**Supporting Information: Grauer’s gorilla population crash**

**Table A.** Covariables used for the analysis of occupancy across the landscape.

|  |  |  |
| --- | --- | --- |
| **Covariable Name** | **Measures** | **Source** |
| *Climate variables* |
| bio2 | Mean diurnal temperature range | WorldClim interpolated climate surfaces<http://www.worldclim.org/> |
| bio12 | Mean annual precipitation |
| bio17 | Precipitation of driest quarter |
| *Topographic and forest variables* |
| dem | Elevation above sea level | SRTM data at University of Maryland<http://glcf.umd.edu/data/srtm/> |
| rugged | Ruggedness of topography | Available at <http://diegopuga.org/data/rugged/#grid>  |
| slope | Slope – calculated from DEM layer | SRTM data at University of Maryland<http://glcf.umd.edu/data/srtm/> |
| stslopdis | Distance to steep slopes | Calculated by Lilian Pintea, Jane Goodall Institute, from SRTM data |
| treecov | Percentage tree cover | Calculated by Lilian Pintea, Jane Goodall Institute, from Hansen *et al*.(2013)\* |
| *Human impact variables* |
| disforlos | Distance to forest recently lost | Calculated by Lilian Pintea, Jane Goodall Institute, from Hansen *et al.* (2013)\* |
| minedist | Distance to artisanal mines | Data from International Peace Information Service and mine location data from SMART |
| rivdis | Distance to rivers | Calculated from  |
| roaddis | Distance to roads | Data from UNOCHA in eastern DRC |
| villdis | Distance to villages | Date from UNOCHA in eastern DRC |

\*M.C. Hansen et al., High-resolution global maps of 21st-century forest cover change. Science342: 850–53 (2013). Data available online from: <http://earthenginepartners.appspot.com/science-2013-global-forest>

**Model A: Model for occupancy analysis:**

The occupancy analysis was performed using a zero-inflated binomial model with spatial autocorrelation (hSDM.ZIB.iCAR() function in the hSDM R package15). This model is hierarchical and structured as follows:

There is an ***ecological process*** – the suitability of the habitat:

*zi ~ Bernoulli (Ɵi)*

*Logit (Ɵi) = XiB + pi*

Where *zi* = habitat suitability at site *i*; *Ɵi* = probability that habitat is suitable at site *i*. Habitat at site *i* is described by environmental variables *Xi* with coefficients *B* and spatial random effect *pi*. *pi* is the spatial random effect for cell *i*.

Secondly, there is a ***spatial auto-correlation*** component:

An intrinsic conditional autoregressive model (iCAR) is assumed:

*pi= Normal (ui, Vp/ni)*

Where *ui*= mean of *pi*in the neighbourhood of cell *i*; *Vp* = variance of the spatial random effects; *ni*= number of neighbours for cell *i*

Thirdly, there is an **observation process**:

*yi = Binomial (zi \* di,ti)*

*Logit (di) = Wiϒ*

Where *yi* = presence of a species at site *i*; *di* = probability of detecting the species at site *i*; *Wi* = covariables explaining the observation process with parameters *ϒ*. *ti* is the number of visits (trials) at site *i.*

Non-informative normal priors were used for parameters B and ϒ (mean=0 and variance=106). For the variance of the spatial random effects (Vp), we used an informative uniform prior on the interval [0,10].

***Gorilla model***

In the final hSDM.ZIB.iCAR model for gorillas, the following coefficients for each covariable that was statistically significant and biologically relevant were obtained:

|  |  |  |  |
| --- | --- | --- | --- |
| **Covariable** | **Mean** | **SD** | **Significance** |
| beta.(Intercept) | -4.074 | 0.449 | P<0.05 |
| beta.dem | 1.237 | 0.313 | P<0.05 |
| beta.disforlos | 1.233 | 0.419 | P<0.05 |
| beta.treecov | 0.794 | 0.243 | P<0.05 |
| gamma.(Intercept) | -2.082 | 0.068 | P<0.05 |
| Vrho | 9.391 | 0.563 |  |
| Deviance | 798.779 | 15.572 |  |
|  |  |  |  |

Gorillas tend to be found at higher elevations, where tree cover is high, and away from active deforestation. Posterior mean detection probability (*di*) was 0.111 and the posterior mean probability of occupancy (*Ɵi*) was 0.073.

**TSS: Computation of TSS and gorilla numbers**

We obtained a probability threshold of 0.35 (Fig A) and a maximal TSS of 0.88. This is a relatively high TSS value, indicating a good correspondence between our species distribution area and observed suitable and unsuitable sites. The species distribution area, defined as the 5x5 km cells with a presence probability value of 0.35 or greater, was 19,700 km2. The weighted mean density of gorillas across all sites, applying the regression of encounter rate on density (Fig B) to sites with encounter rate data, was 0.193 per km2. When multiplied by the surface of the species distribution area, we estimated a total population of 3,800 Grauer’s gorillas across the range.



**Figure A.** Plot of the True Skill Statistic against probability threshold identifying p=0.35 as the probability threshold for a maximum TSS of 0.88.



**Figure B.** Correlation of encounter rate of nests (No. per km walked) and calculated densities (No. per km2) with 95% confidence intervals (dashed lines). Density = 0.507 x e-rate +0.064 (R2adj=0.96). Densities were calculated for nine sites for which transect data were available.

**R-Code**

A project has been established at GitHub, which is open access: <https://github.com/ghislainv/gorillas>