Boumba Bek National Park
Republic of Cameroon
Wildlife and Human Impact Survey 2012

Prepared for:

CITES MIKE — Monitoring the Illegal Killing of Elephants

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Figures

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Executive summary

The Boumba Bek National Park in south-eastern Cameroon has long been known to have an important population of forest elephants, gorillas, chimpanzees and other forest fauna. This report details the second density estimate of the elephants and great apes of the area conducted on a survey that ran between 14 January through 31 March 2012. Standard line transect methodology was used, with a survey effort of just under 106 kilometres (106 transects) covering the majority of the park over an area of 2079 km^2.

A total of 1112 elephant dung were recorded along transects in 2012; encounter rate was 9.5 (95% c.l. 8.1-11.2). Elephant dung density (all dung including S4 & S5, which are the two dung classes considered to have decayed: dung is classified when encountered as stages S1 through S5) was 1549/km² (95% c.l. 1282-1871; cv 9.57%); the corresponding elephant density was 1.2112 (95% c.l. 0.912-1.608), giving a total of 2517 (95% c.l. 1896-3343; CV 14.42%) individual elephants in Boumba-Bek in 2012.

Dung density without S4 and S5 was 1269 (95% c.l. 1043-1544) /km² and individual elephant density (using the dung with S4 and S5 excluded) was estimated at 0.99/km² (95% c.l. 0.74-1.32; CV 14.7%), translating to 2062 (95% c.l. 1545-2752) individual elephants in Boumba-Bek in 2012. We used a locally obtained dung decay rate of 67.30 (SE 7.26) collected using the methods recommended in the MIKE Dung Survey Standards (Hedges and Lawson 2006). When we compared elephant dung density between 2008 and 2012, whether including S4 and S5 dung or not, there was no significant difference between the two survey cycles. As in the previous two cycles (2004 and 2008) the majority of elephant dung was in the southwest of the Park, furthest from roads and villages.

Great ape nests were divided into gorilla and chimpanzee using discriminant analysis. Overall great ape density in 2012 in the Park was 1.60 (95% c.l. 1.22-2.10; CV 13.9) individuals per km^2, or a total of 3326 individuals (95% c.l. 2530-4373). Gorilla density was 1.18 (95% c.l. 0.85-1.64), and an estimated 2459 (95% c.l. 1771-3416; CV 16.6) individuals. Chimpanzee density was estimated at 0.44/ km^2 (95% c.l. 0.32-0.62) and 925 individuals (95% c.l. 662-1291; CV 17.0).

Human sign was evident throughout the whole of the eastern half of the Park (as was the case in 2004 and 2008) which is the part of the site closest to a major road with multiple settlements along it: maps are shown in the body of the report. The area to the southwest, contiguous with Nki National park, is the least affected part of Boumba Bek (reflecting, as always, the “mirror image” effect of elephant distribution and human activity). No elephant carcasses were found on the transects: the data from the recces and the patrols will be more informative on this point. Signs encountered included snares, a hunting camp, and human trails and machete cuts, pointing to the continued use of much of the park as a hunting area. Encounter rate of human sign in 2012 was almost identical to that found in 2004.

Background

Elephants and Great Apes in West Central Africa

Elephants

The main threat to elephants in West and Central Africa is very high poaching pressure for ivory, which has had a devastating effect on their populations (Beyers et al. 2011; Bouche et al. 2011, 2012; CITES 2012, 2013; CITES/ IUCN/ TRAFFIC 2013; Maisels et al. 2013; UNEP et al. 2013). Elephant (and other) poaching 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) and by poor governance (CITES/ IUCN/ TRAFFIC 2013). The sharp increase of ivory seizures since 2007 is mainly due to increased consumption in China (Underwood et al 2013) and it is thought that the main driver of ivory poaching has been the increase in demand –and thus price - in the Far East, especially China (CITES 2012; CITES/ IUCN/ TRAFFIC 2013; Martin and Vigne 2011; UNEP/CITES/IUCN/TRAFFIC 2013, Vigne and Martin 2011; Wittemyer et al. 2011).

Many authorities now consider African forest elephants a separate species (*Loxodonta cyclotis*) from the bush elephant *Loxodonta africana* (Brandt et al. 2012; Ishida et al. 2011a,b; Ishida et al. 2012; Rohland et al. 2010) although both CITES and IUCN consider only a single species (AFESG 2003). The most recent IUCN assessment lists the Central African elephant population as Endangered, and the continental population as Vulnerable (Blanc 2008).

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 (Tranquilli et al. 2012). All species are Red Listed as either Critically Endangered or Endangered, and the populations of all are diminishing (IUCN 2013). 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 2013; Williamson et al. 2013). Because of the ongoing hunting throughout their range, and the additional high risk of the fatal disease Ebola, western lowland gorillas were listed as Critically Endangered within the last few years (Walsh et al. 2008). Central chimpanzees have been listed as Endangered since 1996 (Oates et al. 2007b).

Finally, a new threat is looming on the Central African horizon for all wildlife: large-scale forest clearance for industrial agriculture, especially for oil palm (Carrere 2010; Greenpeace 2012; Senelwa et al. 2012), a type of land use known to be highly unsuitable for most forest-dwelling large mammals (Azhar et al. 2011; Fitzherbert et al. 2008; Rainforest Foundation 2013; Sheil et al. 2009).

Boumba Bek National Park and MIKE surveys

Boumba Bek National Park covers 2389km^2 (according to the WRI 2012 shapefile) and lies in southeastern Cameroon (Fig. 1). It was gazetted in 2005 (CBFP 2006) and had a management plan by 2012[1]. It is one of several protected areas in this part of the country and is contiguous with the Nki National Park which lies just to the west. Together the two Parks form a large (5598km^2) area of humid tropical forest with important populations of wildlife, especially forest elephants, western lowland gorillas, and central chimpanzees. Boumba Bek has been surveyed three times since the beginning of the MIKE program: in 2004 (Blake 2005), in 2008 (Nzooh 2009) and in 2012 (this study). In the recent predictive model of forest elephant distribution (Maisels *et al* 2013), the distribution map clearly shows Boumba Bek and the other protected areas in southeastern Cameroon to be the forest elephant strongholds of the country.

Because of technical misunderstanding of the methodology by some of the field teams, the 2004 data could not be used to estimate elephant dung density (see Blake 2005 report for details). In 2008, the second survey was carried out by WWF Cameroon, and a summary report produced. The summary report is here attached as annex (Annex 5). This report details the results of the 2012 survey and provides summary tables of 2004 and 2008 data as far as is possible.

Objective

The objective of the 2012 survey of Boumba Bek was to assess the abundance and distribution of the elephant and ape population within the Park, and if any changes since the previous MIKE surveys (or the 2008 survey, see below) had changed since the last cycle.

[1] http://www.rapac.org/index.php?option=com_content&view=article&id=483:etat-des-lieux-des-plans-

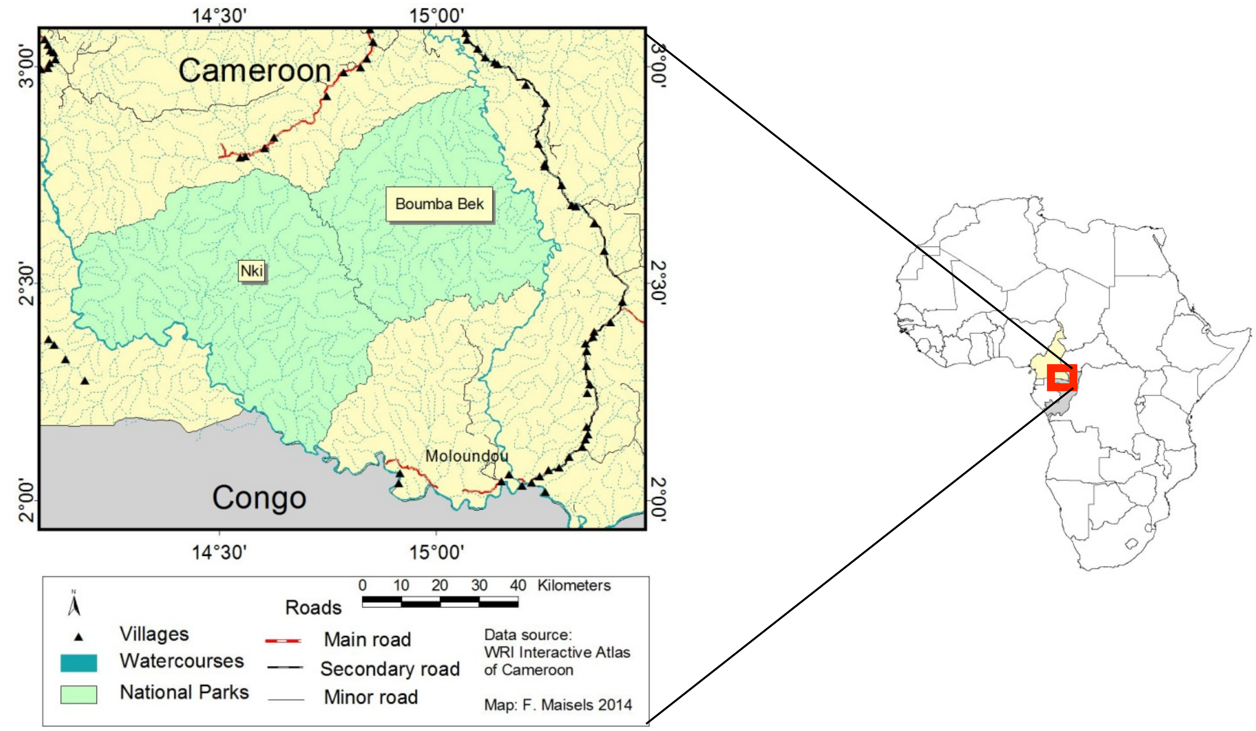


Figure 1 Location of Boumba Bek National Park.

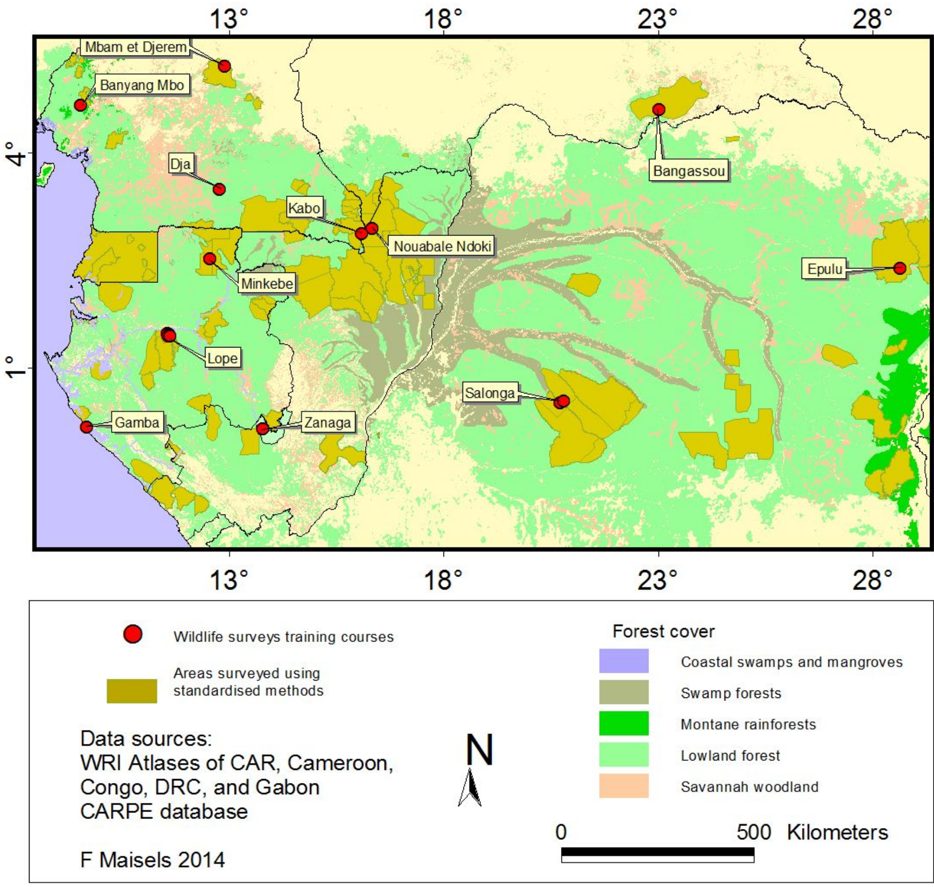


Figure 2. Standardised surveys (2002-2013) and methods training courses (1997-2013) of wildlife and human impact in Central Africa.

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 (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,b; Strindberg 2012; Strindberg et al. 2004). To date, the survey results across the region (Fig. 2) have been used in advising on landscape planning (Blake et al. 2008; Rainey et al. 2010; Stokes et al. 2010; Yackulic et al. 2011) and on IUCN action plans for elephants (IUCN/African elephant range States 2010) and apes (IUCN and ICCN 2012; Morgan et al. 2011; Oates et al. 2007a; Plumptre et al. 2010; Tutin et al. 2005).

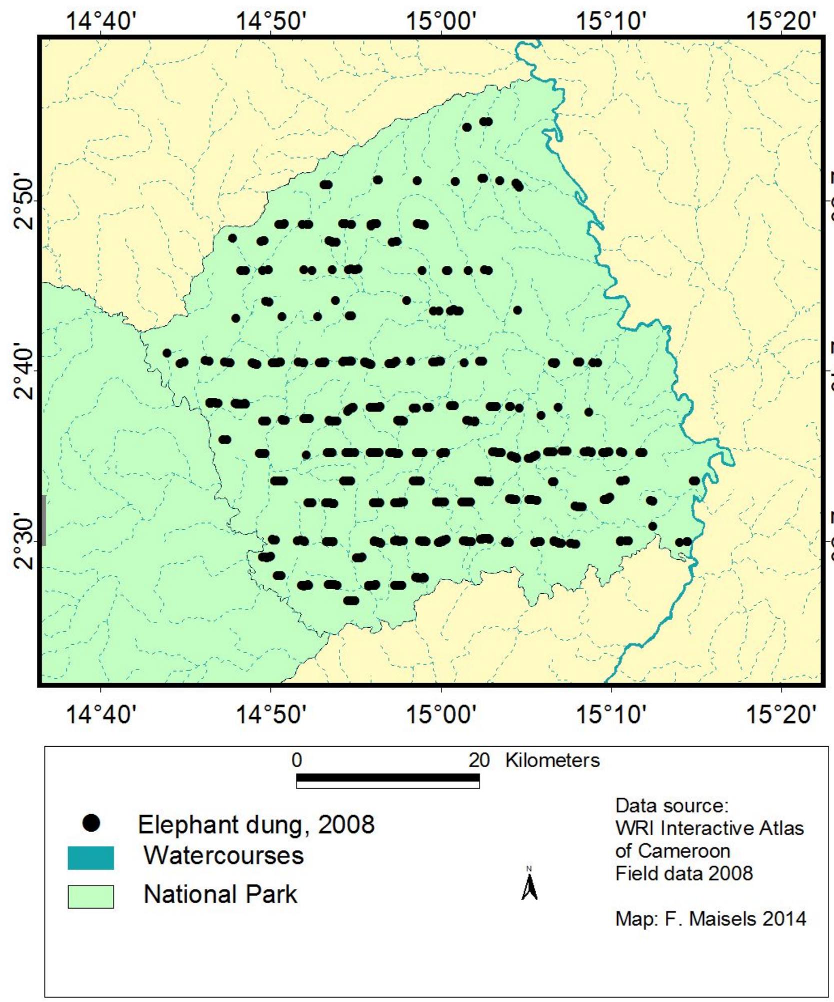


Figure 3. Dung distribution in Boumba Bek in the 2008 survey.

Survey design, 2012

The elephant dung results map from 2008 (Nzooh 2009; Fig. 3) provided the baseline to identify reasonable strata.

The data from 2008 was not available at the time of the survey design for 2012, only the report. However, The overall encounter rate of elephant dung on the 2008 transects in the Park was reported to be about 5.6 per kilometre, and for gorilla nests it was an order of magnitude less (0.5) (Nzooh 2009). It was clear that there was heterogeneity in the elephant abundance pattern within the Park (Fig. 3) so we created three strata in terms of descending elephant abundance. The design did not take into account great ape abundance, as the MIKE surveys are elephant-focused. Great apes were– in 2004 and 2008- more uniformly distributed than elephants, but with an almost inverse distribution to that of elephants (found at higher density in the northern half of the park and to the east (Blake 2005, Nzooh 2009). Stratum 1 comprised the south-western quarter of the site, Stratum 2 the north-western and southeastern quarters, and stratum 3, which was not surveyed due to the absence of elephant sign in 2004 and 2008, was the remaining area running roughly parallel to the road (Fig. 4). This is typical in the region: because hunting is most intense near roads, elephants are usually not found within several kilometres of unprotected roads (Blake et al 2008, Yackulic et al 2011). A systematic design with a random start option is preferable as this tends to improve precision (Strindberg et al. 2004).

Our design comprised a total of 106 transects (105.28km: Table 1, Fig. 4, Annex I) with 72 transects (71.2 kilometres walked) in Stratum 1 and 34 transects (34.06 kilometres walked) in Stratum 2. Stratum 3 was not surveyed at all. The strata covered a total of 2079 km^2 (stratum 1 covered 1016 and stratum 2 covered 1063 km^2). Normally, the total effort (kilometres to be walked) requires the use of the most recent encounter rates (i.e. the last survey), and a predetermined target precision (coefficient of variation) as follows (Buckland et al. 2001):

$$L = \left[\frac{b}{(cv_t(\hat{D}))^2}\right]\left[\frac{L_0}{n_0}\right]$$

Where L = number of kilometres to be walked in the final transect design (for 2012) (the total length of the transects in a stratum);

cv_t = target coefficient of variation, expressed as a number between 0 and 1 (for example, 15% would be expressed as 0.15);

$\hat{D}$ = the estimator of density;

L_0 = total length of the transects;

N_0 = number of objects detected along the transects in the stratum in the previous study (2010).

$$b = \left\{\frac{\mathrm{var}(n)}{n} + \frac{n.\mathrm{var}\{\hat{f}(0)\}}{\{f(0)\}^2}\right\} *$$

*b does not actually have to be computed as an acceptable value for b for these purposes is 3 (Buckland et al. 2001; Burnham 1980).

The encounter rate of elephant dung in 2008 would have allowed a very good overall CV of 10% with just 53 kilometres of effort. However, the overall encounter rate of gorilla nests in 2008 was so low that to obtain just 24% CV, 106 kilometres would have to be walked. Thus, we would expect that with the effort of 106 kilometres, the %CV for gorilla nest density would be around 25%, and for elephant dung density would be around 7%.

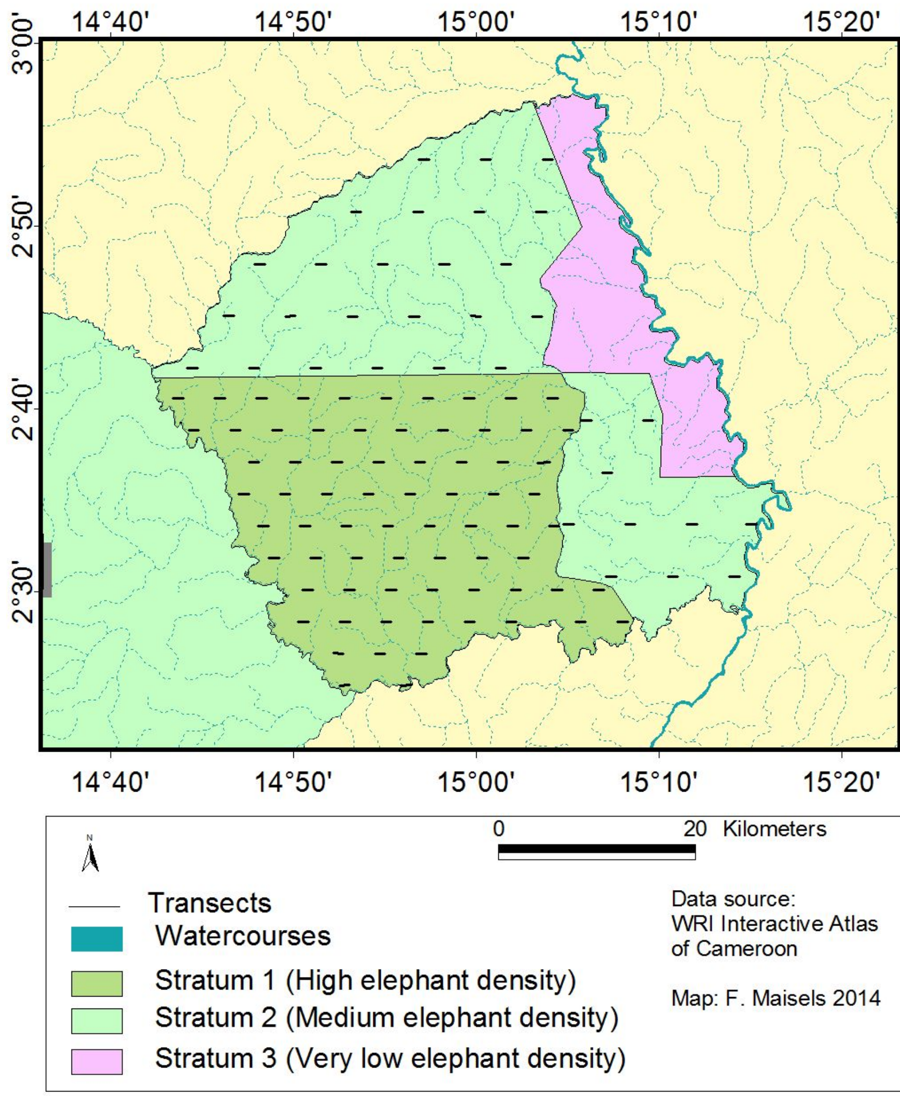


Figure 4. Survey design in 2012, showing the transect locations.

Data analysis: elephants

Elephant density is estimated in a similar manner to great apes: details can be found in Hedges and Lawson 2006; (Hedges 2012; Hedges et al. 2012; Strindberg 2012).

We compared density of dung between the two strata using a z-test (Buckland *et al* 2001).

Data analysis: great apes

Density estimation of great apes is based on the fact that each weaned individual makes a new sleeping nest every night. 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. The methods can be found in Annex 4.

After nest density is calculated (using the DISTANCE programme) then multipliers must be used to estimate animal density. No data were available for the 2008 survey, so a simple comparison table only is presented, and maps of 2004 and 2008 (Nzooh 2009) are presented beside with the map of this cycle.

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).

In the past, the density of nest groups was used, and then multiplied by the mean group size of fresh and recent nests. However, this has been discontinued – the number of groups of fresh or recent nests is generally low in any study (they are only about 10-20% of the total nests, as the old and very old nest classes can last for many weeks), and the DISTANCE statistics are very robust to clumping bias. Thus, the perpendicular distance to each nest was used for analysis, and the option "clusters of objects" used in the great ape, chimpanzee, and gorilla Distance projects.

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

The 2004 dataset contained no data that could be reliably analysed for elephant dung (extreme heaping at zero (see Blake 2005), but did contain great ape nest data that had been correctly collected.

The original elephant dung data from 2008 were made available after the 2012 survey had been completed. It contained dung data on 131 transects, but no great ape or human sign raw data was available from 2008. Six percent of the dung piles recorded (65) had no perpendicular distance and could not, therefore, be included in the distance analysis: of these 65 dung piles, 9 were in decay class S4 or S5, which are usually excluded from dung density analyses. The 2009 report did not mention total effort either per transect or for the whole survey. However, the 2009 report says that there were 191 one-kilometre transects walked in 2008, so we have assumed that of the 60 transects that did not have elephant dung, each was one kilometre long; we thus carried out a DISTANCE analysis on this data using the same production and decay rate as in 2012. The results are compared to the 2012 survey.

We estimated elephant dung and nest density for the 2012 survey. We have presented the comparisons between 2004, 2008 and 2012 in tables, maps that we made and that were made for a previous report (Nzooh 2009), and been able to do a comparison of elephant density 2008-2012, again using a z-test (Buckland *et al* 2001) and ape density 2004 and 2012.

Results

Survey implementation

The surveys lasted between 14 January through 31 March 2012 over 41 field-days (Annex 3). All of the planned transects were completed, and a total of 105.4 kilometres walked (Table 1). This was by far the most compact survey, speaking temporally, of the three surveys done to date for this site (the others had roughly the same number of days in the field for the teams, but were far more spread out through the year (Table 2).

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). Once the data had been cleaned and verified, the next step was to finalise the calculations of encounter rate, density of sign, and, using the standard multipliers (deposition and decay rate of elephant dung and great ape nests), and estimate density (and thus number) of animals present.

Table 1. Transects planned and completed in each stratum, 2012.

Stratum	Area (km2)	No. of transects	Length of each transect (km)	Planned Effort (km)	Final effort (km)	Months (Days in the field)	Reason for stratum
Stratum 1	1016	72	1	72	71.2		High elephant density in 2008
Stratum 2	1063	34	1	34	34.2		Low elephant density in 2008
Total	2079	106	1	106	105.4	January through March (41)	

Dung decay survey

For this survey, a dung decay study was carried out as part of the MIKE protocol.

The retrospective method of estimating dung decay rates described in Hedges and Lawson (2006) was followed. A total of five visits were made to different areas of the park to identify and mark dung piles, with the identification visit taking place in November 2011, three months before the planned start of the transect survey — and the last one mid-way through the survey. A total of 82 fresh (less than 48 hours old) dung piles were located and marked with a metal flag stake labelled with a unique identifier. The area around each dung pile was delimited by a triangle made of flagging tape for easy identification during revisit. Information recorded included the reference number, the state of the dung pile, GPS location, vegetation type, forest floor cover, canopy and weather and a general description of the location where the dung was found. Also recorded was the number of boli, number of heaps and, where possible, the circumference the boli.

Marked dung piles were revisited at the time of the survey to determine whether they were still present or absent, and their status recorded.

Data were analysed using logistic regression as described in Laing et al (2004). To this end, a script in the R language (R Core Team, 2012) written by Mike Meredith of WCS Malaysia was used. The original script is available from www.wcsmalaysia.org/analysis/Nest_dung_decay.htm.

Dung decay

Dung decay rate for the Boumba Bek 2012 survey was 67.299 (SE =7.258) days (November 2011 through April 2012. There was no dung decay rate available for the 2008 survey, which took place between May through early September, 2008, so we have simply shown dung density for the 2008 survey. Dung decay rates can vary in the region and by season (the decay rate over a three-year period in Nouabale-Ndoki (Congo) was 51.3 days (SE =2.81) (Breuer & Hockemba 2007) and was 80.6 days (SE= 9.00) in the Dzanga area through November 2011 - February 2012 (Princee 2012), both of which are geographically very close to Boumba-Bek. The results for the comparisons of the 2008 and 2012 Boumba-Bek dung datasets may therefore not be accurate.

Elephants

Elephant abundance

A total of 1112 elephant dung were recorded along transects in 2012 (Table 2; Annex 2); encounter rate was 9.5 (95% c.l. 8.1-11.2) (Table 3). Dung density was estimated both with and without the S4 and S5 dung classes, as experience in the region has shown that there is often a wide variation between individuals when classifying dung classes. Density of all dung was 1549 (95% c.l. 1282-1871); the corresponding elephant density was 1.2112 (95% c.l. 0.912-1.608), giving a total of 2517 (95% c.l. 1896-3343; CV 14.42%) individual elephants in Boumba-Bek in 2012.

The MIKE dung standards advise that elephant density is calculated excluding S4 and S5 dung, because these classes are considered to be "disappeared" (Hedges & Lawson 2006). Thus, we report on the density of dung without S4 and S5 was 1269 (95% c.l. 1043-1544) (Table 3). Dung density in stratum 1 (the area that had the highest elephant abundance both in 2004 and 2008) was almost three times higher than in Stratum 2, and significantly so (Z test: Z=3.896; P= <0.0001) (Table 3, Fig. 5). If we exclude the S4 and S5 dung, and use the dung decay value found at the site, overall elephant density is 0.99 (95% c.l. 0.74-1.32; CV 14.7%), translating to 2062 (95% c.l. 1545-2752) individual elephants in Boumba-Bek in 2012. Distance printouts can be seen in Annex 6.

When we compared elephant dung density between 2008 and 2012, whether including S4 and S5 dung or not (Fig. 6), there was no significant difference between the two surveys.

Table 2. Overview, 2004, 2008 and 2012 surveys

Year	Months (Days in the field)	N transects	Total effort (km) on transects	Total area surveyed	Total dung (Dung after S4 & S5 excluded)	Stratum 1	Stratum 2
2004	October 2003 through May 2004 (45)	47	46.2	2383	119 (81)	-	-
2008	May through September (50)	191	191	2389	1050 (763)	-	-
2012	January through March (41)	106	105.4	2079	1112 (964)	934 (832)	178 (132)

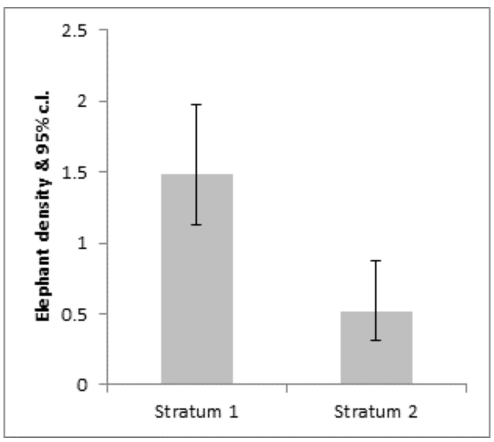


Figure 5. Elephant density in Strata 1 and 2, 2012. The dataset without S4 and S5 dung classes are shown.

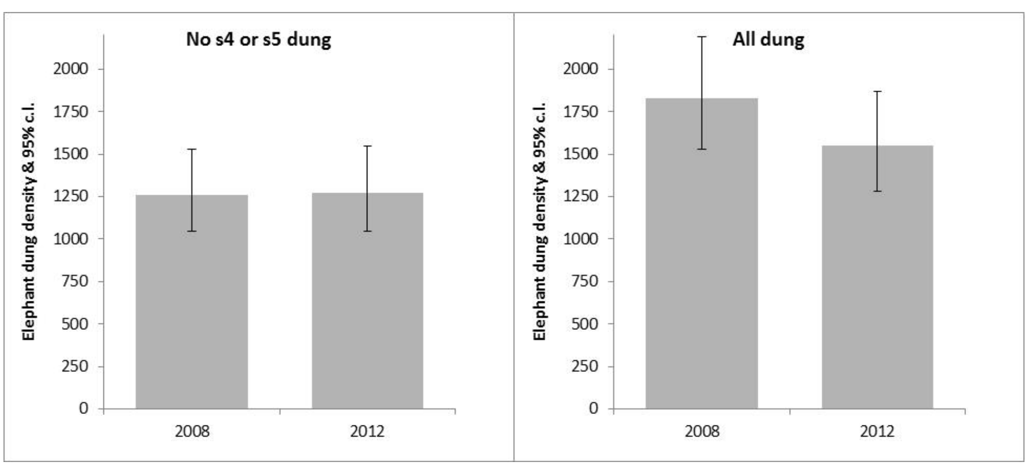


Figure 6. Elephant dung density, whole Park, 2008-2012. Datasets without and with S4 and S5 dung classes are shown.

Table 3. All elephant dung data from the 2004, 2008, 2012 transects. Density and number of animals by stratum for 2012 is shown, after truncation and after DISTANCE had been run on the results. We used a dung production rate of 19; decay rate used was 67.299 (SE 7.258). Analysis for the 2008 data has been done using the raw data made recently available. Also shown are percent coefficient of variation (% cv) and 95% confidence intervals (95% c.l).

Stratum, Year	N dungpiles (S4 & S5 excluded)	Encounter rate of dung (95% c.l)	Dung density/ km^2 (95% c.l)	%cv dung density	Animal density (95% c.l)	%cv animal density	N animals (95% c.l)	Source
2004	119 (81)	2.4	-	-	-	-	-	MIKE (2005)
2008 (All dung)	1050	5.0 4.3-5.9	1831 (1530-2190)	9.1				Data from Nzooh 2009
2008, S4 and s5 dung excluded using decay rate of the Boumba Bek 2012 study	763	3.6 (3.0-4.3)	1262 (1043-1527)	9.7				Data from Nzooh 2009
Stratum 1; 2012: S4 and s5 dung excluded	832	10.4 (8.9-12.3)	1902 (1576-2296)	9.5	1.49 (1.12-1.97)	14.4	1511 (1141-2002)	This study
Stratum 2 2012: S4 and s5 dung excluded	132	3.6 (2.235.8)	663 (410-1073)	24.1	0.52 (0.31-0.87)	26.4	551 (327-927)	This study
Strata combined 2012, S4 and s5 dung excluded	964		1269 (1043-1544)	9.9	0.99 (0.74-1.32)	14.7	2062 (1545-2752)	This study
Strata combined 2012 (All dung)	1112		1549 (1282-1871)	9.4	1.21 (0.91-1.61)	14.4	2517 (1896--3343)	This study

Elephant distribution

As is 2004 and 2008, elephant distribution was clearly highest in the southwestern sector of the park, where (i) Boumba Bek is contiguous with Nki National Park and (ii) furthest from roads (Figs. 7, 8).

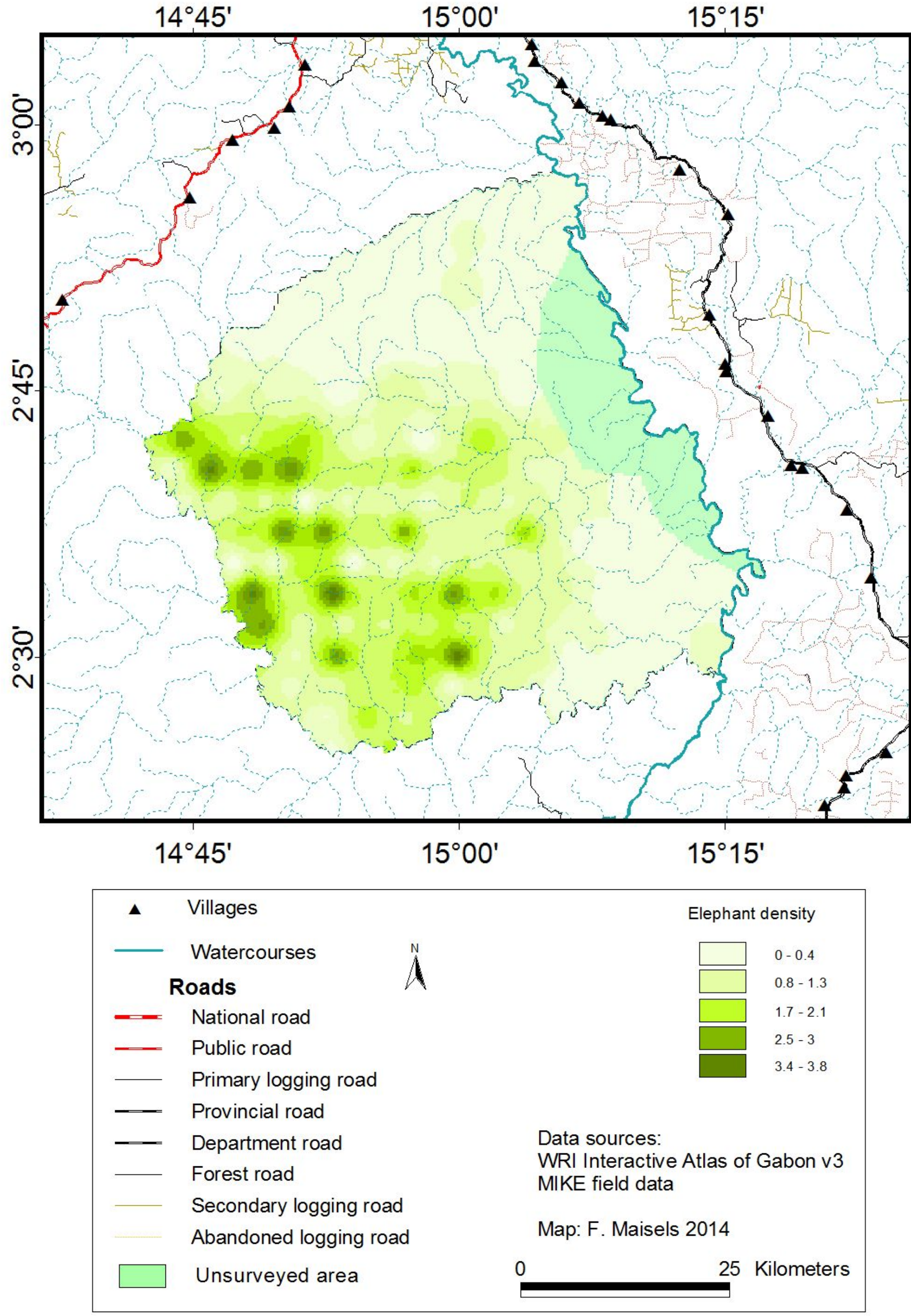
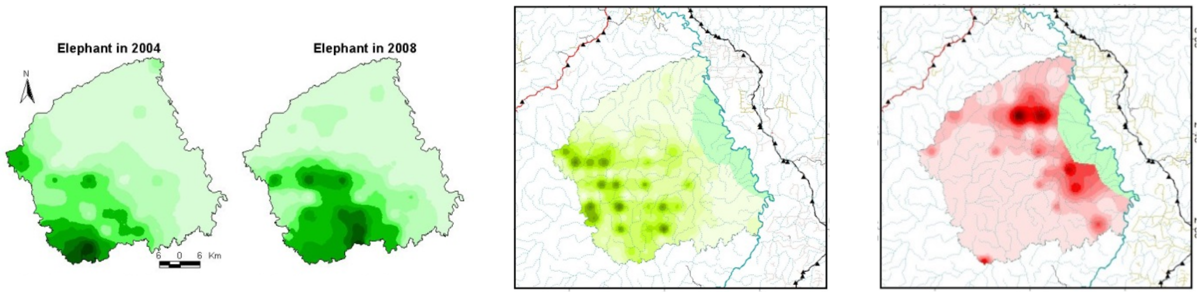


Figure 7. Elephant density and distribution, 2012. Darker colours indicate higher density



2004 **2008** **2012** **2012**

Figure 8. Left to right: Elephant distribution in Boumba Bek, 2004, 2008 and 2012 (green), and human sign interpolation map (red).

2004 and 2008: Elephant dung encounter rates from Nzooh (2009). 2012: elephant density (this study). Human sign: encounter rate of sign. Colours not to scale.

Great apes

A total of 235 great ape nests were recorded in 2012 (and 79 in 2004). Once the data had been cleaned, the next step was to assign each nest to species (chimp or gorilla). A logistic regression model using the 2004 and 2012 data, plus data from surveys in SE Cameroon and Odzala, was used to separate the species (Strindberg 2013). The variables used by Sanz *et al* (2007) were included and worked well: Nest Height and Habitat Type, Nest Type and height of Ground Cover. Additional parameters Canopy Cover and Cover under nest were also useful (see Annex 4 for the analysis details). With just one parameter (Ground Cover) over 99% of the nests were correctly attributed. With other single or combined variables, over 98% of nests were often correctly classified. Thus, for both cycles, the species that constructed the nest could be identified *post hoc*.

Nests in 2012 were found to be roughly equally divided between gorillas (111 nests) and chimps (124 nests) (Table 4).

Table 4. Number of great ape nests recorded during the 2004 and 2012 surveys after logistic regression was used to separate them by species.

Year	All ape nests	Gorilla nests	Chimp nests
2004	79	58	21
2012	235	111	124

Great ape abundance

Overall great ape nest density in 2012 was 142 nests/ km^2 (95% c.l. 109-185), which translated, using the decay factor of 90 days, to 1.58 (95% c.l. 1.21-2.06; CV 13.46) individuals per km^2, or a total of 3283 (95% c.l. 2522-4274) great apes (Table 5).

Of the great apes, gorillas were roughly twice as abundant as chimpanzees. Gorilla nest density was 94 (95% c.l. 69-128); individual density was 1.04 (95% c.l. 0.77-1.42). Using the decay factor of 90 days again, there were an estimated 2171 (95% c.l. 1594-2958; CV 15.75) gorillas in Boumba Bek in 2012.

Chimp abundance was as follows (we kept the 90-day decay rate): nest density 46/ km^2 (95% c.l. 32-64); individual density 0.51/km^2 (95% c.l. 0.36-0.71); suggesting a total of 1056 (95% c.l. 750-1486) chimps in Boumba Bek.

Table 5. All great ape data from 2012. Number, encounter rates and density of great ape 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.l).

Strata: 2012	Encounter rate of nests (95% c.l)	Nest density/ km^2 (95% c.l)	Animal density (95% c.l)	%cv	N animals (95% c.l)
Gorillas: Stratum 1	0.8 (0.5-1.1)	72 (49-107)	0.81 (0.55-1.19)	19.8	820 (556-1209)
Gorillas: Stratum 2	1.5 (1.0-2.3)	139 (90-214)	1.54 (1.00-2.37)	21.6	1639 (1065-2525)
Chimps: Stratum 1	1.3 (0.9-1.8)	55 38-80)	0.62 (0.42-0.89)	19.0	626 (431-910)
Chimps: Stratum 2	0.6 (0.3-1.0)	25 (14-44)	0.28 (0.16-0.49)	28.6	298 (169-526)
All apes: Stratum 1	1.97 (1.52-2.55)	139 (102-189)	1.54 (1.14-2.09)	15.6	1569 (1155-2132)
All apes: Stratum 2	2.11 (1.49-2.98)	148 (102-218)	1.65 (1.13-2.41)	19.1	1756 (1201-2569)
Gorillas- overall		**106 (77-148)**	**1.18 (0.85-1.64)**	**16.6**	**2459 (1771-3416)**
Chimps- overall		**40 (29-56)**	**0.44 (0.32-0.62)**	**17.0**	**925 (662-1291)**
All apes- overall		**144 (109-189)**	**1.60 (1.22-2.10)**	**13.9**	**3326 (2530-473)**

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

When we looked at the two strata separately, although they had been chosen as a function of elephant density in 2008, there was still a difference for chimps (Table 5): there were significantly more chimp nests in Stratum 1 (the area least impacted by humans) than Stratum 2 (Z-test: z=1.834; P=0.0336). There was no significant difference between the strata for gorilla nest density (Z-test: z=-1.453; P= 0.735.

When we reanalysed the 2004 data, we first pooled the species and looked at great ape nest density (Table 6). Nest and individual ape density seemed to be much higher a decade ago at this site: 407 nests/ km2 (95% c.l. 269-616); and ape density 4.53 (95% c.l. 2.99-6.85). For now, we have not split the density estimate per species, as there are clear issues with the data collection (very high spike near the transect line).

We do not have the raw data for great apes for 2008, so no comparison can be made apart from the reported density from Nzooh (2009) where nest density was reported to be also very high compared to 2012: 493 (95% c.l. 353-689). However we suggest that the 2008 dataset is examined carefully and if there are no issues with spiked data, a real fall of as much as two-thirds of the great ape population may well have occurred since 2008. However, a much more detailed analysis of the 2008 results is required.

Table 6. All great ape data from 2004. Number, encounter rates and density of great ape 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.l).

2004	Encounter rate of nests (95% c.l)	Nest density/ km^2 (95% c.l)	Animal density (95% c.l)	%cv	N animals (95% c.l)
Great apes	1.54 (1.14-2.06)	407 (269-616)	4.53 (2.99-6.85)	21.15	10699 (7074-16183)

Great ape distribution

Gorilla nest distribution in 2012 appears to be skewed towards the south and east of the Park (Fig. 9). Due to time constraints, we have not made a chimpanzee-specific map. Over time, great ape distribution seems to have remained roughly stable (Fig. 10).

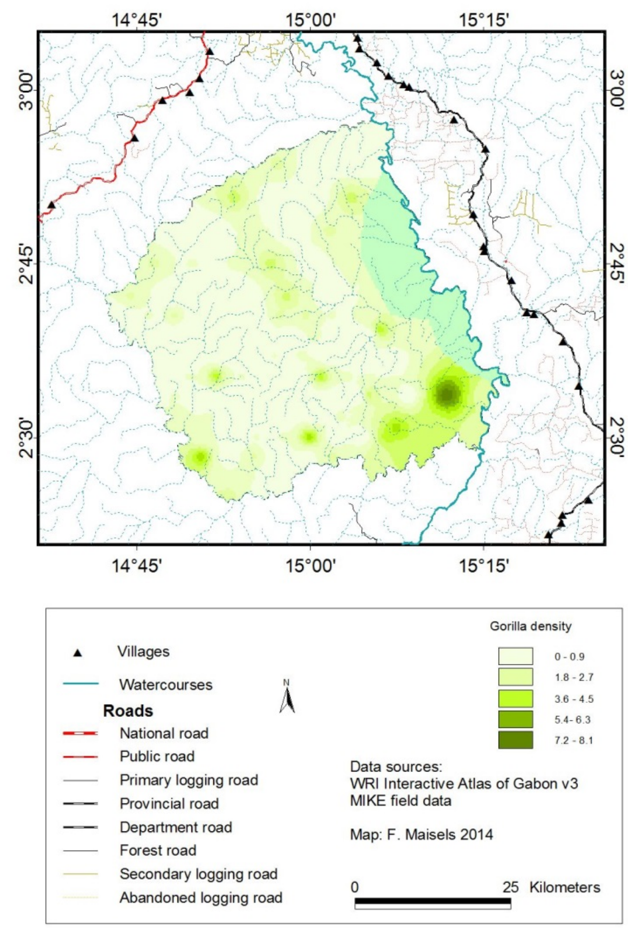
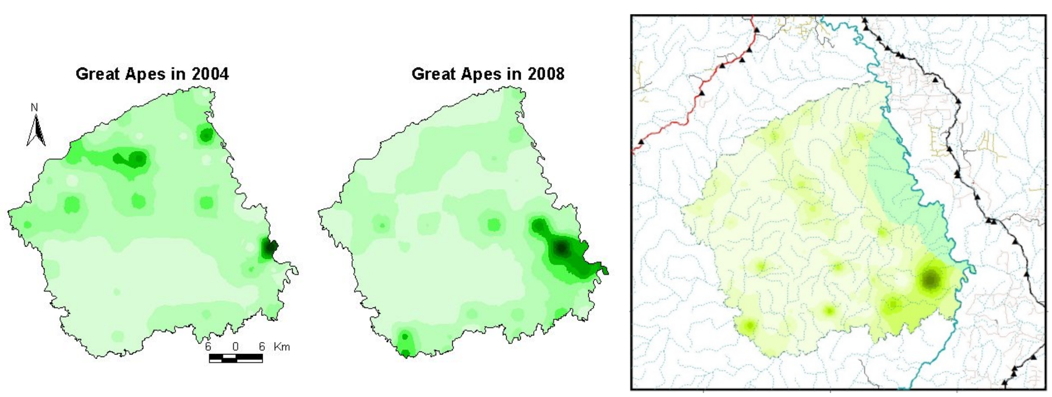


Figure 9. Gorilla nest density and distribution 2012. Darker colours indicate higher density.



2004 **2008** **2012**

Figure 10. Ape nest density and distribution 2004-2012. Darker colours indicate higher density.
2004 and 2008: Ape nest encounter rates from Nzooh (2009). 2012: gorilla (not great ape) density: this study. Colours not to scale.

Human activity

General signs of hunting and other activities seen on transects

Encounter rate of human sign in 2012 was almost identical to that found in 2004 (0.6). Sign on transects this year did not include elephant carcasses: the data from the patrols will be more informative on this point as they (should) cover far more kilometres than a wildlife survey team annually, as they patrol the same areas many times every year. Signs included snares, a hunting camp, and human trails and machete cuts (Table 7), pointing to the continued use of much of the park as a hunting area.

Table 7. Number of human sign seen in the three cycles of monitoring 2004, 2008 and 2012. Only the summary encounter rate is available for 2008 (see Nzooh 2009).

	2004 (Encounter rate on transects*)	**2008 (Encounter rate)**	**2012 (Encounter rate on transects)**
Elephant carcass	1		
Wood extraction	5		
Extraction of bark, honey or palm wine			2
Footprint			2
Hunting camp			1
Machete cut			37
Path	17		13
Snare	6		7
Total	**30 (0.64)**	**(0.71)**	**64 (0.60)**

*In 2004, encounter rate on recces was 0.82 (Blake 2005)

In 2004 and 2008 the hunting signs were mapped (Nzooh 2009). We have done likewise (Fig. 11). The type of activity carried out by humans is essentially poaching. A comparison of the human sign distribution 2004-2008-2012 is shown in Fig. 12. Human sign was evident throughout the entire eastern half of the Park (as in 2004 and 2008). The area to the southwest, contiguous with Nki National park, is the least affected part of Boumba Bek (reflecting, as always, the “mirror image” effect of elephant distribution and human activity).

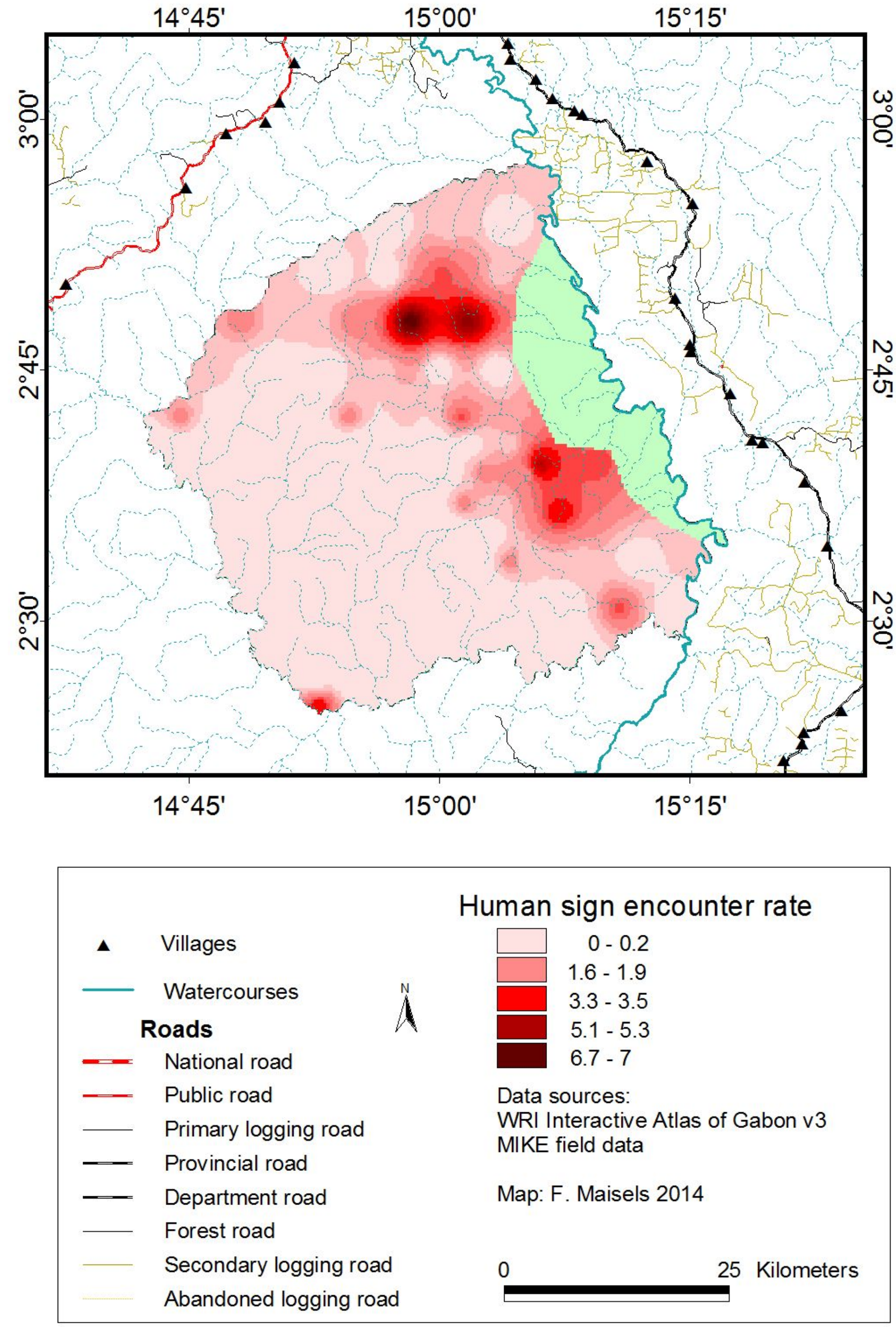


Figure 11. Human sign distribution on transects in 2012.

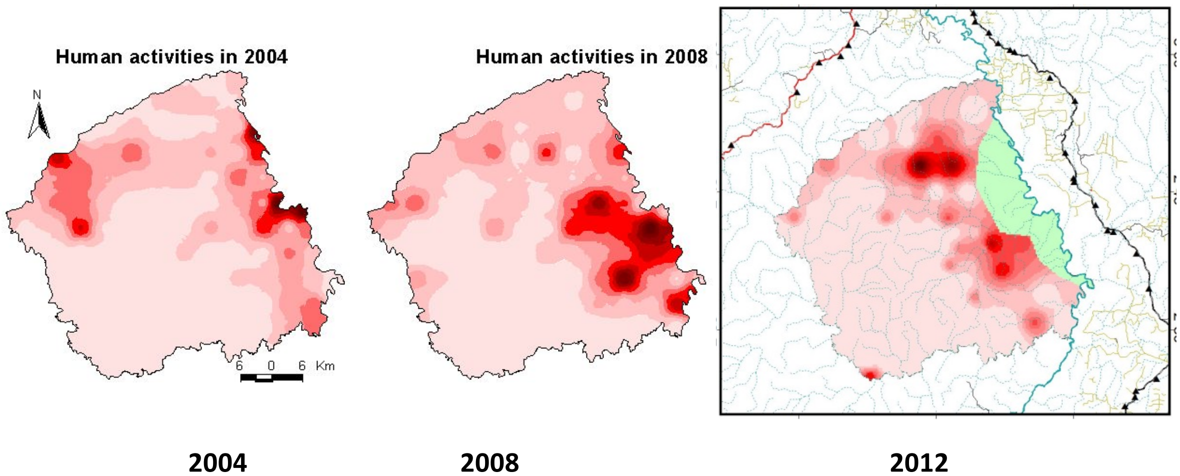


Figure 12. Human sign distribution in 2004, 2008 and 2012.

2004 and 2008: Human sign encounter rates from Nzooh (2009); and 2012: this study. Colours not to scale. Maxima in 2004, 2008 and 2012: 5.7, 3.3, and 7.0, respectively.

Discussion

Overall, the survey was completed as expected. There were difficulties in analysis from the 2008 survey as there were missing values for perpendicular distances for about 6% of the elephant dung, and the total kilometres of effort per transect were not clearly stated in the original report. However, the dung density estimate is likely to be reasonable given these caveats.

The broad conclusion is that the elephant population has remained steady 2008-2012 (at around 2000 individuals). Elephant distribution has remained the same 2004-2008-2012: the bulk of the population is concentrated away from human infrastructure and population centres, in the southwest of the Park. This is the area which is contiguous with the even larger, roadless Nki National Park, which also holds several thousand elephants (Nzooh et al 2006). Human activity distribution has also remained the same 2004-2008-2012- concentrated in the north and east of the park, closest to the road system and the settlements along them. The relatively low number of carcasses encountered by the park authorities over the years may point to an effective anti-poaching presence (although it can also point to poor patrolling: CITES 2013).

The estimate of great ape nest density was almost two-thirds lower than 2008. Nest densities in 2004 were estimated at 407 nests/ km2 (95% c.l. 269-616); in 2008 were reported to be 493 (95% c.l. 353-689); the 2012 survey, by contrast, suggested a nest density estimate of only 142 (95% c.l. 109-185). Ape distribution in the Park has been- since 2004- highest in the northern half of the Park and along the Eastern border- the areas closest to human settlements and roads. Why this distribution is so is perhaps driven by habitat: but it also means that the area where most of the apes live is the same area closest to humans and thus most vulnerable to hunting. It is possible that the apparent drop in the great ape population is due to hunting pressure. However, in the 2004 and 2008 surveys, the whole park was covered, whereas in 2012 most of the area near the road was not surveyed, so part of the ape population- possibly the densest part- was missed out of the survey design. The next survey should cover the entire Park in order to be able to better compare the series of surveys.

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Annexs

Annex 1. Waypoints for Boumba Bek, 2012 (Decimal degrees)

Stratum	Transect	Length (km)	Start point Long	Start point Lat	End point Long	End point Lat
1	1	0.8	14.87790	2.41439	14.88469	2.41447
1	2	0.54	14.93212	2.41453	14.95484	2.44351
1	3	1	14.94581	2.44347	14.95484	2.44351
1	4	1	14.90801	2.44352	14.91696	2.44359
1	5	1	14.86998	2.44356	14.87900	2.44357
1	6	1	15.02786	2.47272	15.03687	2.47259
1	7	1	14.99874	2.47270	14.98946	2.47261
1	8	1	14.96066	2.47255	14.91400	2.47228
1	9	1	14.92289	2.47254	14.91400	2.47265
1	10	1	14.88500	2.47260	14.87611	2.47264
1	11	1	14.84701	2.47265	14.83827	2.47261
1	12	1	15.12918	2.47261	15.13838	2.47255
1	13	1	15.09134	2.47267	15.10020	2.47259
1	14	1	15.11669	2.50162	15.10759	2.50169
1	15	1	15.07861	2.50169	15.06968	2.50167
1	16	1	15.03185	2.50172	15.04088	2.50165
1	17	1	15.00285	2.50169	14.99384	2.50172
1	18	1	14.96492	2.50165	14.95581	2.50172
1	19	1	14.92697	2.50165	14.91784	2.50170
1	20	1	14.88907	2.50172	14.88015	2.50169
1	21	1	14.85129	2.50164	14.84233	2.50167
1	22	1	14.82036	2.53065	14.81133	2.53076
1	23	1	14.85829	2.53080	14.84923	2.53080
1	24	1	14.89618	2.53070	14.88713	2.53070
1	25	1	14.92508	2.53075	14.92519	2.53080
1	26	1	14.97198	2.53076	14.96499	2.53080
1	27	1	15.00997	2.53078	15.00070	2.53085
1	28	1	15.04772	2.53676	15.03864	2.53075
1	29	1	15.07593	2.55984	15.06680	2.55970
1	30	1	15.03802	2.55983	15.02890	2.55961
1	31	1	15.00030	2.55990	14.99087	2.55981
1	32	1	14.96210	2.55983	14.95301	2.55970
1	33	1	14.92464	2.55966	14.99515	2.55966
1	34	1	14.88643	2.55988	14.87742	2.55965
1	35	1	14.84878	2.55597	14.83950	2.55973
1	36	1	14.80159	2.55976	14.81059	2.55985
1	37	1	14.79294	2.58885	14.78382	2.58885
1	38	1	14.83082	2.58897	14.82183	2.58887

Annex 1. Waypoints for Boumba Bek, 2012 (cont)

Stratum	Transect	Length (km)	Start point Long	Start point Lat	End point Long	End point Lat
1	39	1	14.86868	2.58889	14.85970	2.58882
1	40	1	14.90663	2.58885	14.89763	2.58885
1	41	1	14.94421	2.58890	0.00000	0.00000
1	42	1	14.98192	2.58897	0.00000	0.00000
1	43	1	0.00000	0.00000	15.01132	2.58884
1	44	1	15.05821	2.58883	15.04913	2.58897
1	45	1	15.06453	2.61765	15.05543	2.61755
1	46	1	15.02950	2.61785	15.02062	2.61783
1	47	1	15.99139	2.61804	14.98246	2.61801
1	48	1	14.95328	2.61805	14.94429	2.61792
1	49	1	14.91582	2.61792	14.90635	2.61773
1	50	1	14.87775	2.61794	14.86897	2.61788
1	51	1	14.84006	2.61795	14.83114	2.61782
1	52	1	14.79310	2.61790	14.80213	2.61790
1	53	1	2.64704	2.64703	15.07940	15.07935
1	54	1	15.05049	2.64703	15.04150	2.64703
1	55	1	15.01259	2.64703	15.00360	2.64703
1	56	1	14.97469	2.64703	14.96570	2.64703
1	57	1	14.93679	2.64703	14.92779	2.64703
1	58	1	14.89889	2.64703	14.88989	2.64702
1	59	1	14.86099	2.64702	14.85199	2.64702
1	60	1	14.82309	2.64702	14.81409	2.64702
1	61	1	14.78519	2.64701	14.77619	2.64701
1	62	0.88	14.71728	2.64700	2.64700	2.64700
1	63	1	15.07429	2.67610	15.06529	2.67610
1	64	1	15.03638	2.67610	15.02739	2.67610
1	65	1	14.99848	2.67610	14.98949	2.67610
1	66	1	14.96058	2.67610	14.95158	2.67610
1	67	1	14.92259	2.67613	14.91342	2.67609
1	68	1	14.88471	2.67616	15.87582	2.67609
1	69	1	14.84686	2.67608	14.83770	2.67606
1	70	1	14.80894	2.67610	14.79998	2.67605
1	71	1	14.77105	2.67605	14.76189	2.67600
1	72	1	14.73274	2.67610	14.72402	2.67610
2	73	1	15.24023	2.51365	15.24023	2.51369
2	74	1	15.18400	2.51366	15.17507	2.51366
2	75	1	15.12776	2.51367	15.11876	2.51367
2	76	1	15.08892	2.56131	15.07981	2.56131
2	77	1	15.13620	2.56110	15.14547	2.56103
2	78	1	15.19252	2.56124	15.20133	2.56118

Annex 1. Waypoints for Boumba Bek, 2012 (cont)

Stratum	Transect	Length (km)	Start point Long	Start point Lat	End point Long	End point Lat
2	79	1	15.24658	2.56123	15.25516	2.56130
2	80	1.06	15.12453	2.60870	15.11507	2.60873
2	81	1	15.16151	2.65621	15.15257	2.65623
2	82	1	15.10500	2.65606	15.15520	2.65609
2	83	1	15.02693	2.70376	15.01801	2.70374
2	84	1	14.97084	2.70377	14.96187	2.70374
2	85	1	14.91456	2.70360	14.90574	2.70378
2	86	1	14.85631	2.70364	14.84899	2.70371
2	87	1	14.80202	2.70366	14.79294	2.70365
2	88	1	14.74580	2.70376	14.73686	2.70368
2	89	1	14.77037	2.75123	14.77937	2.75123
2	90	1	14.82662	2.75124	14.83562	2.75124
2	91	1	14.88287	2.75124	14.89187	2.75125
2	92	1	14.93912	2.75125	14.94812	2.75125
2	93	1	14.99537	2.75125	14.99535	2.75127
2	94	1	15.05162	2.75125	15.05181	2.75125
2	95	1	15.03222	2.79877	15.02334	2.79866
2	96	1	14.97595	2.79890	14.96712	2.79867
2	97	1	14.91976	2.79873	14.91054	2.79867
2	98	1	14.86339	2.79864	14.85431	2.79860
2	99	1	14.80715	2.79876	14.79814	2.79859
2	100	1	15.06395	2.84629	15.05501	2.84640
2	101	1	15.00790	2.84625	14.99890	2.84646
2	102	1	14.95155	2.84631	14.94252	2.84615
2	103	1	14.89533	2.84630	14.88884	2.84629
2	104	1	15.06089	2.89379	15.06985	2.89379
2	105	1	15.00462	2.89382	15.01363	2.89377
2	106	1	14.94842	2.89378	14.95314	2.89376

Annex 2. All elephant dung data from 2012.

Production rate used was 19 dungpiles/ day; decay rate was 67.29965 (SE 7.258298). Area of Stratum 1 was 1015.77km^2; area of stratum 2 was 1062.75 km2

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	1	0.8	0.24	S1
1	1	0.8	0.46	S2
1	2	0.54	1.35	S3
1	2	0.54	3.02	S2
1	2	0.54	1.28	S2
1	2	0.54	1.02	S3
1	2	0.54	0.38	S1
1	2	0.54	0.23	S3
1	2	0.54	0.28	S1
1	3	1	1.03	S1
1	3	1	6.15	S2
1	3	1	1.63	S3
1	3	1	2.12	S1
1	3	1	1.18	S2
1	3	1	0.76	S1
1	3	1	1.18	S3
1	3	1	0.98	S2
1	3	1	1.09	S1
1	3	1	1.05	S1
1	4	1	0.82	S1
1	4	1	2.63	S2
1	4	1	0.49	S3
1	4	1	0.56	S2
1	4	1	1.63	S1
1	4	1	0.73	S1
1	4	1	8.2	S1
1	4	1	1.41	S2
1	4	1	2.05	S3
1	4	1	3.43	S3
1	4	1	3.07	S1
1	4	1	0.43	S3
1	4	1	2.78	S2
1	4	1	6.25	S2
1	4	1	1.25	S2
1	4	1	5.05	S1
1	4	1	7.83	S2
1	4	1	0.2	S1
1	5	1	0.23	S3
1	5	1	0.18	S3
1	5	1	3.73	S2
1	6	1	1.06	S3
1	6	1	0.72	S3
1	6	1	2.04	S3
1	6	1	0.86	S3
1	6	1	0.64	S4
1	6	1	4.12	S3
1	6	1	1.28	S1
1	6	1	0.43	S4
1	7	1	0.56	S3
1	7	1	3.54	S3
1	7	1	1.39	S2

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	5	1	0.23	S3
1	5	1	0.18	S3
1	5	1	3.73	S2
1	6	1	1.06	S3
1	6	1	0.72	S3
1	6	1	2.04	S3
1	6	1	0.86	S3
1	6	1	0.64	S4
1	6	1	4.12	S3
1	6	1	1.28	S1
1	6	1	0.43	S4
1	7	1	0.56	S3
1	7	1	3.54	S3
1	7	1	1.39	S2
1	8	1	2.52	S1
1	8	1	0.55	S2
1	8	1	2.57	S3
1	8	1	2.91	S2
1	8	1	0.32	S3
1	8	1	2.02	S3
1	8	1	3.73	S1
1	8	1	1.33	S1
1	8	1	0.4	S3
1	8	1	2.44	S1
1	8	1	2.33	S2
1	8	1	2.43	S2
1	8	1	1.07	S1
1	9	1	2.76	S3
1	9	1	0.4	S2
1	9	1	1.68	S2
1	9	1	2.66	S1
1	9	1	0.33	S2
1	9	1	1.52	S2
1	9	1	1.76	S1
1	9	1	3.73	S1
1	9	1	1.13	S2
1	9	1	4.83	S1
1	9	1	0.83	S2
1	9	1	5.06	S1
1	9	1	1.1	S2
1	10	1	3.18	S2
1	10	1	1.46	S3
1	10	1	1.7	S3
1	10	1	0.67	S3
1	10	1	2.83	S3
1	10	1	0.59	S3
1	10	1	3.55	S1
1	10	1	0.59	S2
1	10	1	6.25	S2

Annex 2 (cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	10	1	6.25	S2
1	11	1	0.27	S1
1	11	1	0.37	S3
1	11	1	1.12	S3
1	11	1	1.47	S3
1	11	1	0.57	S3
1	12	1		
1	13	1	0.71	S5
1	13	1	1.19	S4
1	14	1	0.81	S4
1	14	1	0.76	S4
1	15	1	6.58	S3
1	15	1	3.47	S3
1	15	1	5.94	S3
1	15	1	1.21	S5
1	15	1	0.24	S3
1	15	1	0.93	S3
1	15	1	5.72	S3
1	15	1	0.19	S3
1	15	1	1.87	S1
1	15	1	0.12	S3
1	15	1	1.42	S3
1	15	1	0.39	S3
1	16	1	4.31	S3
1	16	1	1.27	S3
1	16	1	1.61	S4
1	16	1	3.97	S3
1	16	1	1.52	S3
1	16	1	2.71	S3
1	16	1	0.61	S3
1	16	1	2.29	S3
1	16	1	2.74	S3
1	16	1	0.52	S3
1	16	1	1.34	S4
1	16	1	1.07	S4
1	17	1	0.64	S3
1	17	1	0.76	S3
1	17	1	4.02	S3
1	17	1	1.35	S2
1	17	1	5.04	S3
1	17	1	5.49	S3
1	17	1	3.04	S3
1	17	1	1.58	S3
1	17	1	4.83	S3
1	17	1	1.95	S3
1	17	1	3.12	S3
1	17	1	0.33	S2
1	17	1	0.58	S3
1	17	1	0.84	S3
1	17	1	0.22	S3
1	17	1	1.98	S3

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	17	1	2.92	S3
1	17	1	0.96	S3
1	17	1	1.67	S3
1	17	1	2.27	S3
1	17	1	1.74	S3
1	17	1	1.01	S1
1	17	1	0.21	S3
1	17	1	0.52	S3
1	17	1	0.38	S3
1	17	1	0.45	S3
1	17	1	0.44	S1
1	17	1	0.39	S3
1	18	1	3.13	S3
1	18	1	1.96	S3
1	18	1	0.11	S3
1	18	1	2.06	S3
1	18	1	0.92	S4
1	18	1	1.38	S3
1	18	1	0.37	S3
1	18	1	1.47	S4
1	18	1	2.16	S3
1	18	1	2.97	S3
1	18	1	4.52	S3
1	18	1	1.82	S3
1	18	1	0.11	S3
1	18	1	1.53	S3
1	18	1	0.24	S4
1	18	1	5.02	S3
1	18	1	3.32	S3
1	18	1	0.42	S3
1	18	1	2.33	S3
1	18	1	3.01	S3
1	18	1	0.12	S3
1	19	1	1.16	S3
1	19	1	0.26	S3
1	19	1	1.08	S3
1	19	1	4.02	S3
1	19	1	2.72	S3
1	19	1	0.57	S3
1	19	1	2.44	S3
1	19	1	0.86	S3
1	19	1	2.88	S3
1	19	1	3.61	S3
1	19	1	0.59	S5
1	20	1	1.26	S3
1	20	1	2.44	S3
1	20	1	2.29	S3
1	20	1	3.29	S3
1	20	1	0.67	S3
1	20	1	0.42	S3
1	20	1	2.84	S3
1	20	1	2.17	S3

Annex 2 (cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	20	1	0.22	S3
1	20	1	6.53	S3
1	20	1	2.09	S3
1	20	1	0.51	S3
1	20	1	0.86	S3
1	20	1	0.67	S3
1	20	1	0.39	S3
1	20	1	1.58	S3
1	20	1	0.39	S3
1	20	1	1.16	S3
1	20	1	2.84	S3
1	20	1	1.89	S2
1	20	1	2.06	S4
1	20	1	1.26	S4
1	20	1	1.38	S4
1	20	1	2.47	S3
1	20	1	0.73	S3
1	20	1	1.54	S3
1	21	1	1.27	S3
1	21	1	0.68	S3
1	21	1	0.49	S3
1	21	1	0.51	S3
1	21	1	1.86	S3
1	22	1	0.42	S4
1	22	1	3.71	S3
1	22	1	1.1	S3
1	22	1	1.22	S3
1	22	1	3.64	S3
1	22	1	4.59	S3
1	22	1	0.17	S3
1	22	1	0.49	S3
1	22	1	0.78	S2
1	22	1	1.77	S3
1	22	1	1.73	S3
1	22	1	0.21	S4
1	22	1	1.13	S3
1	22	1	3.4	S3
1	22	1	0.9	S3
1	22	1	2.08	S3
1	22	1	0.93	S3
1	22	1	1.02	S3
1	22	1	0.63	S3
1	22	1	0.9	S2
1	22	1	2.99	S3
1	22	1	0.04	S3
1	22	1	1.63	S3
1	22	1	0.73	S3
1	23	1	4.65	S2
1	23	1	3.1	S2
1	23	1	4.31	S2
1	23	1	0.63	S2

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	23	1	0.35	S4
1	23	1	0.61	S2
1	23	1	1.13	S2
1	24	1	3.49	S2
1	24	1	1.99	S1
1	24	1	0.46	S2
1	24	1	2.63	S2
1	24	1	1.32	S1
1	24	1	4.4	S1
1	24	1	0.5	S2
1	25	1	4.36	S1
1	25	1	2.69	S2
1	25	1	1.7	S1
1	25	1	4.63	S1
1	25	1	1.59	S1
1	25	1	0.46	S1
1	25	1	5.24	S1
1	25	1	0.9	S1
1	25	1	3.29	S2
1	25	1	0.4	S1
1	26	1	0.6	S1
1	26	1	0.46	S1
1	26	1	4.06	S1
1	26	1	4.06	S3
1	26	1	1.23	S2
1	26	1	0.63	S2
1	26	1	0.65	S2
1	26	1	1.72	S1
1	26	1	4.67	S1
1	26	1	1.51	S1
1	27	1	3.03	S3
1	27	1	3.77	S3
1	27	1	0.33	S3
1	27	1	4.6	S3
1	27	1	1.54	S3
1	27	1	0.59	S4
1	27	1	3.12	S1
1	27	1	1.45	S3
1	27	1	4.42	S2
1	27	1	0.37	S3
1	27	1	2.2	S1
1	28	1	3.69	S1
1	28	1	0.2	S3
1	28	1	0.35	S4
1	28	1	0.6	S4
1	28	1	2.03	S4
1	28	1	2.51	S3
1	28	1	2.52	S3
1	29	1	9.91	S3
1	29	1	4.41	S3
1	29	1	3.83	S3

Annex 2 (cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	29	1	0.47	S3
1	29	1	5.53	S3
1	29	1	3.23	S3
1	29	1	2.31	S2
1	29	1	5.22	S3
1	29	1	2.45	S3
1	29	1	5.51	S3
1	29	1	6.64	S2
1	29	1	0.48	S3
1	29	1	0.47	S2
1	29	1	9.48	S2
1	29	1	0.97	S2
1	29	1	2.76	S4
1	29	1	7.49	S2
1	29	1	5.82	S3
1	30	1	3.81	S2
1	30	1	0.91	S2
1	30	1	1.14	S2
1	30	1	0.85	S2
1	30	1	0.8	S2
1	30	1	2.46	S4
1	30	1	2.93	S2
1	30	1	0.34	S4
1	30	1	0.22	S4
1	30	1	8.82	S2
1	30	1	7.11	S2
1	30	1	3.45	S2
1	30	1	1.04	S2
1	30	1	1.77	S3
1	30	1	2.58	S2
1	30	1	2.35	S3
1	30	1	3.58	S3
1	30	1	1.76	S2
1	30	1	6.25	S2
1	30	1	3.55	S2
1	30	1	8.03	S2
1	30	1	2.99	S2
1	30	1	1.03	S2
1	31	1	1.38	S2
1	31	1	4.8	S2
1	31	1	1.36	S2
1	31	1	1.6	S2
1	31	1	9.91	S3
1	31	1	5.02	S2
1	31	1	0.46	S3
1	31	1	4.02	S3
1	31	1	2.88	S2
1	31	1	4.08	S2
1	31	1	4.3	S2
1	31	1	1.64	S2
1	31	1	2.11	S4

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	31	1	1.07	S4
1	31	1	0.44	S4
1	31	1	0.42	S3
1	31	1	6.25	S3
1	31	1	2.05	S2
1	31	1	0.82	S2
1	31	1	1.35	S1
1	31	1	3.54	S1
1	31	1	2.48	S4
1	31	1	1.03	S2
1	31	1	5.91	S2
1	31	1	4.89	S2
1	31	1	1.8	S2
1	31	1	1.5	S2
1	31	1	2.38	S4
1	31	1	3.34	S2
1	31	1	1.2	S3
1	31	1	1.37	S3
1	31	1	0.76	S3
1	31	1	1.47	S4
1	32	1	0.42	S3
1	32	1	2.72	S3
1	32	1	3.11	S3
1	32	1	1.82	S2
1	32	1	0.98	S3
1	32	1	1.99	S2
1	32	1	9.27	S3
1	32	1	6.83	S2
1	32	1	6.87	S3
1	32	1	0.14	S3
1	32	1	3.17	S3
1	32	1	2.83	S2
1	32	1	0.48	S3
1	32	1	3.87	S2
1	32	1	3.69	S2
1	32	1	8.71	S2
1	32	1	3.02	S4
1	32	1	4.46	S2
1	32	1	2.42	S2
1	32	1	1.17	S2
1	32	1	1.83	S2
1	33	1	1.29	S2
1	33	1	1.21	S3
1	33	1	1.1	S2
1	33	1	0.37	S2
1	33	1	0.42	S3
1	33	1	1.31	S3
1	33	1	1.07	S2
1	33	1	0.36	S2
1	33	1	2.96	S3
1	33	1	0.87	S2

Annex 2 (cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	33	1	0.52	S2
1	33	1	4.12	S4
1	33	1	4.57	S2
1	34	1	0.82	S3
1	34	1	1.38	S2
1	34	1	2.32	S2
1	34	1	1.11	S3
1	34	1	2.6	S2
1	34	1	0.1	S3
1	34	1	0.36	S2
1	34	1	1.48	S2
1	34	1	1.7	S2
1	34	1	2.37	S3
1	34	1	1.35	S2
1	34	1	1.17	S2
1	34	1	3.41	S2
1	34	1	1.89	S2
1	34	1	2.22	S3
1	34	1	2.62	S3
1	34	1	1.43	S3
1	34	1	0.34	S2
1	34	1	1.71	S2
1	34	1	0.23	S2
1	34	1	1.82	S2
1	34	1	2.54	S4
1	34	1	1.08	S2
1	34	1	0.12	S2
1	34	1	2.14	S2
1	34	1	4.15	S1
1	34	1	1.23	S2
1	34	1	2.39	S2
1	35	1	3.22	S4
1	35	1	1.62	S2
1	35	1	0.34	S2
1	35	1	0.98	S2
1	35	1	6.68	S2
1	35	1	3.24	S2
1	35	1	1.18	S2
1	35	1	1.87	S2
1	35	1	0.41	S2
1	35	1	2.42	S2
1	35	1	5.85	S2
1	35	1	1.16	S4
1	35	1	3.14	S2
1	35	1	3.26	S2
1	35	1	5.73	S2
1	36	1	1.81	S2
1	36	1	0.84	S4
1	36	1	0.76	S2
1	36	1	3.3	S2
1	36	1	2.34	S2
1	36	1	3.47	S2
1	36	1	4.53	S2
1	36	1	2.33	S3
1	36	1	0.28	S2
1	36	1	1.91	S3
1	36	1	0.8	S4
1	36	1	0.54	S2
1	36	1	1.38	S2
1	36	1	0.76	S2
1	36	1	0.23	S2
1	36	1	1.47	S2
1	36	1	0.89	S2
1	36	1	0.9	S2
1	36	1	2.76	S2
1	36	1	3.61	S2
1	36	1	0.44	S2
1	36	1	0.62	S3
1	36	1	1.4	S3
1	36	1	0.76	S3
1	36	1	0.48	S3
1	36	1	0.61	S2
1	36	1	2.5	S2
1	37	1	1.57	S3
1	38	1	0.67	S3
1	38	1	1.46	S2
1	38	1	1.77	S2
1	39	1	0.76	S3
1	39	1	1.82	S2
1	39	1	5.43	S2
1	39	1	0.72	S3
1	39	1	2.05	S1
1	39	1	0.34	S2
1	39	1	0.56	S1
1	39	1	2.04	S1
1	39	1	12.93	S1
1	39	1	1.27	S3
1	39	1	0.41	S1
1	39	1	0.26	S1
1	39	1	0.31	S1
1	39	1	0.73	S3
1	39	1	4.21	S3
1	39	1	3.71	S3
1	40	1	0.51	S3
1	41	1	0.91	S2
1	41	1	4.38	S2
1	41	1	2.55	S2
1	41	1	3.55	S1
1	42	1	0.32	S3
1	42	1	4.61	S1
1	42	1	2.46	S3
1	42	1	0.36	S2

Annex 2 (cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	42	1	4.51	S2
1	43	1	1.55	S3
1	43	1	0.26	S1
1	43	1	4.14	S2
1	43	1	3	S2
1	43	1	1.9	S2
1	43	1	2.8	S1
1	43	1	6.8	S2
1	43	1	1.82	S2
1	43	1	0.14	S3
1	43	1	0.57	S2
1	44	1	0.8	S4
1	44	1	0.77	S3
1	44	1	1.75	S3
1	44	1	2	S3
1	44	1	0.36	S2
1	44	1	4.1	S2
1	44	1	0.46	S2
1	45	1	0.63	S4
1	45	1	2.02	S2
1	45	1	1.28	S2
1	45	1	1.03	S3
1	45	1	0.76	S3
1	45	1	1.29	S4
1	45	1	0.8	S4
1	45	1	1.57	S2
1	45	1	1.24	S2
1	45	1	2.86	S4
1	45	1	3.68	S3
1	45	1	1.43	S4
1	45	1	0.58	S2
1	45	1	0.77	S2
1	45	1	1.33	S2
1	45	1	2.62	S2
1	45	1	3.08	S2
1	45	1	0.92	S2
1	45	1	2.31	S2
1	45	1	8.13	S2
1	45	1	2.18	S4
1	45	1	2.87	S2
1	45	1	0.75	S2
1	45	1	2.53	S2
1	45	1	2.26	S4
1	45	1	5.18	S4
1	46	1	2.01	S2
1	46	1	0.38	S2
1	46	1	1.36	S1
1	46	1	0.19	S1
1	46	1	6.38	S2
1	46	1	3.12	S2
1	46	1	3.59	S4

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	46	1	3.1	S3
1	46	1	2.66	S3
1	46	1	0.93	S4
1	46	1	5.06	S3
1	46	1	7.07	S2
1	46	1	2.57	S4
1	46	1	8.93	S3
1	47	1	0.7	S2
1	47	1	0.64	S4
1	47	1	3.82	S2
1	47	1	3.7	S4
1	47	1	6.75	S3
1	47	1	7.32	S2
1	47	1	3.31	S4
1	47	1	1.69	S2
1	47	1	0.28	S2
1	47	1	0.58	S2
1	47	1	0.93	S2
1	48	1	0.59	S2
1	48	1	0.94	S2
1	48	1	1.76	S2
1	48	1	4.06	S2
1	48	1	0.55	S2
1	48	1	5.32	S2
1	48	1	1.7	S3
1	48	1	6.46	S2
1	48	1	7.07	S2
1	48	1	0.63	S4
1	48	1	2.35	S4
1	48	1	2.03	S2
1	48	1	7.61	S2
1	48	1	2.55	S2
1	48	1	1.84	S3
1	48	1	2.49	S2
1	48	1	3.03	S2
1	48	1	2.06	S2
1	48	1	3.86	S2
1	48	1	0.99	S4
1	48	1	0.19	S3
1	48	1	2.8	S2
1	48	1	1.17	S2
1	48	1	0.4	S4
1	48	1	4.57	S2
1	48	1	4.2	S4
1	48	1	0.52	S4
1	48	1	3.37	S2
1	48	1	0.44	S4
1	48	1	1.78	S3
1	48	1	1.83	S2
1	48	1	0.55	S4
1	48	1	0.86	S4

Annex 2 (cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	49	1	4.68	S2
1	49	1	1.31	S3
1	49	1	2.05	S4
1	49	1	0.15	S4
1	49	1	0.98	S2
1	49	1	3.21	S2
1	49	1	1.01	S2
1	49	1	0.31	S2
1	49	1	2.4	S2
1	49	1	3.92	S2
1	49	1	1.27	S2
1	49	1	1.86	S2
1	49	1	2.22	S2
1	49	1	1.11	S3
1	50	1	1.64	S3
1	50	1	1.79	S3
1	50	1	3.84	S2
1	50	1	2.28	S3
1	50	1	3.33	S2
1	50	1	0.69	S2
1	50	1	0.85	S2
1	50	1	1.23	S2
1	50	1	0.52	S2
1	50	1	2.2	S2
1	50	1	0.54	S2
1	50	1	3.21	S1
1	50	1	0.48	S2
1	50	1	2.34	S2
1	50	1	2.52	S2
1	50	1	3.69	S2
1	50	1	1.08	S3
1	50	1	2.25	S2
1	50	1	2.5	S3
1	50	1	0.28	S4
1	50	1	6.16	S4
1	50	1	3.74	S4
1	50	1	5.34	S2
1	50	1	4.33	S2
1	50	1	0.48	S3
1	50	1	3.55	S2
1	50	1	2.87	S3
1	51	1	0.14	S4
1	51	1	4.17	S3
1	51	1	4.35	S2
1	51	1	1.35	S4
1	51	1	7.58	S3
1	51	1	5.46	S2
1	51	1	0.29	S2
1	51	1	1.12	S1
1	51	1	1.35	S2
1	51	1	9.15	S1

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	51	1	11.07	S1
1	51	1	4.2	S2
1	51	1	1.68	S1
1	51	1	0.08	S1
1	51	1	5.41	S1
1	51	1	6.54	S1
1	51	1	2.38	S1
1	51	1	3.52	S1
1	51	1	4.84	S1
1	51	1	4.54	S2
1	51	1	7.94	S1
1	51	1	11.79	S2
1	51	1	11.64	S2
1	51	1	3.94	S1
1	51	1	7.05	S2
1	51	1	3.09	S1
1	51	1	4.24	S2
1	51	1	1.71	S4
1	51	1	1.45	S2
1	51	1	4.12	S2
1	51	1	2.02	S3
1	51	1	1.99	S2
1	51	1	0.36	S1
1	51	1	1.13	S4
1	51	1	1.67	S4
1	51	1	2.33	S2
1	51	1	5.55	S2
1	51	1	4.34	S2
1	51	1	2.47	S2
1	51	1	3.13	S2
1	52	1	1.52	S4
1	52	1	3.98	S2
1	52	1	8.11	S2
1	52	1	5.83	S2
1	52	1	6.73	S2
1	52	1	3.08	S2
1	52	1	0.33	S2
1	52	1	1.93	S2
1	52	1	1.97	S2
1	52	1	1.12	S2
1	52	1	4.19	S2
1	52	1	2.04	S2
1	52	1	5.66	S2
1	52	1	5.69	S2
1	52	1	1.86	S2
1	52	1	1.64	S2
1	52	1	3.76	S2
1	52	1	2.88	S2
1	52	1	2.87	S2
1	53	1	0.95	S4
1	53	1	1.29	S3

Annex 2 (cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	53	1	5.09	S4
1	53	1	3.32	S4
1	53	1	0.7	S4
1	53	1	2.02	S2
1	53	1	0.2	S3
1	53	1	1.5	S3
1	53	1	2.23	S3
1	53	1	2.91	S3
1	54	1	0.2	S3
1	54	1	2.06	S3
1	54	1	0.09	S3
1	54	1	1.9	S3
1	54	1	0.3	S3
1	55	1	0.28	S2
1	55	1	0.44	S3
1	55	1	2.91	S3
1	55	1	1.05	S3
1	55	1	5.07	S3
1	55	1	1.5	S3
1	55	1	2.16	S4
1	55	1	1.04	S2
1	55	1	0.47	S3
1	55	1	2.05	S3
1	55	1	3.82	S3
1	55	1	2.26	S3
1	56	1	0.79	S3
1	56	1	2.5	S3
1	56	1	0.39	S3
1	57	1	0.62	S3
1	57	1	2.01	S3
1	57	1	1.06	S3
1	57	1	0.3	S3
1	57	1	1.46	S3
1	57	1	1.36	S1
1	58	1	0.27	S3
1	58	1	0.4	S3
1	58	1	2.76	S4
1	58	1	2.25	S2
1	58	1	0.39	S3
1	58	1	2.31	S1
1	59	1	0.56	S4
1	59	1	1.4	S4
1	59	1	1.43	S3
1	60	1	3.2	S2
1	60	1	0.6	S1
1	60	1	2.57	S3
1	60	1	1.61	S3
1	60	1	2.04	S3
1	60	1	2.15	S3
1	60	1	0.68	S1
1	60	1	0.27	S3

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	61	1	0.34	S2
1	61	1	2.62	S3
1	61	1	2.9	S2
1	61	1	0.51	S1
1	61	1	0.69	S3
1	61	1	0.65	S2
1	62	0.88	0.24	S2
1	62	0.88	3.92	S2
1	62	0.88	0.47	S1
1	62	0.88	1.8	S1
1	63	1	4.08	S3
1	63	1	2.62	S3
1	63	1	5.54	S3
1	63	1	4.74	S3
1	63	1	1.58	S3
1	63	1	0.21	S3
1	64	1	5.58	S3
1	64	1	0.44	S3
1	64	1	0.52	S3
1	64	1	3.81	S3
1	64	1	0.99	S3
1	64	1	0.43	S3
1	64	1	2.84	S3
1	64	1	7.02	S3
1	64	1	0.52	S1
1	64	1	2.27	S3
1	64	1	4.87	S3
1	64	1	1.78	S3
1	64	1	0.33	S3
1	64	1	2.33	S3
1	65	1	1.17	S2
1	65	1	0.17	S3
1	65	1	0.17	S3
1	65	1	0.68	S3
1	65	1	4.51	S1
1	65	1	5.91	S1
1	65	1	0.41	S1
1	65	1	4.01	S3
1	65	1	2.22	S3
1	65	1	5.97	S1
1	65	1	1.68	S2
1	65	1	0.32	S3
1	66	1	0.61	S4
1	66	1	0.15	S2
1	66	1	1.83	S3
1	66	1	1.72	S3
1	66	1	0.76	S3
1	66	1	3.21	S2
1	66	1	0.6	S3
1	66	1	4.96	S3
1	66	1	8.28	S3

Annex 2 (Cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	66	1	2.87	S2
1	66	1	0.91	S1
1	66	1	3.12	S3
1	66	1	0.56	S1
1	66	1	4.12	S3
1	66	1	1.94	S3
1	66	1	3.89	S3
1	66	1	1.16	S3
1	66	1	4.03	S3
1	66	1	12.03	S3
1	66	1	0.48	S3
1	67	1	4.37	S3
1	67	1	2.74	S4
1	67	1	3.03	S3
1	67	1	3.64	S3
1	67	1	0.52	S3
1	67	1	2.24	S3
1	67	1	3.36	S3
1	67	1	0.94	S3
1	67	1	2.44	S3
1	67	1	3.57	S3
1	67	1	3.96	S3
1	67	1	6.33	S1
1	67	1	0.43	S4
1	67	1	1.79	S4
1	67	1	3.89	S3
1	67	1	3.25	S1
1	68	1	2.09	S4
1	68	1	0.53	S3
1	68	1	5.78	S2
1	68	1	2.94	S4
1	68	1	2.23	S4
1	68	1	2.86	S3
1	68	1	0.04	S3
1	68	1	0.26	S3
1	68	1	3.53	S4
1	68	1	0.26	S3
1	68	1	1.68	S3
1	68	1	2.75	S3
1	68	1	2.23	S3
1	68	1	0.34	S3
1	68	1	2.24	S3
1	68	1	4.37	S3
1	68	1	3.54	S3
1	69	1	1.64	S4
1	69	1	0.46	S4
1	69	1	4.83	S3
1	69	1	2.31	S3
1	69	1	3.53	S4
1	69	1	0.53	S3
1	69	1	2.88	S3

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	69	1	0.41	S3
1	69	1	0.46	S3
1	69	1	3.43	S3
1	69	1	3.36	S3
1	69	1	5.61	S3
1	69	1	2.67	S3
1	69	1	0.05	S3
1	69	1	0.99	S3
1	69	1	3.26	S3
1	69	1	2.74	S3
1	69	1	0.32	S3
1	69	1	2.09	S4
1	69	1	2.28	S3
1	69	1	4.56	S3
1	69	1	0.14	S3
1	69	1	2.46	S3
1	69	1	0.36	S3
1	69	1	0.09	S3
1	69	1	2.82	S3
1	69	1	3.11	S3
1	69	1	0.13	S3
1	69	1	5.53	S3
1	69	1	4.82	S3
1	70	1	1.34	S3
1	70	1	2.12	S3
1	70	1	2.42	S3
1	70	1	1.58	S3
1	70	1	2.69	S3
1	70	1	3.57	S3
1	70	1	1.41	S3
1	70	1	1.54	S3
1	70	1	5.22	S3
1	70	1	1.16	S3
1	70	1	1.84	S3
1	70	1	0.71	S3
1	70	1	2.88	S3
1	70	1	0.47	S2
1	70	1	0.76	S3
1	70	1	0.27	S3
1	70	1	0.29	S3
1	70	1	2.54	S3
1	70	1	0.97	S3
1	70	1	0.03	S3
1	70	1	0.07	S3
1	70	1	1.33	S3
1	71	1	1.85	S2
1	71	1	4.11	S2
1	71	1	5.18	S2
1	71	1	3.08	S4
1	71	1	2.33	S3
1	71	1	1.93	S3

Annex 2 (Cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
1	71	1	0.27	S4
1	71	1	1.74	S3
1	71	1	4.41	S3
1	71	1	3.13	S1
1	71	1	4.14	S3
1	71	1	0.48	S3
1	71	1	4.13	S3
1	71	1	4.06	S3
1	71	1	0.64	S3
1	71	1	0.43	S3
1	71	1	6.37	S3
1	71	1	8.52	S3
1	71	1	4.85	S3
1	71	1	0.31	S3
1	71	1	1.51	S3
1	71	1	2.62	S2
1	71	1	0.16	S3
1	71	1	0.24	S2
1	71	1	1.81	S3
1	71	1	2.26	S3
1	71	1	1.74	S3
1	71	1	0.97	S3
1	71	1	2.61	S3
1	71	1	6.51	S3
1	71	1	4.31	S3
1	71	1	0.52	S4
1	72	1	3.47	S3
1	72	1	0.38	S3
1	72	1	3.68	S5
1	72	1	0.72	S2
1	72	1	0.13	S5
1	72	1	0.56	S4
1	72	1	3.16	S3
2	73	1	1.32	S3
2	73	1	0.45	S3
2	73	1	0.25	S3
2	73	1	4.11	S3
2	73	1	0.31	S3
2	74	1		
2	75	1	2.62	S3
2	75	1	1.1	S2
2	75	1	0.93	S1
2	75	1	0.47	S3
2	75	1	3.64	S3
2	76	1	2.41	S4
2	76	1	0.81	S2
2	76	1	3.94	S4
2	76	1	6.03	S4
2	76	1	1.97	S2
2	76	1	2.19	S1
2	76	1	5.47	S1

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
2	76	1	0.25	S2
2	76	1	3.77	S4
2	76	1	2.75	S3
2	76	1	1.57	S3
2	76	1	1.87	S4
2	76	1	1.08	S4
2	76	1	1.03	S2
2	77	1	0.76	S3
2	77	1	0.66	S4
2	77	1	2.67	S3
2	78	1	1.97	S3
2	78	1	0.46	S4
2	79	1	0.93	S4
2	79	1	4.54	S4
2	80	1.06		
2	81	1	0.11	S5
2	81	1	0.65	S2
2	81	1	1.46	S4
2	81	1	0.94	S3
2	82	1	0.41	S3
2	82	1	0.73	S3
2	82	1	0.27	S3
2	82	1	0.34	S3
2	82	1	0.94	S4
2	83	1	3.93	S3
2	83	1	2.42	S3
2	83	1	2.47	S3
2	83	1	0.89	S3
2	83	1	4.28	S3
2	83	1	3.24	S3
2	83	1	0.53	S4
2	83	1	3.57	S3
2	83	1	2.01	S3
2	83	1	1.79	S3
2	83	1	13.26	S3
2	83	1	3.42	S3
2	83	1	2.32	S3
2	83	1	0.84	S4
2	83	1	1.74	S4
2	83	1	1.51	S4
2	83	1	2.98	S4
2	83	1	2.98	S4
2	83	1	0.29	S4
2	83	1	0.38	S3
2	83	1	0.14	S3
2	83	1	1.88	S3
2	83	1	0.47	S3
2	83	1	6.72	S3
2	83	1	3.27	S4
2	84	1	0.67	S4
2	84	1	5.56	S3

Annex 2 (Cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
2	84	1	3.08	S4
2	84	1	1.28	S4
2	84	1	2.13	S4
2	84	1	0.64	S5
2	85	1	4.48	S3
2	85	1	0.79	S3
2	85	1	1.72	S3
2	85	1	1.79	S4
2	85	1	3.14	S4
2	85	1	1.09	S4
2	85	1	0.12	S4
2	85	1	2.98	S4
2	85	1	2.09	S4
2	85	1	0.89	S4
2	85	1	1.34	S4
2	85	1	1.64	S3
2	86	1	2.91	S3
2	86	1	1.79	S3
2	86	1	1.14	S3
2	86	1	4.76	S3
2	86	1	2.72	S3
2	86	1	1.34	S3
2	86	1	2.59	S3
2	86	1	3.97	S1
2	86	1	5.19	S3
2	86	1	3.24	S3
2	86	1	4.71	S3
2	86	1	2.71	S3
2	86	1	1.31	S3
2	86	1	3.69	S1
2	86	1	4.77	S3
2	86	1	1.68	S3
2	86	1	4.81	S3
2	87	1	1.86	S4
2	87	1	0.64	S3
2	87	1	1.88	S3
2	87	1	4.74	S3
2	87	1	6.91	S3
2	87	1	0.29	S3
2	87	1	0.46	S3
2	87	1	2.09	S3
2	87	1	0.49	S3
2	87	1	1.59	S3
2	87	1	2.33	S3
2	88	1	0.22	S3
2	88	1	0.12	S3
2	88	1	0.59	S3
2	88	1	0.56	S3
2	88	1	0.54	S3
2	88	1	1.29	S3
2	88	1	4.64	S3

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
2	88	1	1.06	S3
2	88	1	0.44	S3
2	88	1	2.71	S3
2	88	1	3.84	S3
2	88	1	0.11	S3
2	88	1	0.66	S3
2	88	1	2.89	S4
2	88	1	0.84	S4
2	88	1	4.18	S3
2	88	1	5.81	S3
2	88	1	0.62	S3
2	88	1	2.14	S3
2	88	1	2.33	S3
2	88	1	1.81	S3
2	88	1	1.84	S3
2	88	1	0.44	S3
2	89	1	0.18	S3
2	89	1	0.94	S3
2	89	1	1.27	S4
2	89	1	2.23	S3
2	90	1	0.98	S1
2	90	1	0.43	S1
2	90	1	0.72	S3
2	90	1	2.92	S1
2	91	1		
2	92	1	0.43	S3
2	92	1	0.82	S3
2	92	1	0.77	S4
2	92	1	3.1	S3
2	92	1	0.6	S3
2	92	1	1.98	S3
2	92	1	2.06	S3
2	92	1	4.96	S3
2	92	1	0.33	S3
2	92	1	1.17	S3
2	92	1	2.07	S3
2	93	1	0.96	S3
2	93	1	1.17	S3
2	93	1	3.17	S3
2	93	1	0.98	S2
2	93	1	1.07	S2
2	94	1	0.87	S2
2	95	1	3.65	S4
2	95	1	1.83	S4
2	95	1	0.42	S3
2	95	1	0.92	S4
2	95	1	0.13	S4
2	96	1		
2	97	1		
2	98	1		
2	99	1		

Annex 2 (Cont)

Stratum	Transect	Length (km)	Perp Dist (m)	Dung class
2	100	1		
2	101	1	3.11	S2
2	101	1	0.21	S2
2	101	1	0.41	S2
2	101	1	0.32	S2
2	101	1	2.05	S2
2	102	1	0.65	S4
2	102	1	1.05	S3
2	102	1	0.27	S3
2	103	1		
2	104	1		
2	105	1	2.81	S3
2	105	1	0.59	S3
2	105	1	0.44	S2
2	105	1	0.48	S1
2	105	1	2.06	S4
2	105	1	3.41	S4
2	106	1		

Annex 3. Mission dates

Team leader	Transects	Date start	Date end
Bariga	6	06 February 2012	06 February 2012
	12 to 21	08 February 2012	04 February 2012
	63 to 72	15 January 2012	23 January 2012
	82 to 88	14 January 2012	03 March 2012
	100 to 106	24 March 2012	29 March 2012
Bechem	29 to 36	04 February 2012	11 February 2012
	45 to 52	16 January 2012	24 January 2012
	76 to 80	03 February 2012	14 January 2012
	95 to 99	29 February 2012	04 March 2012
Mahop	22 to 28	08 February 2012	04 February 2012
	53 to 62	16 January 2012	24 January 2012
	73 to 75	15 February 2012	12 February 2012
	89 to 94	04 March 2012	28 February 2012
	81	14 January 2012	
Mengamenya	1 to 5	11 February 2012	10 February 2012
	7 to 11	07 February 2012	09 February 2012
	37 to 44	23 January 2012	18 January 2012

Annex 4. Logistic regression model to separate gorillas from chimps

Analysis to predict ape species for ape nests from Odzala / SE Cameroon / Messok Dja surveys (guided recces removed)

Samantha Strindberg – April 2013

A logistic regression model was used to predict the ape species for those nests not attributed to either chimpanzee or gorilla (excluding the Messok Dja data to fit the model, as the nest heights were likely overestimated). Explanatory variables considered included:

Nest Height (this was measured in meters),

Tree Height (this was a categorical variable 0-8 rather than an exact measurement),

Habitat Type – habitat classes were combined to deal with small sample size issues (e.g. a category only used by GG was combined with another only used by GG)

Nest Type and various forms of cover were standardized.

The logistic regression analysis was conducted using the R software. Chimpanzees (PT) were coded as zero and gorillas (GG) as one, and a binomial distribution with a "cloglog" link. The predicted probability decreases, i.e. more likely PT, for increasing Nest Height. GG were more likely in the consolidated FM, FMSFM, RAP & TR Habitats and PT more likely in FMSF, FMSO & MC. PT were more likely with increased Canopy Cover and height of Ground Cover and a Ground Cover of type A. .

Key variables used to accurately determine nest builder included Nest Height, Habitat Type, Nest Type and height of Ground Cover. The same models were used to make builder predictions for Messok Dja where all Nest Height and Habitat Type data had been recorded.

Table 1: Key models used to predict nest builder 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.

Model	% Correctly classified Overall	Species breakdown of incorrect classifications		Total incorrect classifications	Total NAs
		%GG	% PT		
Nest Height + Habitat	**98.79**	31.58	68.42	19	31
Nest Height	**98.61**	40.91	59.09	22	17
Habitat	93.37	85.71	14.29	105	18
Nest Type	**98.29**	0	100	27	19
Canopy Cover	72.5	80.3	19.7	66	1362
Ground Cover	84.62	10	90	40	1342
Ground Cover Height	**99.16**	100	0	3	1243
Cover under Nest	87.57	100	0	22	1425

Annex 5. Summary report of 2008.

SUMMARY OF LARGE MAMMAL POPULATION AND SPATIAL DISTRIBUTION IN BOUMBA NATIONAL PARK BETWEEN 2004 -2008

SUMMARY

Zacharie-L NZOOH DONGMO[2]

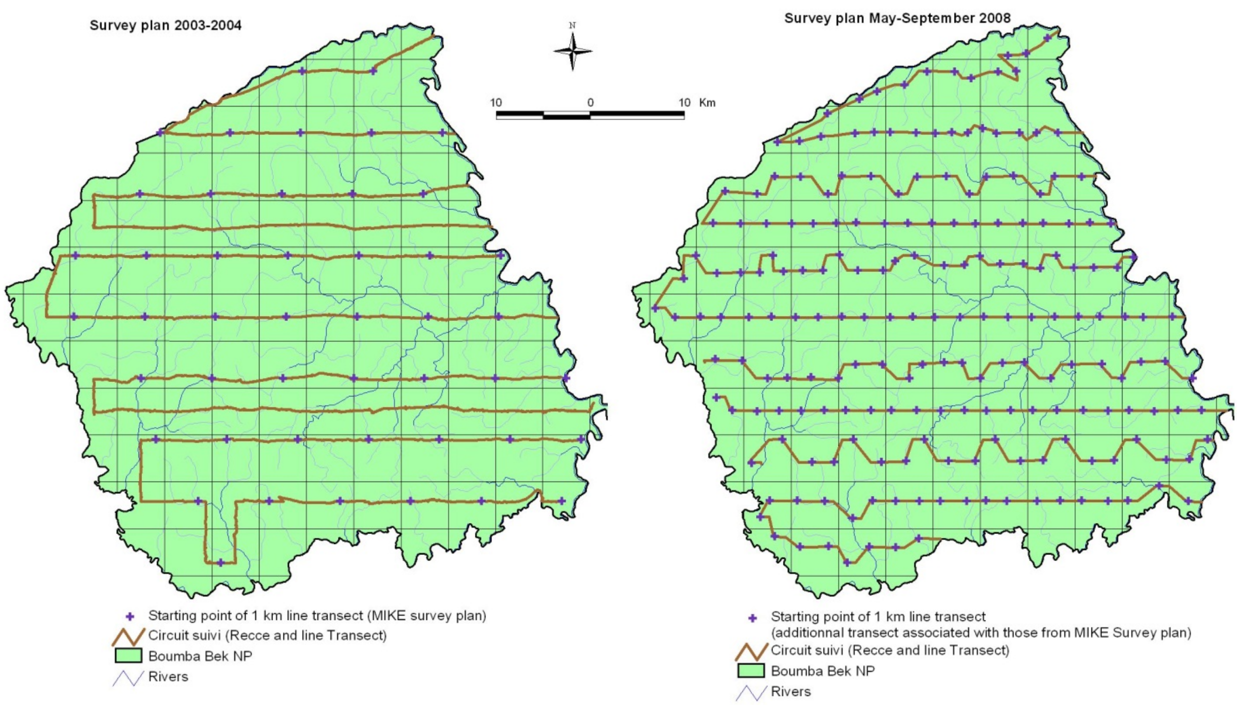
WWF

November 2009

[2] **Contact address : WWF CCPO JSEFP, BP 6776 Yaoundé**

Znzooh@wwfcarpo.org / nzooh_dongmo@yahoo.com

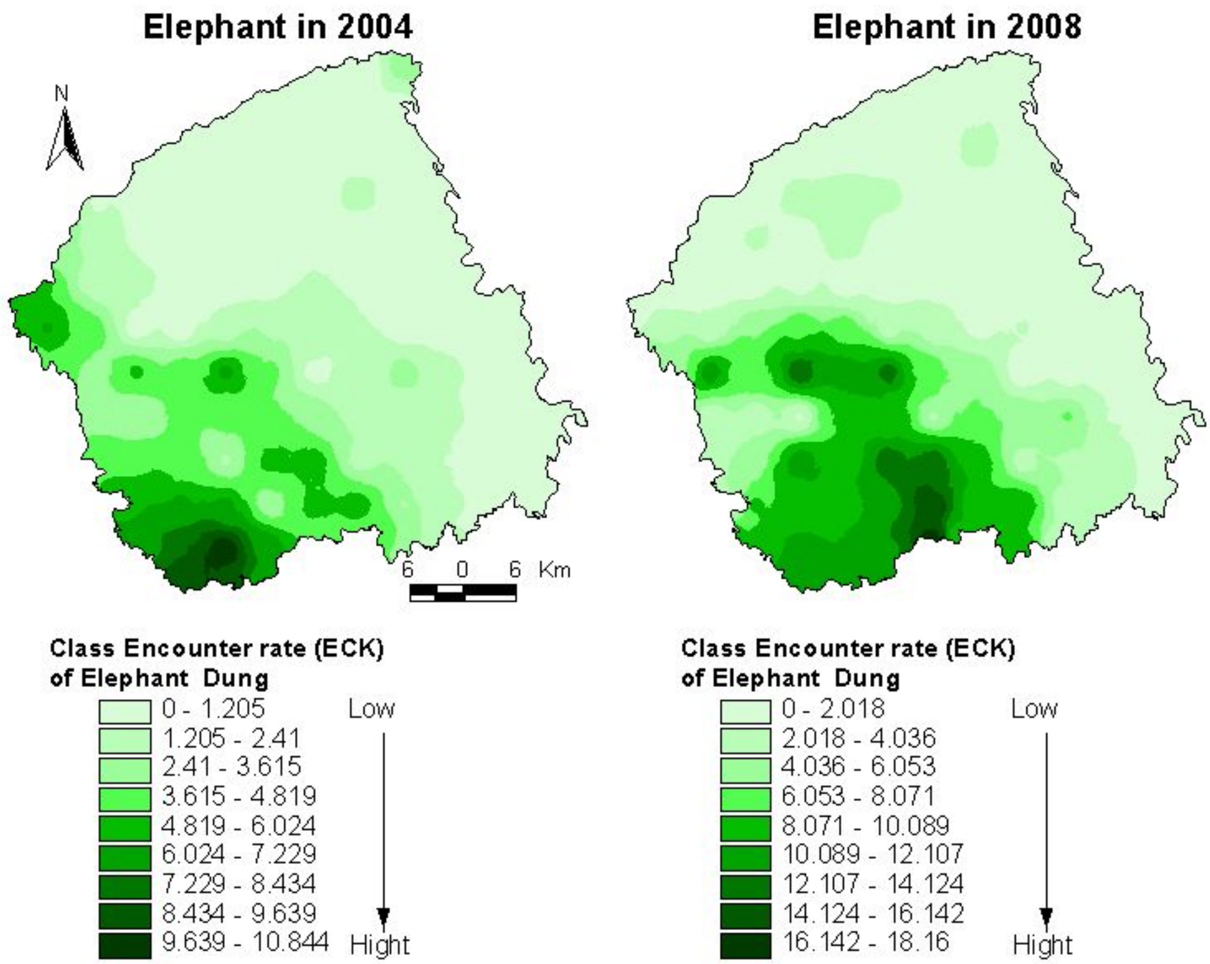
Summary of survey methods



Map of surveys plan for 2003-2004 and for 2008

Data was collected along the line transect of 1km and reccee. A total of 44 line transect was made in 2004 (based on Mike survey plan), and 191 transect in 2008. The survey plan in 2004 was made, using the encounter rate of elephant dung pile from pilot survey. That for 2008 was from the grid of 5 x 5 km from the Park; in each grid, at least 2 transect was made (base on national norm stipulating that at least 2.5 km of transect should be made in each grid of 5x5 km).

ELEPHANT POPULATION DYNAMICS AND TREND WITHIN BOUMBA BEK NATIONAL PARK BETWEEN 2004 TO 2008

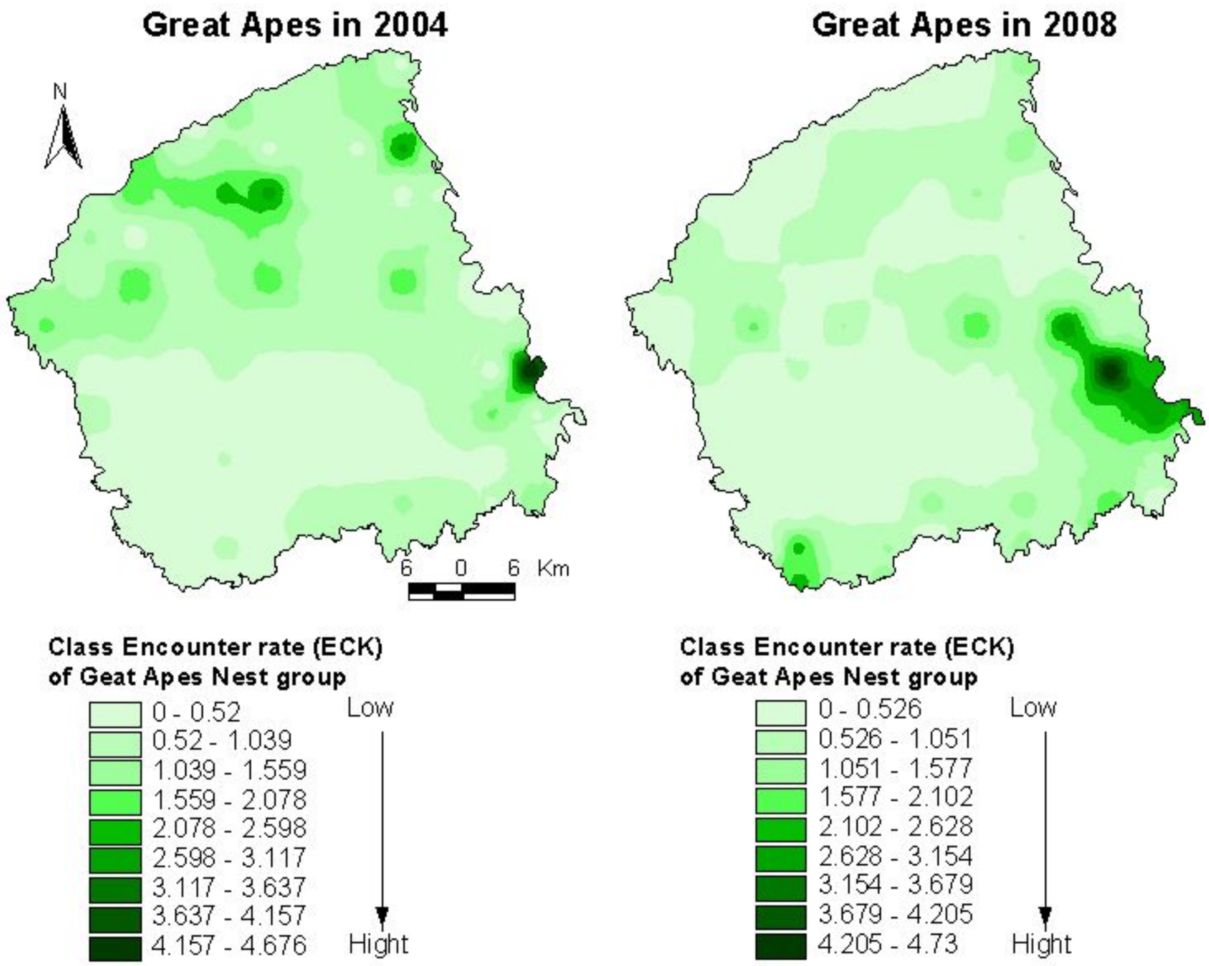


Statistical data of elephant population trend

	2004	**2008**
Kilometric encounter rate of dung pile	2.00 ± 0.25	5.588 ± 0.21
Dung pile density (dung/km2)	-	1934.9 [1606.7 - 2330.1]
Estimated elephant density	-	0.87 [0.73 – 1.05]
Estimated total population	**-**	**2183 [1813 – 2629]**

Comments: During the surveys period, logging activities in the concession UFA 10-015, close to Boumba Bek and Nki NPs, coupled with the increase of elephant poaching using war guns (AK47 Kalachnikov) resulted with the massive immigration of elephant within the park

GREAT APES (GORILLA AND CHIMPANZEE) POPULATION DYNAMICS AND TREND WITHIN BOUMBA BEK NATIONAL PARK BETWEEN 2004 TO 2008

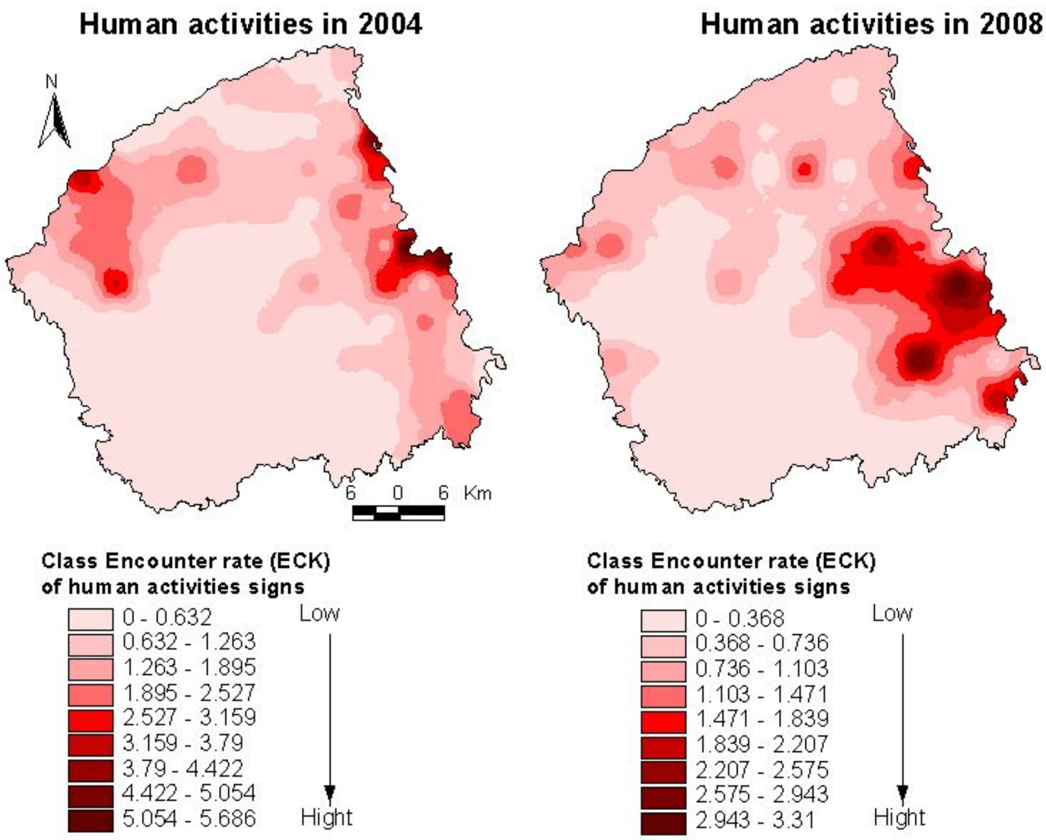


Statistical data of Apes population trend

	2004	2008
Kilometric encounter rate of Apes nest group	0.32 ± 0.06	0.491 ± 0.004
Apes nest density (Nest/km2)		493.3 [353.29 - 688.79])

Comments: Relative stability of Apes.

HUMAN ACTIVITIES DYNAMICS AND TREND WITHIN LOBEKE NATIONAL PARK BETWEEN FROM 2004 TO 2008



Statistical data of human activities

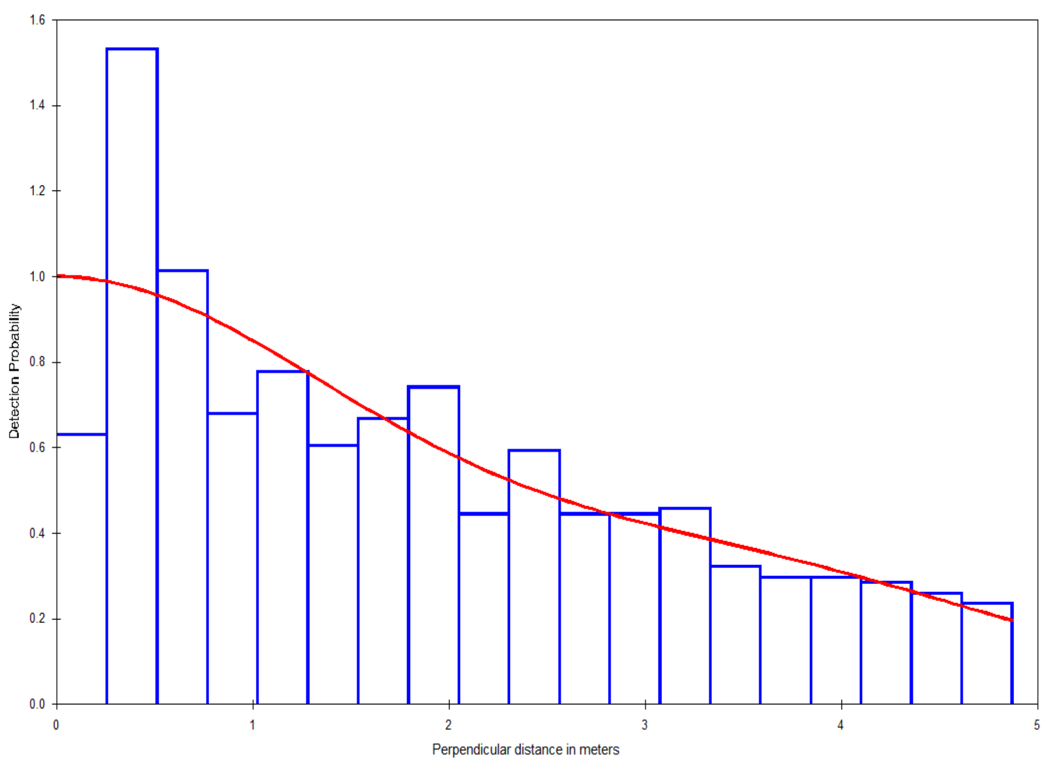
	2004	2008
Encounter rate of human activities signs	0.82 ± 0.13	0.709 ± 0.004

Annex 6. Distance printouts

1. Elephant dung 2012: no s4 or s5

```
Effort        :    105.2800
 # samples     :    106
 Width         :     4.870000
 # observations:    868

 Model
    Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
    Cosine adjustments of order(s) :  2

              Point         Standard    Percent Coef.        95 Percent
  Parameter   Estimate        Error      of Variation     Confidence Interval
  ---------  -----------  -----------  --------------  ----------------------
    A( 1)      2.697        0.1125
    A( 2)     0.1407        0.4694E-01
    f(0)     0.36424      0.17585E-01        4.83      0.33133       0.40042
    p        0.56375      0.27217E-01        4.83      0.51281       0.61974
    ESW       2.7454      0.13255            4.83       2.4974        3.0182
  ---------  -----------  -----------  --------------  ----------------------


 Sampling Correlation of Estimated Parameters


         A( 1)   A( 2)
 A( 1)  1.000   0.109
```

1. A(2) 0.109   1.000



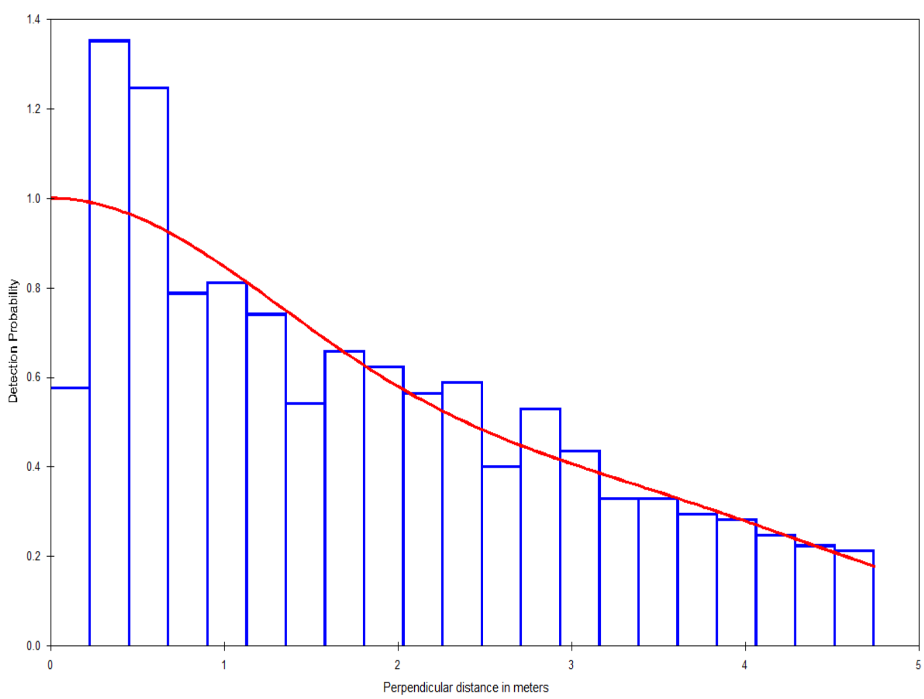
2. Elephant dung 2012: includes s4 & s5

```
Effort        :    105.2800
 # samples     :    106
 Width         :     4.740000
 # observations:   1001

 Model
    Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
    Cosine adjustments of order(s) :  2
```

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95 Percent Confidence Interval	
A(1)	2.555	0.9697E-01			
A(2)	0.1271	0.4437E-01			
f(0)	0.37675	0.16985E-01	4.51	0.34486	0.41158
p	0.55998	0.25246E-01	4.51	0.51259	0.61175
ESW	2.6543	0.11967	4.51	2.4297	2.8997

Sampling Correlation of Estimated Parameters

	A(1)	A(2)
A(1)	1.000	0.140
A(2)	0.140	1.000



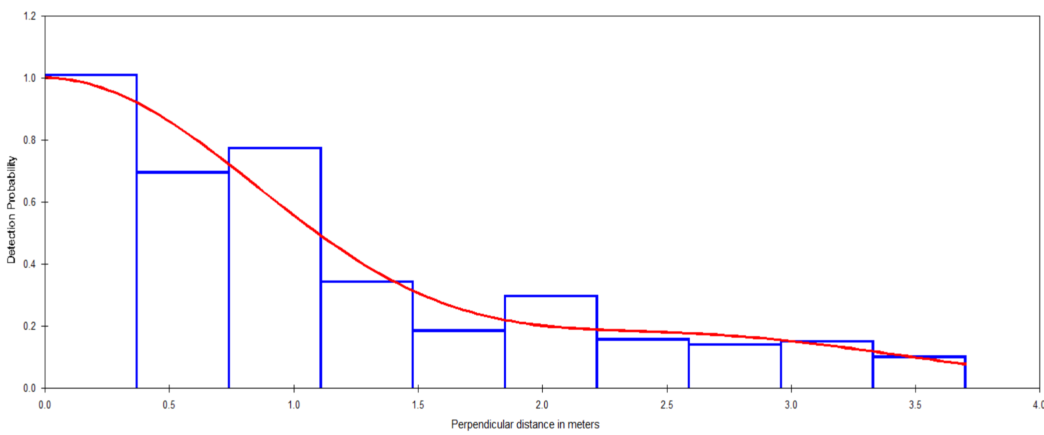
3. Elephant dung 2008: no s4 or s5

```
Effort        :    191.0000
 # samples     :   191
 Width         :    3.700000
 Left          :       0.0000000
 # observations:   687

 Model
    Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
    Cosine adjustments of order(s) :  2
```

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95 Percent Confidence Interval	
A(1)	1.637	0.5743E-01			
A(2)	0.4106	0.5346E-01			
f(0)	0.70177	0.28176E-01	4.02	0.64859	0.75931
p	0.38513	0.15463E-01	4.02	0.35594	0.41670
ESW	1.4250	0.57213E-01	4.02	1.3170	1.5418

Sampling Correlation of Estimated Parameters

	A(1)	A(2)
A(1)	1.000	0.255
A(2)	0.255	1.000



4. Elephant dung 2008: includes s4 & s5

```
Effort        :    191.0000
 # samples     :    191
 Width         :     3.700000
 Left          :        0.0000000
 # observations:    962

 Model
    Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))
    Cosine adjustments of order(s) :  2
```

Parameter	Point Estimate	Standard Error	Percent Coef. of Variation	95 Percent Confidence Interval	
A(1)	1.551	0.4460E-01			
A(2)	0.4018	0.4622E-01			
f(0)	0.72703	0.24081E-01	3.31	0.68129	0.77585
p	0.37174	0.12313E-01	3.31	0.34836	0.39670
ESW	1.3755	0.45558E-01	3.31	1.2889	1.4678

Sampling Correlation of Estimated Parameters

	A(1)	A(2)
A(1)	1.000	0.299
A(2)	0.299	1.000