

Western Lowland Gorilla (*Gorilla gorilla gorilla*)

Additional supporting information for *G. gorilla gorilla* assessment: Figures 1 & 2; Tables 1 & 2; and Appendix 1.

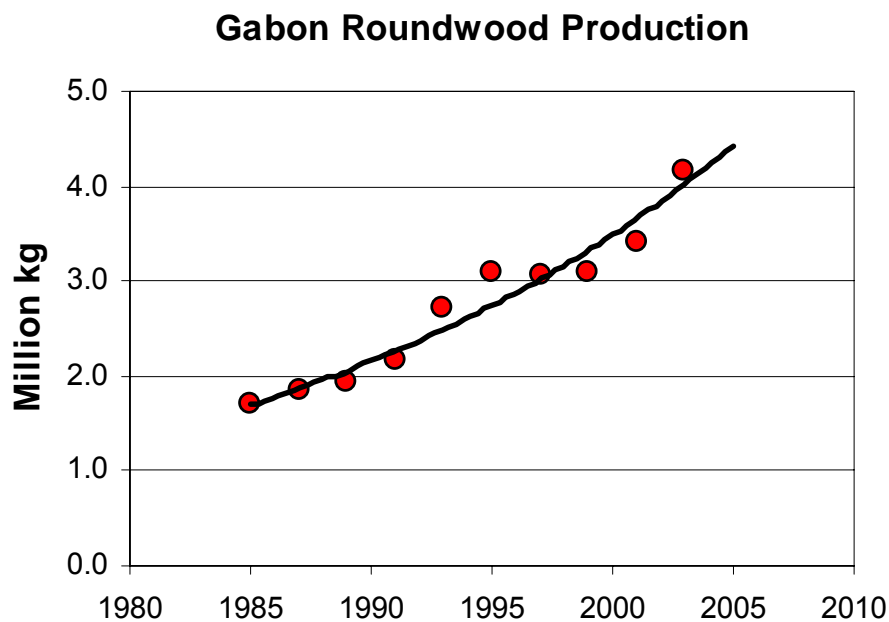


Figure 1. Roundwood production in Gabon (1980-2005). Source: <http://faostat.fao.org/>.

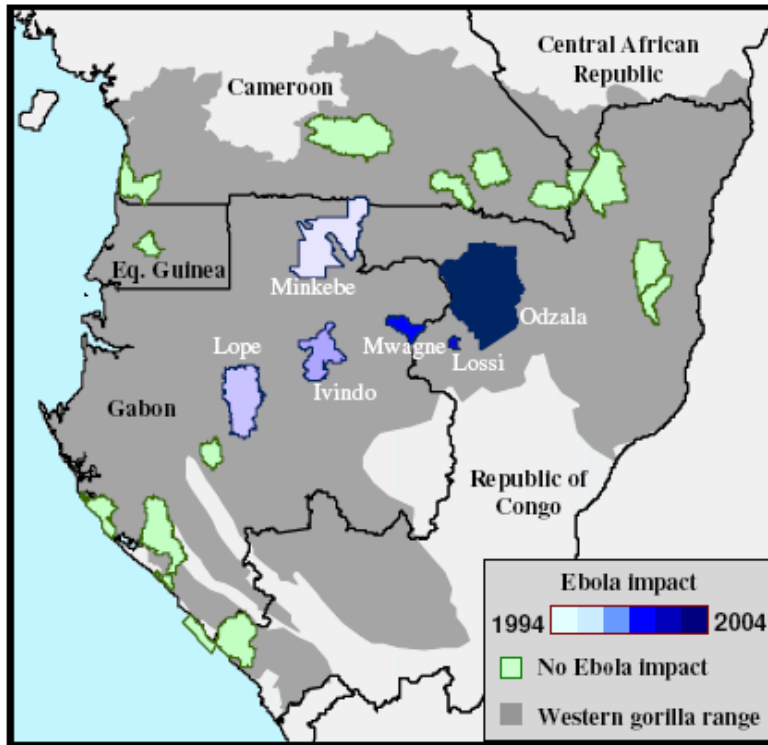


Figure 2. Protected areas with important western lowland gorilla populations.

Table 1a. Estimates of percent decline in gorilla abundance in six survey zones.

| Site | Outbreak Date | Survey Area (km ²) | Survey Effort (km) | | Nests per km | | % zone affected | % Decline |
|---------|---------------|--------------------------------|--------------------|---------------|---------------------------|---------------|-----------------|-------------|
| | | | Pre-Ebola | Post-Ebola | Pre-Ebola | Post-Ebola | | |
| Minkébé | 1994-96 | 22,300 | 81 | 2,911 | 4.11 | 0.12 | | 97.1 |
| Lopé* | 1996 | 2,000 | | | | | | 0.0* |
| Ivindo | 1996-8? | 4,700 | 67 | 124 | 2.40 | 1.33 | | 44.6 |
| Mwagné | 2001 | 3,600 | 23 | 289 | 1.85 | 0.03 | | 98.2 |
| | | | Non-Out | Outbrk | Non-Out | Outbrk | | |
| Lossi | 2002-3 | 4,300 | 267 | 332 | 1.98 | 0.081 | 62 | 59.0 |
| Odzala | 2003-5 | 13,100 | 61 | 62 | 8.34 | 0.38 | 58 | 55.6 |
| | Total | 50,000 | 565 | 3,652 | weighted mean % decline = | | | 74.2 |

*A chimpanzee carcass testing positive for Ebola was found at Lopé National Park. However, because of inadequate sampling coverage and pre-Ebola logging at Lopé, no decline estimate has been attempted. Rather, the gorilla population in Lopé is arbitrarily assumed to have experienced zero impact from Ebola. This assumption of zero impact exerts a conservative influence on the combined estimate of population decline due to Ebola.

Table 1b. Estimates of percent decline in gorilla abundance in five survey zones.

| Site | Outbreak Date | Survey Area (km ²) | Survey Effort (km) | | Nests per km | | % zone affected | % Decline |
|---------------|---------------|--------------------------------|--------------------|------------|---------------------------|------------|-----------------|---------------|
| | | | Pre-Ebola | Post-Ebola | Pre-Ebola | Post-Ebola | | |
| Minkébé ** | 1994-96 | 22,300 | 81 | 2,911 | 4.11 | 0.12 | | 97.1 |
| Ivindo | 1996-8? | 4,700 | 67 | 124 | 2.40 | 1.33 | | 44.6 |
| Mwagné | 2001 | 3,600 | 23 | 289 | 1.85 | 0.03 | | 98.2 |
| | | | Non-Out | Outbrk | Non-Out | Outbrk | | |
| Lossi | 2002-3 | 4,300 | 267 | 332 | 1.98 | 0.081 | 62 | 59.0 |
| Odzala | 2003-5 | 13,100 | 61 | 62 | 8.34 | 0.38 | 58 | 55.6 |
| | Total | 50,000 | 565 | 3,652 | weighted mean % decline = | | | 73.1** |

** Lopé has been removed since Ebola impact could not be discriminated from hunting impact. Decline rate estimates are based on relative abundance (function of nest encounter rates and surface area), rather than just park surface area. Using only surface area (no abundance), the estimate climbs to 77.3% decline.

Table 2. Protected areas holding significant pre-Ebola outbreak populations of western lowland gorilla, and Ebola-induced declines.

| Protected Area | Country | Pre-Ebola Area (km ²) | Post-Ebola Area (km ²) |
|---|------------|-----------------------------------|------------------------------------|
| Protected areas with no documented Ebola impact (*areas in epizootic path) | | | |
| Monte Alen | Eq. Guinea | 2,000 | 2,000 |
| Campo | Cameroon | 2,315 | 2,315 |
| Ngotto | CAR | 733 | 733 |
| Moukalaba Doudou | Gabon | 4,500 | 4,500 |
| Loango | Gabon | 1,550 | 1,550 |
| Birougou | Gabon | 690 | 690 |
| Conkouati | Congo | 3,465 | 3,465 |
| Dja | Cameroon | 5,260 | 5,260 |
| *Nki | Cameroon | 1,882 | 506 |
| *Boumba Bek | Cameroon | 2,501 | 672 |
| *Lobéké | Cameroon | 2,179 | 585 |
| *Dzanga Sangha | CAR | 959 | 258 |
| *Dzanga Ndoki | CAR | 190 | 51 |
| *Nouabalé Ndoki | Congo | 4,243 | 1,140 |
| *Lac Télé | Congo | 4,564 | 1,226 |
| Total | | 37,031 | 24,951 |
| % post-Ebola decline | | 32.6% | |
| Protected areas with documented Ebola impact | | | |
| Lopé (assumed to have zero impact) | Gabon | 4,970 | 4,970 |
| Ivindo | Gabon | 3,000 | 806 |
| Minkébé | Gabon | 7,570 | 2,034 |
| Mwagné | Gabon | 1,160 | 312 |
| Odzala | Congo | 13,200 | 3,547 |
| Lossi | Congo | 320 | 86 |
| Total PA area with documented Ebola impact (km²) | | 30,220 | 11,755 |
| Total PA area (all PAs) (km²) | | 67,251 | 36,706 |
| % post-Ebola decline (all PAs) | | 45.4% | |

Appendix 1

Supplementary documentation for *Gorilla gorilla gorilla* Red List

Based on correspondence from Damien Caillaud to Liz Williamson (5th May 2007): **Generation length of *Gorilla gorilla gorilla* Maya Nord, Congo = 22 years**

A method to estimate the generation time of western lowland gorilla is outlined below.

The main issue is the lack of long-term data on this species. The longest, ongoing study is Mbeli Bai, launched in 1995. Some life history trait estimates from this population (and also from habituated groups and from Maya Nord population) were published in 2004 (Robbins *et al.*, Int. J. Prim.). Though this publication does not provide estimates of adult mortality, which would be necessary to estimate the mean generation time, it gives some interesting evidence that inter-birth interval could be longer in western gorilla than in mountain gorilla. As in mammals interbirth interval is positively correlated with life expectancy, this observation could indicate that the generation time may be longer in western lowland gorilla than in mountain gorilla.

So, which available dataset may be useful to estimate western lowland gorilla adult survival and some other life history traits? Does longitudinal observation data constitute the only source of information? Under the main assumption that the few populations studied in clearings are demographically stable (i.e., their structure has reached an equilibrium and does not change with time anymore), we can imagine that population structure data conveys information concerning the life history traits they result from. D. Caillaud has developed a method to extract this (life history) information, using a Bayesian statistical method that has been developed in population genetics (which is not strange since one of the aims of population genetics is to infer historical events from cross sectional data, namely DNA sequences). The purpose of Caillaud's work was mainly to estimate age-specific migration parameters in western lowland gorilla, but it was also used to estimate age-specific survivals.

This work used the population structure data from Lokoué: 365 individuals observed from October 2003 to January 2004 (just before the Ebola outbreak). However, as a part of this dataset is useless to answer the question we are interested in here (composition of each group or number of adult males for example), Caillaud simplified it. The other published population structure data from Mbeli (Parnell 2002, Am. J. Prim.) and Maya Nord (Magliocca *et al.* 2002) was also included. Finally, the method was simplified, giving up the Bayesian algorithm as it is not necessary to estimate the generation time.

The assumptions made to estimate the adult female survival are:

- The populations are demographically stable.
- It is assumed initially that individuals could be assigned one of the following age classes: infant (<3.5 years), juveniles (<6 years), subadult (<8 years) and adult (≥8 years). The infant age class is slightly extended.
- The annual survival of adult females varies according to their age (senescence). It is assumed that this variation follows the same pattern as that observed in mountain gorillas (Robbins and Robbins 2005, agent based model). This does not mean that the age specific survivals are assumed to be the same, but that the decrease of the annual survival is assumed to follow a similar pattern (notably with a max age of 40 years).
- The sex-ratio of immatures (namely, infants+juv+subadults) is 1.

- The survival of infants (to the age of 3) varies between 0.3 and 0.5 (following Robbins *et al.* 2004).
- The survival of juveniles equals the survival of subadults. This assumption would not be necessary if we knew exactly at what age juveniles become subadults. The 6 years transition age will probably be revised in a next future (or the morphological criteria it is based on).

Caillaud also first assumed that the transition age between infants and adults was 8 years old. However this assumption led to an important site-dependant variation of the adult survival estimates, which is interpreted as an effect of the observer (as this variation is very large, it is very unlikely to be a consequence of ecological difference). The morphological criteria currently used are probably not reproducible enough (i.e, they are too subjective). Basically, it seems that Caillaud's morphological criteria imply a transition age of 7 years rather than 8 years at Lokoué, and an inverse bias at Mbeli, where the subadult-adult transition age seems to be 9 years. Maya Nord seems somewhere between 8 and 9 year. So Caillaud chose to suppress the distinction between subadults and adults, and set the annual immature survival probability to an arbitrary but plausible value of 0.95 (0.98 was also tested). The results were as follows:

Case 1: Infant survival probability to the age of 3 equals 0.7, juv and sub annual survival probability both equal 0.98.

| | infancy duration | |
|---------------|------------------|---------|
| | 3.5 years | 4 years |
| model1 | 19.8 | 20.8 |
| model2 | 20.1 | 21.1 |
| model3 | 20.4 | 21.3 |

Case 2: Infant survival probability to the age of 3 equals 0.7, juv and sub annual survival probability both equal 0.95.

| | infancy duration | |
|---------------|------------------|---------|
| | 3.5 years | 4 years |
| model1 | 21.0 | 22.0 |
| model2 | 21.2 | 22.1 |
| model3 | 21.4 | 22.3 |

Case 3: Infant survival probability to the age of 3 equals 0.5, juv and sub annual survival probability both equal 0.98.

| | infancy duration | |
|---------------|------------------|---------|
| | 3.5 years | 4 years |
| model1 | 20.8 | 21.7 |
| model2 | 21.4 | 22.2 |
| model3 | 21.9 | 22.6 |

Case 4: Infant survival probability to the age of 3 equals 0.5, juv and sub annual survival probability both equal 0.95.

| | infancy duration | |
|--------|------------------|---------|
| | 3.5 years | 4 years |
| model1 | 21.9 | 22.8 |
| model2 | 22.4 | 23.2 |
| model3 | 22.8 | 23.5 |

The above tables provide estimates of the mean age of females aged 10 years or more, obtained using population structure data from 3 sites (Lokoué, Mbeli, MayaN). The 3 models denoted model1, model2 and model3 correspond to three different ways to parameterize the survivals of the immature individuals. Caillaud also tested two durations for the infant age class (3.5 and 4 years). The generation time estimates, defined as the mean age of females aged 10+, range from 20.8 to 23.5 years.

Caillaud therefore advises using **22 years** as the (temporary) reference value for the generation time of western lowland gorilla.

It is important to note that that these estimates mainly rely on 3 assumptions. The first is that the populations are demographically stable. The second is that the decrease of adult female survival depends on their age in a similar pattern to that observed in *G. beringei beringei*. The third is that the duration of the infant age class varies between 3.5 and 4 years. Among these three assumptions, the second one is the most likely to be invalidated in the future. The maximum life duration is indeed likely to differ among the two gorilla species.