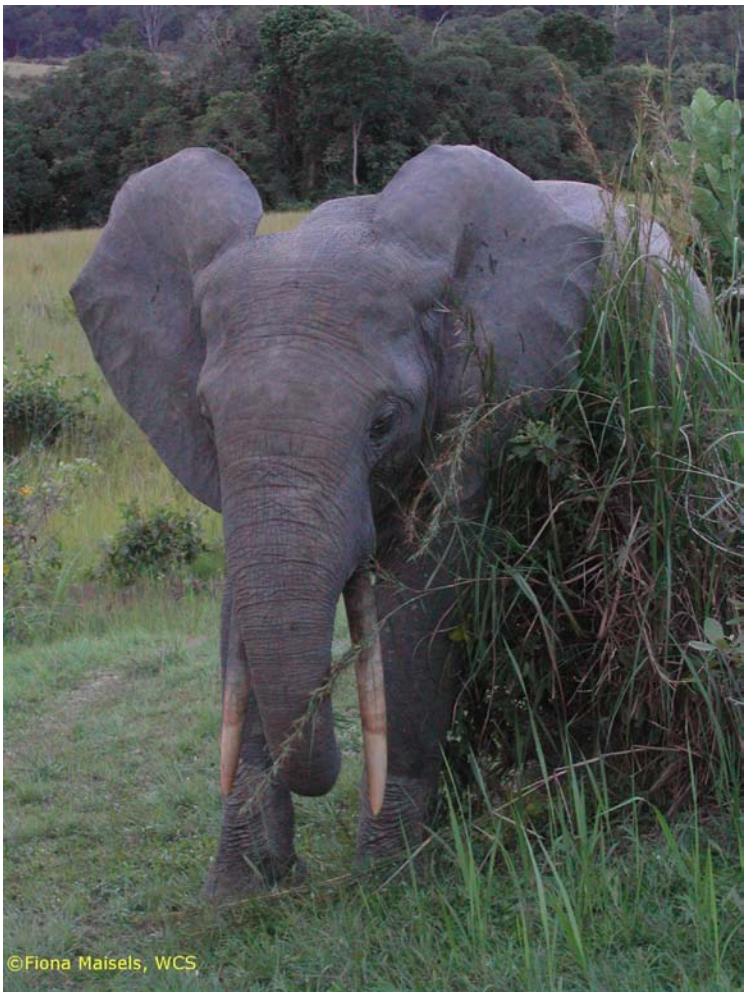
# Review of Gabon's elephant status

**Fiona Maisels and Samantha Strindberg, 2012**



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# Forest elephants

African forest elephants are likely a distinct species (Ishida et al. 2011a; Ishida et al. 2011b; Rohland et al. 2010) and the most recent IUCN assessment lists the Central African elephant population as Endangered (Blanc 2008). This is because they are now under very high pressure from poaching, and have been reduced to very low numbers in many parts of West and Central Africa (Beyers et al. 2011; Blake et al. 2007; Bouché et al. 2011; CITES 2011, 2012a; TRAFFIC 2011; Wittemyer et al. 2011). The reason for the poaching is to obtain ivory, and although some meat is sold as a by-product (Stiles 2011). There has been a spike in ivory seizures since 2009 –at least 23 tons were seized in 2011 (TRAFFIC 2011). Hunting has been greatly facilitated by the rapidly growing, extensive road network throughout the region (Blake et al. 2008; Yackulic et al. 2011) but the driver has been the increase in demand –and thus price - in the Far East, especially China (Martin & Vigne 2011; Vigne & Martin 2011; Wittemyer et al. 2011). At least 66 million Chinese people (5% of the population) now earn over $24,000 per year and a further 20 million or so earn $12,000-$24,000 (CIA 2011; McKinsey&Company 2011), wealth which easily allows the purchase of a small ivory sculpture per household. If only 1% of the middle class want a small 50g sculpture, this translates to over 35,000 elephants (using a likely average tusk weight of 5kg in the forest: although it may be less than that for African elephants overall (Stiles 2004) and would thus be even more individuals).

## The importance of Gabon for forest elephants

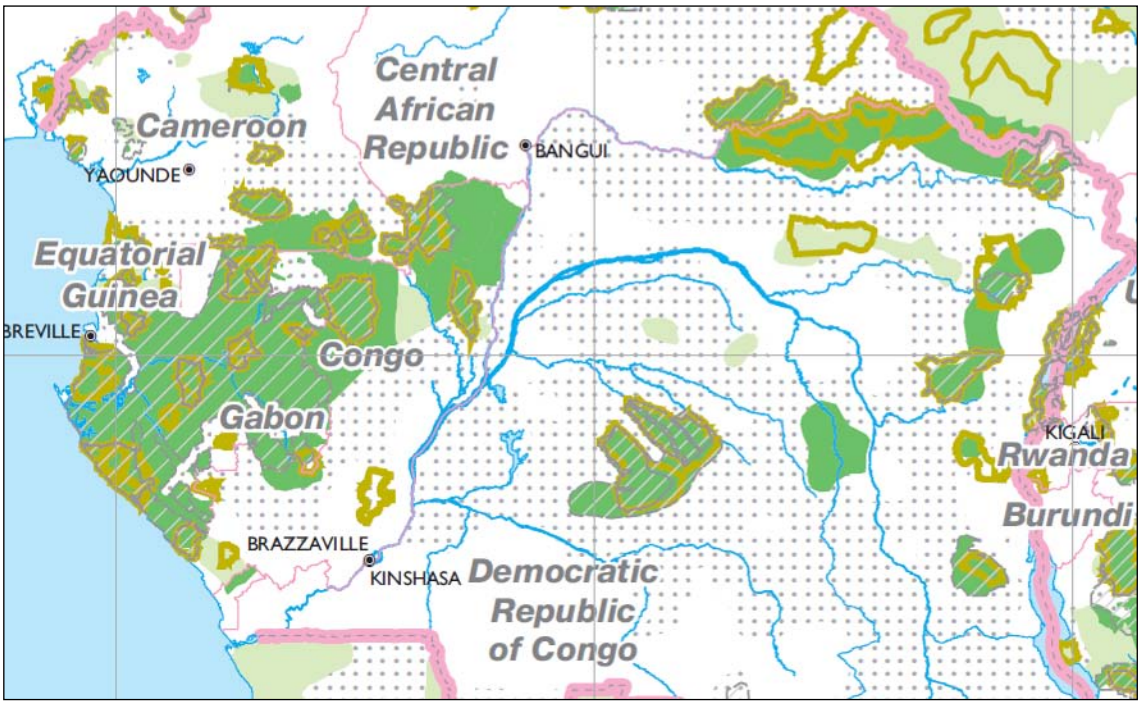
Half of all remaining forest elephants are in Gabon (Blanc et al. 2007; Maisels et al. in review); Fig. 1), although the country covers only 13% of the Central African forest area (Iremonger et al. 1997). Gabon has a low human population density compared to the other Central African countries and is by far the most developed country in sub-Saharan Africa (UNDP 2011). It is mostly (82%) covered by tropical moist forests (CBFP 2006) and has very low rates of deforestation (Sannier et al. 2010), and a fairly low corruption index compared to the other Central African countries (Corruption_Perceptions_Index 2011). Elephant range in Central Africa is known to be constrained by roads, which give poachers access to previously remote forests (Blake et al. 2008; Yackulic et al. 2011). Gabon has a relatively large proportion of its forests still lightly roaded (WCS/CIESN 2005) and thirteen National Parks located to best represent the biodiversity of the country (Government_of_Gabon 2002, 2007; Laurance et al. 2006).

This review summarizes the current knowledge of elephants in Gabon, based on the ground surveys carried out since 2004. The situation for elephants at all survey sites is likely to have deteriorated since the time of the survey. It is recognized that sites surveyed in 2004 are highly likely to have lost a significant proportion of their elephants in the last few years.

# Methods

Since about 2000 large mammal surveys in large forested areas in Central Africa have used distance sampling along line transects (Buckland et al. 2001) where wildlife density was high enough to assure a reliable estimate of abundance. Reconnaissance walks, known as “recces” (Walsh et al. 2001) are used where wildlife is at low density or where transect surveys would be too costly; on recces, animal sign on the ground is only recorded if it is within a metre each side of the observer, in order to control for the large variation in visibility caused by different ground-level vegetation types. The most commonly used program for both survey design and data analysis is DISTANCE (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 et al. 2012; Hedges & Lawson 2006; Kühl et al. 2008; Maisels 2010; Maisels & Aba'a 2010; Maisels et al. 2008a; Maisels et al. 2008b; Strindberg 2012; Strindberg et al. 2004). To date, the

survey results 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 assessing Red List status of great apes (Oates et al. 2007b; Walsh et al. 2008) and elephants (IUCN 2010) and IUCN ape action plans (Morgan et al. 2011; Oates et al. 2007a; Plumptre et al. 2010; Tutin et al. 2005).

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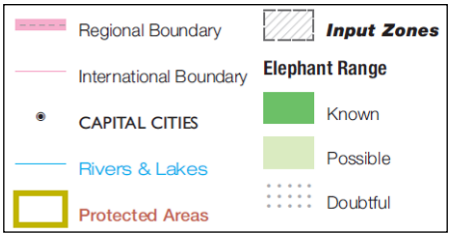


**Figure 1** Distribution of forest elephants from the IUCN African Elephant Database 2007 (Blanc et al. 2007).

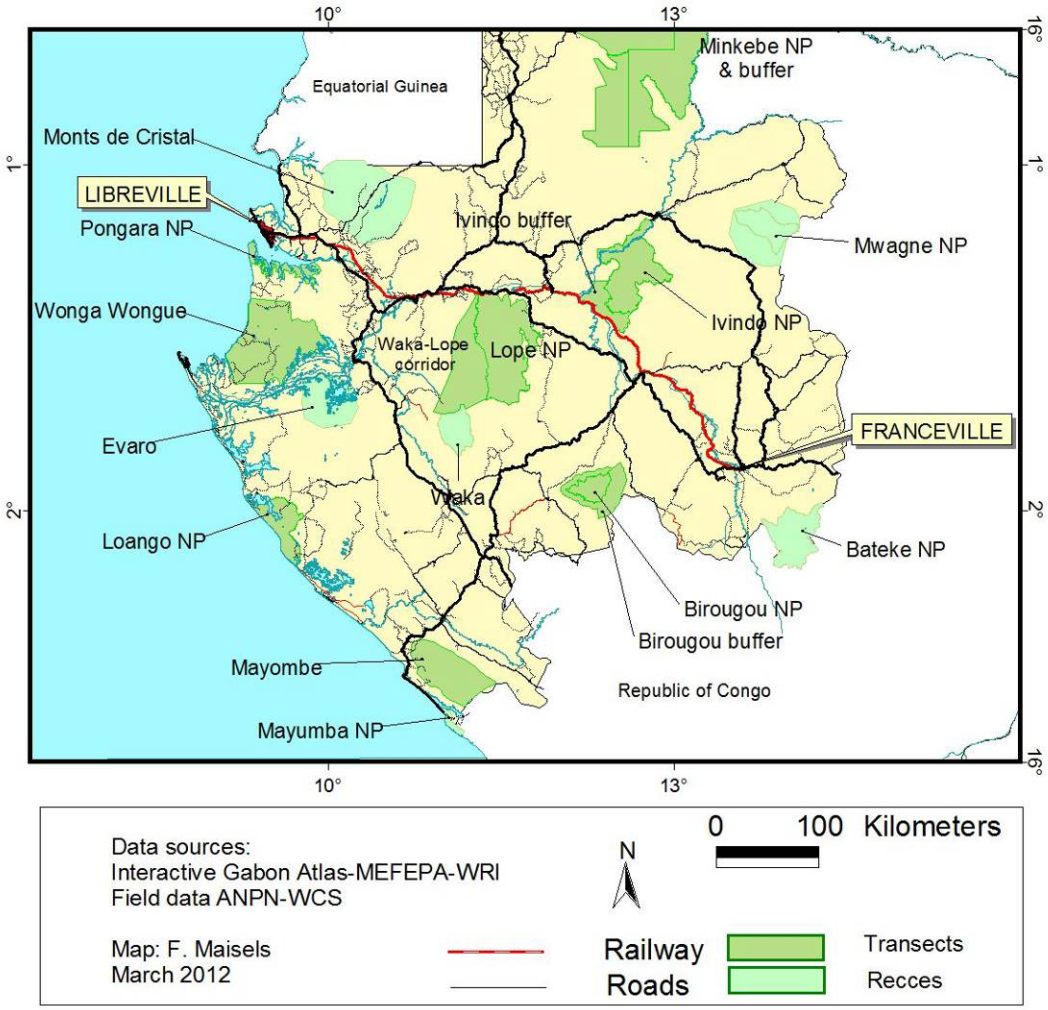


**Figure 2.** Sites surveyed for wildlife 2004-2011

Here we present a summary of the wildlife surveys carried out in Gabon since 2004 (Table 1). Almost 43,000 km$^2$ were covered, a total of 16% of the surface area of the country (Table 1). Many of the areas surveyed (Fig. 2) were National Parks or areas adjacent to National Parks. Some sites were known in advance to have low wildlife abundance (Bateké, Monts de Cristal), and some were suspected to have a high abundance of wildlife but funding was not available to carry out a full transect survey at the time (Evaro, Mayumba, Mwagna, Waka). The sampling effort required to achieve reasonable precision in the line transect survey estimates was calculated either from recent data, where it existed (encounter rate of elephant dung and of great ape nests), or by carrying out a pilot survey, where no recent data existed, following standard theoretical (Buckland et al. 2001) and field (Maisels & Aba'a 2010) procedure. Field staff had been trained on one of the thirteen intensive, university-standard regional field training courses that have been held from 1997 through to 2010 in Central Africa (Congo, DRC, Gabon and Cameroon), maintaining both continuity of trainers and of methods (example: a recent report to USFWS, (Maisels et al. 2010).

# Results

## Dung density

A set of 35 line transect surveys across Central Africa (including the ones in this report plus others in Congo, DRC, and Cameroon) was used to establish the relationship between dung encounter rate per kilometre walked within a meter of the transect line, and dung density per $km^2$ estimated using the Distance software (Thomas et al. 2010). The relationship was:

$y=560.42x - 10.771$ *(1)*

where $y$= density and $x$= encounter rate. We used this formula to estimate dung density for the sites where only recces had been carried out and thus where only an encounter rate of dung was available within the two-metre strip (Table 1).

**Table 1. Sites surveyed in Gabon for wildlife between 2004-2011.**

| Area surveyed | Area ($km^2$) | Year of survey | Method | Dung encounter rate/ km (2m wide) | Dung density/ $km^2$* | Human sign/ km |
|---|---|---|---|---|---|---|
| Birougou NP & buffer zone | 2014 | 2007 | Transects | 0.87 | 445 | 0.48 |
| Evaro zone | 2000 | 2006 | Recces | 1.31 | 723 | 0.89 |
| Ivindo NP | 2967 | 2009 | Transects | 2.5 | 1285 | 0.33 |
| Ivindo NP buffer zone (south) | 863 | 2010 | Transects | 1.97 | 874 | 0.60 |
| Loango NP | 1510 | 2007 | Transects | 3.12 | 1526 | 0.96 |
| Lope NP | 4942 | 2009 | Transects | 2.95 | 1332 | 0.22 |
| Mayombe area | 1682 | 2011 | Transects | 1.22 | 656 | 0.15 |
| Mayumba NP | 161 | 2011 | Recces | 2.08 | 1155 | 1.05 |
| Minkébé NP & buffer | 7535 | 2004 | Transects | 9.08 | 5867 | 0.27 |
| Monts de Cristal NP & buffer zone | 5300 | 2006 | Recces | 2.53 | 1407 | 0.73 |
| Mwagna NP | 1167 | 2004 | Recces | 7.2 | 4024 | 0.28 |
| Mwagna buffer | 2020 | 2004 | Recces | 0.43 | 230 | 8.82 |
| Plateaux Bateké NP | 2042 | 2006 | Recces | 0.83 | 454 | 2.89 |
| Pongara NP | 960 | 2006 | Transects | 1.92 | 1053 | 2.40 |
| Waka NP | 1061 | 2006 | Recces | 3.60 | 2007 | 0.17 |
| Waka-Lope corridor | 2991 | 2008 | Transects | 1.27 | 614 | 0.15 |
| Wonga-Wongue Reserve | 4967 | 2011 | Transects | 1.88 | 871 | 0.17 |

*Figures in red are calculated from $y=560.42x - 10.771$, where $y$= density and $x$= encounter rate, derived from 35 transect surveys across Central Africa. Figures in black were calculated using the DISTANCE software.

## Elephant density and number

Estimation of elephant density from dung density, and eventually the number of elephants at a given site depends on the dung production and decay rate, and the area of the site.

*Production*

The figure of 19.77 was used for production (Tchamba 1992): this seems not to vary greatly across sites but is partly dependent on rainfall; it falls within the estimate of around 18-20, which fits with the rainfall of the region (Theuerkauf & Gula 2010).

*Decay rate*

Decay rate is more problematical, and estimates vary between around 50 to 106 days, but the mean time to dung decay (reciprocal of the decay rate) was estimated as just over 80 days using 14 studies (Maisels, Strindberg, *et al.* in review). We present three possibilities (Table 2), but the central one is most likely (80). Each dung pile was classified using the Barnes A/B to E system (Barnes 1996). Normally when calculating elephant density from dung density, the "E" dung are excluded (Barnes 1996); From 35 studies we estimated that the mean proportion of "E" dung was 32.1 % (SE 3.7).

**Table 2. Elephant number* from line transect data in Gabon sites.**

| Site | Time to elephant dung decay | | |
|---|---|---|---|
| | **50 days** | **80 days** | **106 days** |
| Birougou NP & buffer zone | 616 | 385 | 290 |
| Ivindo NP | 2,619 | 1,637 | 1,235 |
| Ivindo NP buffer zone (south) | 518 | 324 | 244 |
| Loango NP | 1,583 | 989 | 747 |
| Lope NP | 4,522 | 2,826 | 2,133 |
| Mayombe area | 758 | 474 | 358 |
| Minkébé NP & buffer | 30,366 | 18,979 | 14,324 |
| Pongara NP | 694 | 434 | 328 |
| Waka-Lope corridor | 1,260 | 788 | 595 |
| Wonga-Wongue Reserve | 616 | 385 | 290 |
| **Total** | 45,908 | **28,692** | 21,655 |

*Formula: Elephant number = Area * Dung density /(Production rate * Length of time to dung decay) where production rate=19.77 (Tchamba 1992), after removing 32.1% of "E" dung.

**Table 3. Elephant number* from recce data in Gabon sites.**

| | Time to elephant dung decay | | |
|---|---|---|---|
| **Site** | **50 days** | **80 days** | **106 days** |
| Evaro zone | 994 | 621 | 469 |
| Mayumba NP | 128 | 80 | 60 |
| Monts de Cristal NP and buffer zone | 5,123 | 3,202 | 2,416 |
| Mwagna NP | 3,226 | 2,016 | 1,522 |
| Mwagna buffer | 319 | 200 | 151 |
| Plateaux Bateké NP | 637 | 398 | 301 |
| Waka NP | 1,463 | 914 | 690 |
| **Total** | 11,889 | **7,431** | 5,608 |

*As Table 2; except dung density calculated from encounter rate using Formula 1.

*Number*

Using the three different times to decay of 50, 80 and 106 days, and the known area of each site, we estimated the number of animals after removing the likely proportion of "E" dung both at the sites with transects (Table 2) and at the sites where recces only had been run (Table 3). The estimates of the total numbers of elephants (recces plus transects) for the three different decay rates at the sites surveyed was 58,000 (50 days), 36,000 (80 days) and 27,000 (106 days). Although the area surveyed was 16% of the country, large areas either have no elephants at all, or elephant density is likely to be very low: the sites surveyed were deliberately chosen as part of the surveys of protected areas and potential protected areas of Central Africa. Thus, although the remaining 84% of the country certainly contains elephants, outside of the Parks, densities are likely to be much lower than within them. Mapping the individual recce and transect dung data (Fig. 3) shows some detail within the sites: Lope National Park, for example, has more elephants in the northeast than in the south; eastern Bateké, and central Birougou have the lowest elephant densities.

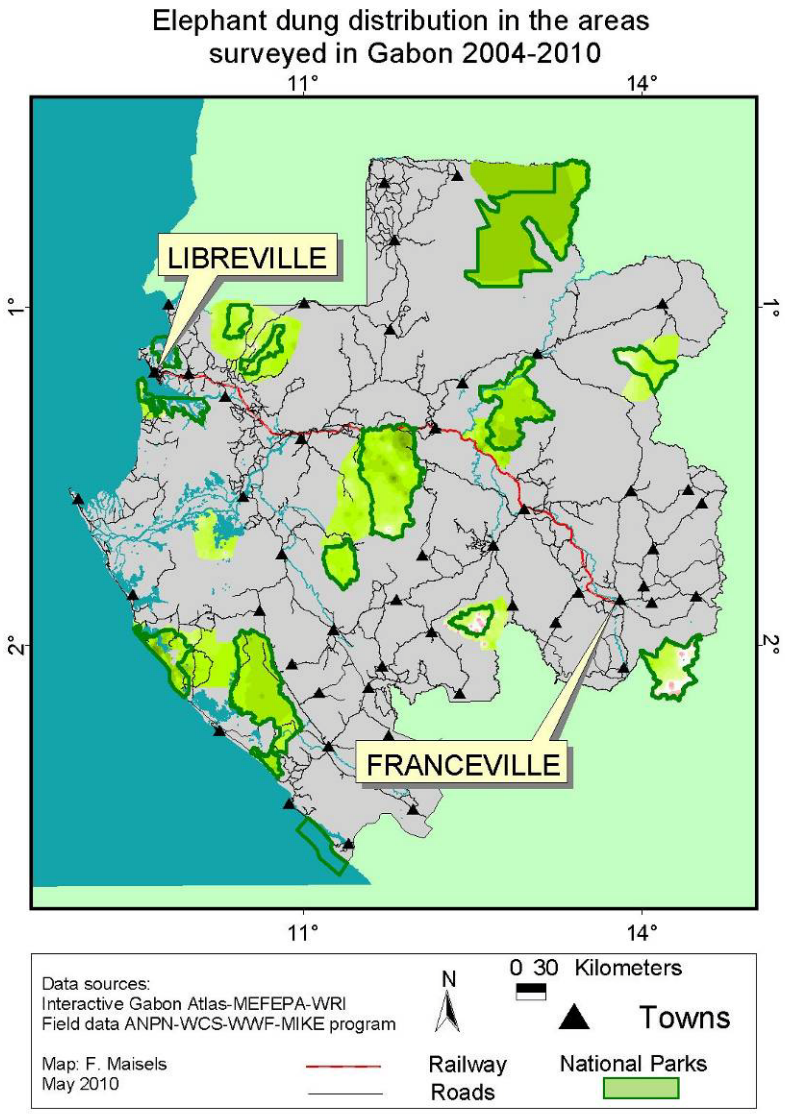


Figure 3. Distribution of Gabon's elephants within the surveyed sites (interpolation map) with darker green areas corresponding to higher elephant dung counts per km.

## Human pressure

In 1991, it was already recognized that human pressure, which could essentially be mapped by proximity to roads, was a hugely important predictor of elephant distribution and abundance in Gabon (Barnes et al. 1991) and elsewhere (Michelmore et al. 1994) and see Fig. 4; more recent data has confirmed and refined this (Blake et al. 2008; Yackulic et al. 2011). An as yet unpublished analysis of the whole dataset suggests that in 2011 Gabon contained around 50,000 elephants (Maisels et al. in review). Human pressure at each site varied greatly (Table 1, Fig. 5) but was indeed clearly associated by distance to the nearest road, by ease of movement through the savannahs in the case of Bateké, and, importantly, by proximity to the borders of Congo, Cameroon, and Equatorial Guinea (Fig. 5) with sites more centrally located within the country being less impacted by hunters.

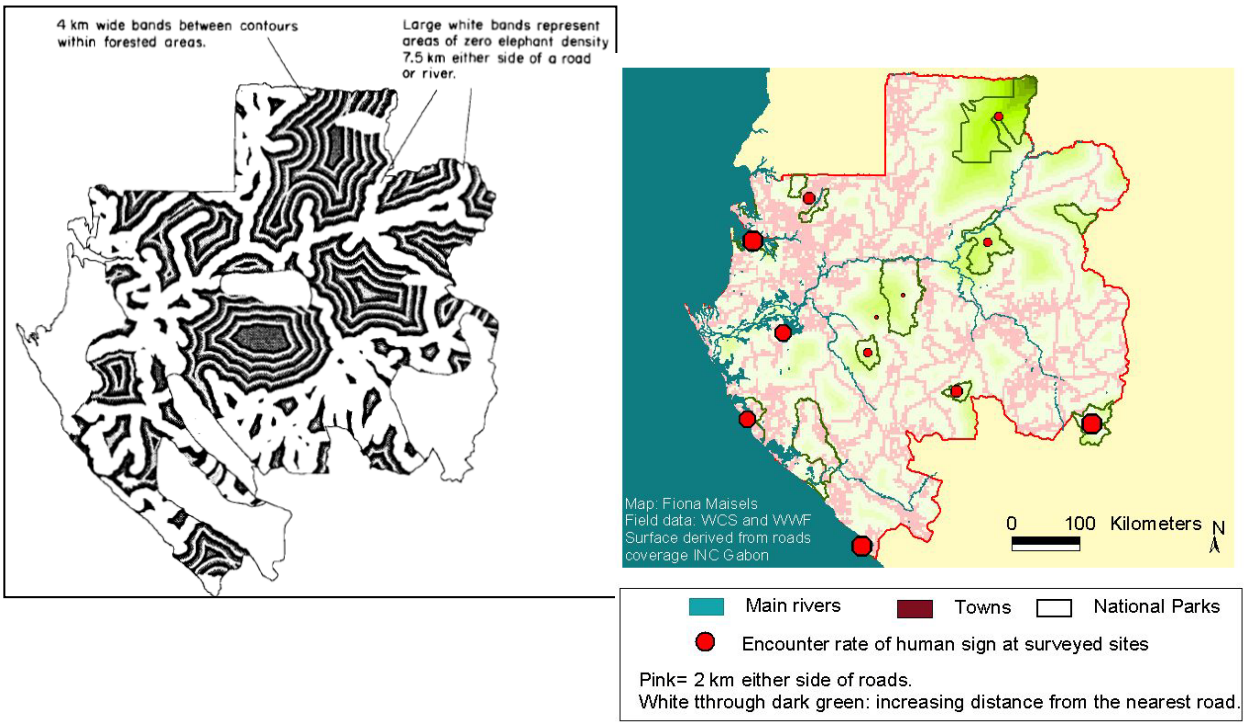


**Figure 4. Left:** Michelmore's map of 1994 (Michelmore et al. 1994) and right: a recent and more detailed map (2010). Both indicate the more remote areas of Gabon most likely to host elephants, predicted by distance from roads. The map on the right also shows the encounter rate of human sign in the surveys as red circles, where the size of the circles is proportional to encounter rate.

We considered the relationship between the encounter rates of dung and human sign and fit a linear model to log transformed values of both elephant dung encounter rate and human sign encounter rate (Fig. 6). The results of the model indicate a statistically significant effect of the intensity of human sign on dung encounter rates ($p=0.034$). It is especially evident that very high dung encounter rates only occurred in the quasi-absence of humans. The relationships between elephant dung density and the distance to the nearest road, or the amalgam of human pressure encapsulated in the Human Influence Index (WCS/CIESN 2005) were also statistically significant using the much larger ($N=80$) dataset of the Central African sites (Maisels et al. in review).

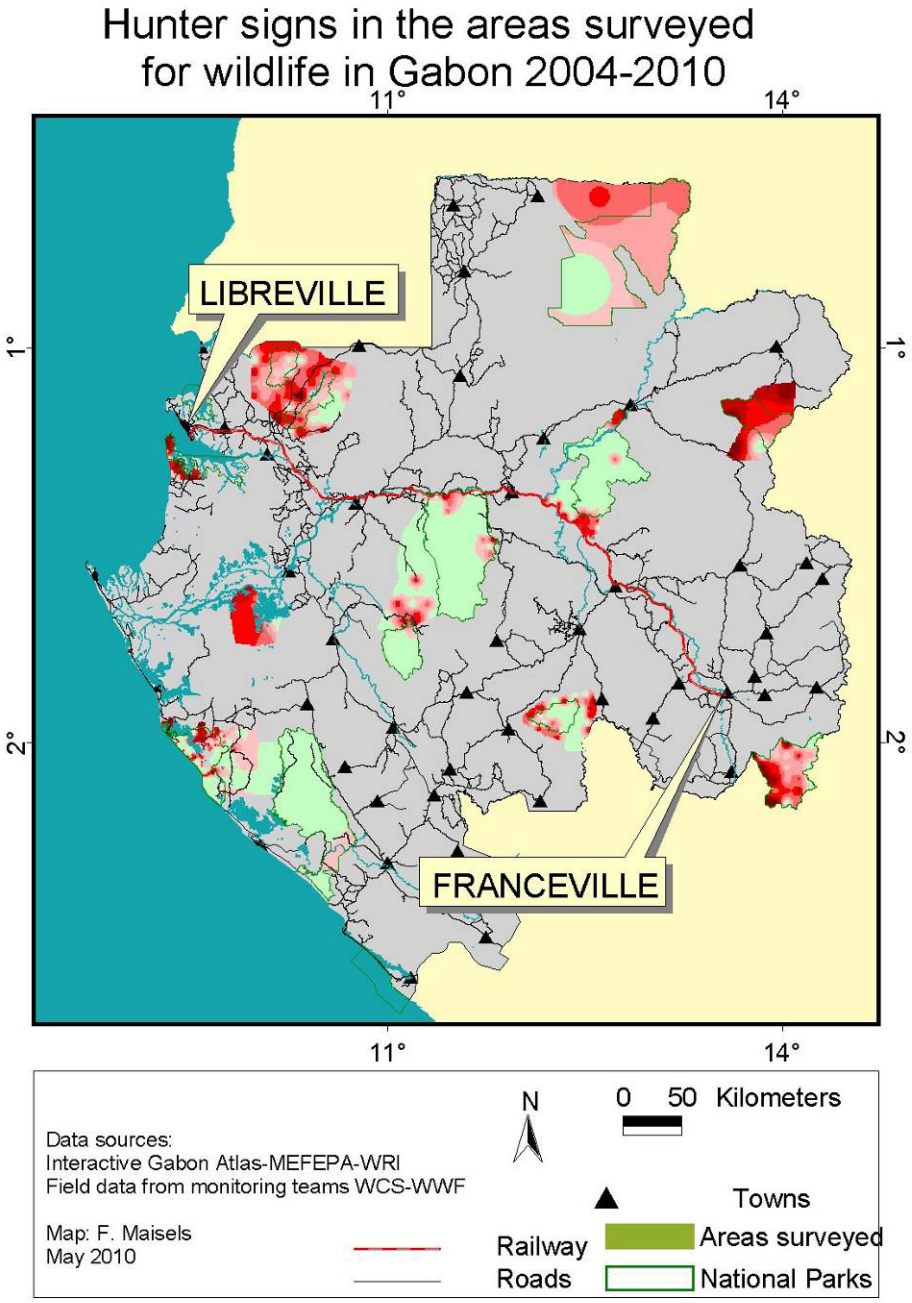


**Figure 5.** Interpolation map of the encounter rates of human sign at the Gabon sites with darker red areas corresponding to higher human sign counts per km.

Importantly, protected areas which have forest guards are far more likely to have elephants than areas without, which is of primary importance in planning for elephant conservation at a national scale. The three large Parks of Minkebe, Lope, and Ivindo will have most of the country's elephants, with significant numbers also occurring in the Mwagna and coastal Parks, especially Loango. Areas near international borders will fare badly for elephant conservation, now and in the future, unless they are effectively protected. The number and easy availability of automatic weapons in the neighbouring Republic of Congo, in particular, but also Cameroon is of concern (Alpers & Wilson 2012), as is the poor governance profile of those states- again, particularly in Congo and Equatorial Guinea, but also, again, Cameroon (Corruption_Perceptions_Index 2011), a situation which leads to at

best, a lack of law enforcement, and at worst an increase in the use of military weapons available for poaching and often a complete absence of prosecution for poachers and traffickers.

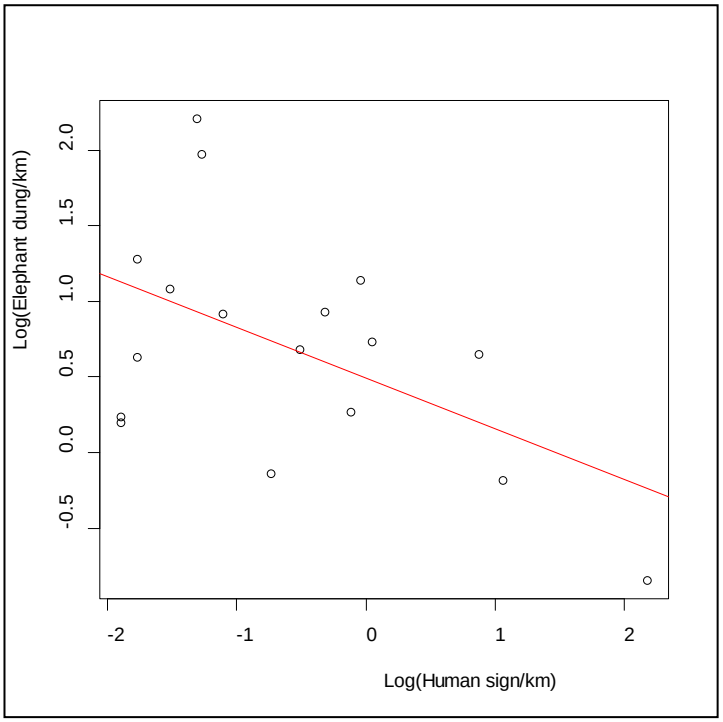


**Figure 6.** Encounter rates of elephant dung and human sign at the Gabon sites.

## Conclusions

Forest elephant density is still relatively high in Gabon, but distribution is clearly controlled by human pressure. Strongholds are the large, central protected areas of Lope, Ivindo, and perhaps Minkebe, but this latter needs to be confirmed by planned surveys of 2012-13. Mwagna still seems to have an important elephant population as well. The coastal areas (Loango, Moukalaba Doudou) are also still of importance for elephants, and some of the logging concessions (especially those to the west of Ivindo in the Rougier concession). Connectivity between some of the areas is still possible- for example between Ivindo and the concessions, and possibly between Ivindo and Mwagne, and between the coastal Parks of Loango and Moukalaba Doudou- but between others it is now unlikely that elephants will be able to cross. Ivindo and Lope are separated by a hundred kilometres, and the Ogooué River, the main railway line, and a relatively busy National Road separate the two. The important parks of Minkebe and Ivindo are similarly separated by a busy and populous major road with a fairly wide agricultural strip on each side where there are villages.

# Recommendations

***Ensuring effective protection***. An efficient, visible, and well trained body of forest guards will be the best way of ensuring Gabon's elephants survive in the immediate future. In 2011, a 240-strong military "Jungle Brigade" was created to support the antipoaching service of the National Parks Agency (Republic 2011). This brigade is tasked with assuring the safety of Gabon's wildlife. As the demand for ivory from China is very high, this brigade needs to be as effective as possible over the huge forest area where elephants and other important wildlife species still occur.

***Maintaining transparency***. In Central Africa, corruption spans the lowest ranks of Government services (forest guards, policemen, soldiers, customs officers) and upwards through their hierarchies. The judiciary can be involved- wildlife criminals can escape prosecution or punishment through collusion with individuals in the courts. Gabon is the least corrupt country in Central Africa, (Corruption_Perceptions_Index 2011), and has seen recent improvements including sentencing of several wildlife criminals (AALF 2011), satisfying CITES ivory regulations (CITES 2012b) and is about to publicly burn all its ivory stockpile in order to stop the ivory getting on to the black market (TRAFFIC 2012). It is working towards a system where corruption and complicity is eradicated and monitored at all levels, but this must be maintained, especially in the face of rising ivory prices.

***Ensuring wildlife-focused land use planning*.** Africa, including Gabon and the other Central African countries, is fast increasing the surface area of land under industrial agricultural (such as oil palm) and mining concessions. This requires forest clearance, development of road networks and other infrastructure. The attraction of these new centres of employment and business will cause rapid changes in human settlement patterns. As the salaried employees in the new industrial and agricultural development zones gain purchasing power, suppliers of goods and services will also arrive. As elsewhere, roads and easy access into once-remote tracts of forest will result in the rapid extraction of bushmeat and ivory. It is therefore of very high priority to assure that these new developments are carefully planned to minimise degradation of the country's natural heritage, assuring that the core elephant strongholds and connective corridors between them remain untouched. For example, land that is already cleared or degraded near major towns can be used for development, in order to minimise damage to the closed-canopy intact forest areas. Gabon has already started on its National Land Use Plan, exactly to respond to these types of concerns, and this summary of elephant distribution in the country will be of great use for reducing to the absolute minimum the pressure currently faced by Gabon's elephants.

## References


AALF. 2011. Rapport annuel d'activities Sept 2010-Sept 2011. Page 11. Appui a l'Application de la Loi sur la Faune http://www.conservation-justice.org/wordpress/wp-content/uploads/2011/08/AALF_Annuel_Sept2010-Sept2011.pdf.

Alpers, P., and M. Wilson. 2012. Guns in Cameroon: Facts, Figures and Firearm Law. GunPolicy.org. Sydney School of Public Health, The University of Sydney., Sydney.

Barnes, R. F. W. 1996. Estimating forest elephant abundance by dung counts. . Pages 33-48 in K. Kangwana, editor. Studying elephants: AWF Technical handbook 7. African Wildlife Foundation, , Nairobi, Kenya. .

Barnes, R. F. W., K. L. Barnes, M. P. T. Alers, and A. Blom. 1991. Man determines the distribution of elephants in the rain forests of northeastern Gabon. . African Journal of Ecology **29**:54-63.

Beyers, R., T. Sinclair, J. Hart, F. Grossman, S. Dino, and B. Klinkenberg. 2011. Resource wars and conflict ivory. The impact of civil conflict on elephants in the Okapi Faunal Reserve: 1995 - 2006. PLoS One **6**:e27129.

Blake, S., S. L. Deem, S. Strindberg, F. Maisels, L. Momont, I. B. Isia, I. Douglas-Hamilton, W. B. Karesh, and M. D. Kock. 2008. Roadless Wilderness Area Determines Forest Elephant Movements in the Congo Basin. PLoS One **3**:e3546.

Blake, S., S. Strindberg, P. Boudjan, C. Makombo, I. Bila-Isia, O. Ilambu, F. Grossmann, L. Bene-Bene, B. de Semboli, V. Mbenzo, D. S'Hwa, R. Bayogo, L. Williamson, M. Fay, J. Hart, and F. Maisels. 2007. Forest elephant crisis in the Congo Basin. PLoS Biology **5**:e111.

Blanc, J. 2008. *Loxodonta africana*. IUCN Red List of Threatened Species 2011. IUCN.

Blanc, J., R. F. W. Barnes, G. C. Craig, H. T. Dublin, C. R. Thouless, I. Douglas Hamilton, and J. Hart. 2007. African Elephant Status report 2007: an update from the African Elephant Database. Page vi + 276 pp. Occasional Paper Series of the IUCN Species Survival Commission, N° 33. IUCN / SSC African Elephant Specialist Group, Gland, Switzerland.

Bouché, P., I. Douglas-Hamilton, G. Wittemyer, A. J. Nianogo, J. L. Doucet, P. Lejeune, and C. Vermeulen. 2011. Will Elephants Soon Disappear from West African Savannahs? PLoS One **6**:e20619.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas 2001. Distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford.

CBFP 2006. Congo Basin Forest Partnership- The forests of the Congo Basin: State of the Forest 2006. CBFP, Kinshasa, DRC.

CIA. 2011. World Factbook (China).

CITES. 2011. Convention on International Trade in Endangered Species of Wild Fauna and Flora- Status of elephant populations, levels of illegal killing and the trade in ivory: a report to the standing committee of CITES. SC61 Doc. 44.2 (Rev. 1) Annex 1.

CITES. 2012a. CITES Secretary-General expresses grave concern over reports of mass elephant killings in Cameroon- Press release. http://www.cites.org/eng/news/pr/2012/20120228_elephant_cameroon.php.

CITES. 2012b. Notification to the Parties: Withdrawal of recommendation to suspend trade; concerning Gabon http://www.cites.org/eng/notif/2012/E008.pdf.

Corruption_Perceptions_Index. 2011. Corruption Perceptions Index 2011. Transparency International. http://cpi.transparency.org/cpi2011/in_detail/.

Government_of_Gabon. 2002. La politique des parcs nationaux: Ordonnance 6/2002. Hebdo **463**:209-224.

Government_of_Gabon. 2007. Loi n°003/2007 du 27 août 2007, relative aux parcs nationaux. Page 10 in G. d. Gabon, editor. 10, Journal officiel de la Republique Gabonaise.

Hedges, S. 2012. Estimating absolute elephant density from dung pile density: theoretical concepts in S. Hedges, editor. Monitoring elephants and assessing threats: a manual for researchers, managers and conservationists. Centre for Wildlife Studies, Bangalore, India.

Hedges, S., S. Blake, and F. Maisels. 2012. Estimating elephant population density and abundance from dung pile density: field methods in S. Hedges, editor. Monitoring elephants and assessing threats: a manual for researchers, managers and conservationists. Centre for Wildlife Studies, Bangalore, India.

Hedges, S., and D. P. Lawson. 2006. Monitoring the illegal killing of elephants- Dung survey standards for the CITES MIKE programme. . Page 80. CITES-MIKE programme; Central coordinating unit. .

Iremonger, S., C. Ravilious, and T. Quinton. 1997. A statistical analysis of global forest conservation. Including: GIS files of forests and protected areas, version 2. CD-ROM in S. Iremonger, C. Ravilious, and T. Quinton, editors. A global overview of forest conservation. CIFOR and WCMC, Cambridge, U.K.

Ishida, Y., Y. Demeke, P. J. v. C. de Groot, N. J. Georgiadis, K. E. A. Leggett, V. E. Fox, and A. L. Roca. 2011a. Distinguishing Forest and Savanna African Elephants Using Short Nuclear DNA Sequences. Journal of Heredity **102**:610-616.

Ishida, Y., T. K. Oleksyk, N. J. Georgiadis, V. A. David, K. Zhao, R. M. Stephens, S.-O. Kolokotronis, and A. L. Roca. 2011b. Reconciling Apparent Conflicts between Mitochondrial and Nuclear Phylogenies in African Elephants. PLoS One **6**.

IUCN. 2010. African Elephant (*Loxondonta africana*): Further Details on Data Used for the Global Assessment.

Kühl, H., F. Maisels, M. Ancrenaz, and E. A. Williamson, editors. 2008. Best Practice Guidelines for Surveys and Monitoring of Great Ape Populations. . IUCN, Gland, Switzerland.

Laurance, W., A. Alonso, M. Lee, and C. P. 2006. Challenges for forest conservation in Gabon, Central Africa. Futures **38**:454–470.

Maisels, F. 2010. Case study 4: Monitoring of wildlife populations: lessons learned from Central Africa. Pages 335-343 in D. Yanggen, Angu, K., & Tchamou, N., editor.

Landscape-Scale Conservation in the Congo Basin : Lessons Learned from the Central Africa Regional Program for the Environment (CARPE). IUCN.

Maisels, F., and R. Aba'a. 2010. Section 3: Survey design. Page 16 in M. Kühl H., F., Ancrenaz, M., and Williamson, E.A. , editor. Best Practice Guidelines for Surveys and Monitoring of Great Ape Populations. IUCN Ape Species Specialist Group.

Maisels, F., A. Colom, and B. Inogwabini. 2008a. Section 6: Training. in H. Kühl, Maisels, F., Ancrenaz, M., and Williamson, E.A., editor. Best Practice Guidelines for Surveys and Monitoring of Great Ape Populations. . SSC Primate Specialist Group of the International Union for Conservation of Nature and Natural Resources. , Gland, Switzerland.

Maisels, F., I. Herbinger, and C. Duvall. 2008b. Section 5: Field Issues: Logistics and data collection protocols in H. Kuehl, editor. Best Practice Guidelines for Surveys and Monitoring of Great Ape Populations IUCN SSC Primate Specialist Group (PSG).

Maisels, F., T. Nishihara, and P. Telfer. 2010. Great ape and human impact monitoring training, surveys, and protection in the Ndoki-Likouala Landscape, Republic of Congo. GACF Agreement: 96200-9-G247 Interim report. Page 20. WCS.

Maisels, F., S. Strindberg, Stephen Blake, George Wittemyer, John Hart, Elizabeth Williamson, Rostand Aba'a, Gaspard Abitsi, Ruffin D. Ambahe, Fidel Amsini, Parfait C. Bakabana, Cleve Hicks, Rosine E. Bayogo, Martha Bechem, Rene Beyers, Anicet N. Bezangoye, Patrick Boudjan, Nicolas Bout, Marc Ella Akou, Lambert Bene Bene, Bernard Fosso, Elizabeth Greengrass, Falk Grossmann, Clement Ikamba-Nkulu, Omari Ilambu, Bila-Isia Inogwabini, Fortune Iyenguet, Frank Kiminou, Max Kokangoye, Deo Kujirakwinja, Stephanie Latour, Innocent Liengola, Quevain Mackaya, Jacob Madidi, Bola Madzoke, Calixte Makoumbou, Guy-Aimé Malanda, Richard Malonga, Olivier Mbani, Valentin Mbendzo, Edgar Ambassa, Albert Ekinde, Yves Mihindou, Bethan J. Morgan, Prosper Motsaba, Gabin Moukala, Anselme Mounguengui, Brice S. Mowawa, Christian Ndzai, Stuart Nixon, Pele Nkumu, Fabian Nzolani, Lilian Pintea, Andy Plumptre, Hugo Rainey, Bruno de Semboli, Adeline Serckx, Emma Stokes, Andrea Turkalo, Hilde Vanleeuwe, Ashley Vosper, and Y. Warren. in review. Devastating Decline of Forest Elephants in Central Africa. PLoS Biology.

Martin, E. B., and L. Vigne. 2011. A report on the soaring demand for elephant and mammoth ivory in southern China. Elephant Family, The Aspinall Foundation and Columbus Zoo and Aquarium http://www.elephantfamily.org/uploads/copy/EF_Ivory_Report_2011_web.pdf.

McKinsey&Company. 2011. Tapping China’s luxury-goods market. Page 48. McKinsey Quarterly.

Michelmore, F., K. Beardsley, R. Barnes, and I. Douglas-Hamilton. 1994. A model illustrating the changes in forest elephant numbers caused by poaching. African Journal of Ecology **32**:89-99.

Morgan, B. J., A. Adeleke, T. Bassey, R. Bergl, A. Dunn, K. Gonder, D. Koulagna, G. Mbah, A. Nicholas, J. Oates, F. Omeni, Y. Saidu, V. Sommer, J. Sunderland-Groves, J. Tiebou, and E. A. Williamson. 2011. Regional Action Plan for the Conservation of the Nigeria-Cameroon Chimpanzee (*Pan troglodytes ellioti*). IUCN, Gland, Switzerland.

Oates, J., J. Sunderland-Groves, R. Bergl, A. Dunn, A. Nicholas, E. Takang, F. Omeni, I. Imong, R. Fotso, L. Nkembi, and E. A. Williamson. 2007a. Regional Action Plan for

the Conservation of the Cross River Gorilla (*Gorilla gorilla diehli*). IUCN/SSC Primate Specialist Group and Conservation International., Arlington, VA, USA.

Oates, J. F., C. E. G. Tutin, T. Humle, and M. L. Wilson, Baillie, J.E.M., Balmforth, Z., Blom, A., Boesch, C., Cox, D., Davenport, T., Dunn, A., Dupain, J., Duvall, C., Ellis, C.M., Farmer, K.H., Gatti, S., Greengrass, E., Hart, J., Herbinger, I., Hicks, C., Hunt, K.D., Kamenya, S., Maisels, F., Mitani, J.C., Moore, J., Morgan, B.J., Morgan, D.B., Nakamura, M., Nixon, S., Plumptre, A.J., Reynolds, V., Stokes, E.J. & Walsh, P.D. . 2007b. *Pan troglodytes*. 2007 IUCN Red List of Threatened Species. . IUCN.

Plumptre, A. J., R. Rose, G. Nangendo, E. A. Williamson, K. A. Didier, J. Hart, F. Mulindahabi, C. Hicks, B. Griffin, H. Ogawa, S. Nixon, L. Pintea, A. Vosper, M. McLennan, F. Amsini, A. McNeilage, Makana J-R, M. Kanamori, A. Hernandez, A. Piel, F. Stewart, J. Moore, K. Zamma, M. Nakamura, S. Kamenya, G. Idani, T. Sakamaki, M. Yoshikawa, D. Greer, S. Tranquilli, R. Beyers, C. Hashimoto, T. Furuichi, and E. Bennett. 2010. Eastern Chimpanzee (*Pan troglodytes schweinfurthii*): Status Survey and Conservation Action Plan 2010–2020. Page 56. IUCN, Gland, Switzerland.

Rainey, H. J., F. C. Iyenguet, G. A. F. Malanda, B. Madzoke, D. Dos Santos, E. J. Stokes, F. Maisels, and S. Strindberg. 2010. Survey of Raphia swamp forest, Republic of Congo, indicates high densities of Critically Endangered western lowland gorillas *Gorilla gorilla gorilla*. Oryx **44**:124-132.

Republic, P. P. S. o. t. G. 2011. Creation of a special Gabonese unit to fight poaching. http://www.presidentalibongo.com/les-actions/environnement/biodiversite.

Rohland, N., D. Reich, S. Mallick, M. Meyer, R. E. Green, N. J. Georgiadis, A. L. Roca, and M. Hofreiter. 2010. Genomic DNA Sequences from Mastodon and Woolly Mammoth Reveal Deep Speciation of Forest and Savanna Elephants. PloS Biology **8**:e1000564.

Sannier, C., E. K. M. Makaga, L. V. Fichet, B. Mertens, and F. Huynh. 2010. Monitoring of Forest Cover Change in the Republic of Gabon between 1990, 2000 and 2010 Following IPCC Guidelines. International Society for Photogrammetry and Remote Sensing.

Stiles, D. 2004. The ivory trade and elephant conservation. Environmental Conservation **31**:309-321.

Stiles, D. 2011. Elephant Meat Trade in Central Africa. Page 104. Occasional Paper of the IUCN Species Survival Commission. IUCN, Gland, Switzerland.

Stokes, E. J., S. Strindberg, P. C. Bakabana, P. W. Elkan, F. C. Iyenguet, B. Madzoke, G. A. F. Malanda, B. S. Mowawa, C. Moukoumbou, F. K. Ouakabadio, and H. J. Rainey. 2010. Monitoring great ape and elephant abundance at large spatial scales: Measuring effectiveness of a conservation landscape. PLoS One **5**:e10294.

Strindberg , S. 2012. Estimating absolute densities using line transect surveys of elephants: statistical concepts in S. Hedges, editor. Monitoring elephants and assessing threats: a manual for researchers, managers and conservationists. Centre for Wildlife Studies, Bangalore, India.

Strindberg , S., S. T. Buckland, and L. Thomas. 2004. Design of distance sampling surveys and Geographic Information Systems. . Pages 190–228 in S.T. Buckland, D.R. Anderson,

K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas, editors. Advanced distance sampling. Oxford University Press, Oxford.

Tchamba, M. 1992. Defaecation by the African forest elephant *Loxodonta africana cyclotis* in the Santchou Reserve, Cameroon. Mammalia **56**:155-158.

Theuerkauf, J., and R. Gula. 2010. Towards standardisation of population estimates: defecation rates of elephants should be assessed using a rainfall model. Annales Zoologici Fennici **47**:398-402.

Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology **47**:5-14.

TRAFFIC. 2011. 2011: "Annus horribilis" for African Elephants, says TRAFFIC. www.traffic.org/home/2011/12/29/2011-annus-horribilis-for-african-elephants-says-traffic.html. TRAFFIC.

TRAFFIC. 2012. Gabon to incinerate audited ivory stockpiles. http://www.traffic.org/home/2012/4/5/gabon-to-incinerate-audited-ivory-stockpiles.html?utm_source=twitterfeed&utm_medium=twitter.

Tutin, C., E. Stokes, C. Boesch, D. Morgan, C. Sanz, T. Reed, A. Blom, P. Walsh, S. Blake, and R. Kormos. 2005. Regional Action plan for the Conservation of Chimpanzees and Gorillas in Western Equatorial Africa. Page 36. Conservation International. , Washington, DC. .

UNDP. 2011. Human Development Tables. http://hdr.undp.org/en/media/HDR_2011_Statistical_Tables.xls. Page 4

Vigne, L., and E. B. Martin. 2011. Consumption of elephant and mammoth ivory increases in southern China. Pachyderm **49**: 79-89.

Walsh, P. D., C. E. G. Tutin, J. E. M. Baillie, F. Maisels, E. J. Stokes, and S. Gatti. 2008. *Gorilla gorilla ssp. gorilla*. IUCN Red List of Threatened Species. Version 2011.2. IUCN.

Walsh, P. D., L. J. T. White, C. Mbina, D. Idiata, Y. Mihindou, F. Maisels, and M. Thibault. 2001. Estimates of forest elephant abundance: projecting the relationship between precision and effort. Journal of Applied Ecology **38**:217-228.

WCS/CIESN. 2005. Last of the Wild Data Version 2: Global Human Influence Index (HII). Wildlife Conservation Society (WCS) and Center for International Earth Science Information Network (CIESIN)

Wittemyer, G., D. Daballen, and I. Douglas-Hamilton. 2011. Rising ivory prices threaten elephants. Nature **476**:282-283.

Yackulic, C. B., S. Strindberg, F. Maisels, and S. Blake. 2011. The spatial structure of hunter access determines the local abundance of forest elephants (*Loxodonta africana cyclotis*). Ecological Applications **21**:1296-1307.

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