51332.3	0.46427	16.45887	0	27.856	16	27.532
Ntokou-Pikounda+Pikounda N	182	363	655276.6	44261.3	0.40033	16.39533	0	24.020	16	23.720
Ntokou-Pikounda+Pikounda N	182	364	653862.3	42847.0	0.38754	16.38262	0	23.252	16	22.957
Ntokou-Pikounda+Pikounda N	183	365	646791.3	35776.0	0.32359	16.31908	0	19.415	16	19.145
Ntokou-Pikounda+Pikounda N	183	366	645377.1	34361.8	0.3108	16.30637	0	18.648	16	18.382
Ntokou-Pikounda+Pikounda N	184	367	638306.0	27290.7	0.24685	16.24283	0	14.811	16	14.570
Ntokou-Pikounda+Pikounda N	184	368	636891.8	25876.5	0.23406	16.23013	0	14.044	16	13.808
Ntokou-Pikounda+Pikounda N	185	369	629820.7	18805.4	0.1701	16.16659	0	10.206	16	9.995
Ntokou-Pikounda+Pikounda N	185	370	628406.5	17391.2	0.15731	16.15388	0	9.439	16	9.233
Ntokou-Pikounda+Pikounda N	186	371	635851.1	10693.6	0.09673	16.22077	0	5.804	16	13.246
Ntokou-Pikounda+Pikounda N	186	372	637265.3	12107.8	0.10952	16.23347	0	6.571	16	14.008
Ntokou-Pikounda+Pikounda N	187	373	644336.4	19178.9	0.17347	16.29701	0	10.408	16	17.821
Ntokou-Pikounda+Pikounda N	187	374	645750.6	20593.1	0.18626	16.30972	0	11.176	16	18.583
Ntokou-Pikounda+Pikounda N	188	375	652821.6	27664.2	0.25021	16.37325	0	15.013	16	22.395
Ntokou-Pikounda+Pikounda N	188	376	654235.8	29078.4	0.263	16.38596	0	15.780	16	23.158
Ntokou-Pikounda+Pikounda N	189	377	661306.9	36149.5	0.32695	16.44949	0	19.617	16	26.969
Ntokou-Pikounda+Pikounda N	189	378	662721.1	37563.7	0.33974	16.4622	0	20.384	16	27.732
Ntokou-Pikounda+Pikounda N	190	379	660645.1	21345.5	0.19306	16.44353	0	11.584	16	26.612
Ntokou-Pikounda+Pikounda N	190	380	659230.9	19931.3	0.18027	16.43083	0	10.816	16	25.850
Ntokou-Pikounda+Pikounda N	191	381	652159.8	12860.2	0.11632	16.36729	0	6.979	16	22.037
Ntokou-Pikounda+Pikounda N	191	382	650745.6	11446.0	0.10353	16.35459	0	6.212	16	21.275
Ntokou-Pikounda+Pikounda N	192	383	656391.8	2950.1	0.02668	16.40531	0	1.601	16	24.319
Ntokou-Pikounda+Pikounda N	192	384	657806.0	4364.3	0.03947	16.41802	0	2.368	16	25.081
Ntokou-Pikounda+Pikounda N	193	385	669520.6	1936.7	0.01752	16.52326	0	1.051	16	31.396
Ntokou-Pikounda+Pikounda N	193	386	668106.4	522.5	0.00473	16.51055	0	0.284	16	30.633

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