HNE Eberswalde
Hochschule für nachhaltige Entwicklung

Szkoła Główna Gospodarstwa Wiejskiego w Warszawie

The Potential Impacts of Land use and land cover change to the distribution of Apes Population at the Lobeke National Park, South East Cameroon

Course Module – Students Research Colloquium

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Presentation outline

- Introduction
- Research Objectives
- Materials and Methods
- Results
- Discussion
- Conclusion
- Acknowledgements
- Recommendations

Introduction

- Over the past two decades, a tremendous amount of work has been undertaken to map species' distributions and use the collected information to identify suitable habitats (Austin, 2002; Ara_ujo et al. 2005; Franklin 2010).
- A good number of sophisticated modeling tools have been used by ecologist in predicting species occurrence and distribution (Elith and Leathwick 2009; Kissling et al. 2012).
- The chimpanzees and gorillas of Cameroon are classified as 'Endangered' and of global conservation concern. Numbers are declining because of hunting for bush meat, disease, loss of habitat to agriculture and mining as well as habitat fragmentation (Craigie et al. 2010, Morrison et al. 2007) leading to the isolation of small populations which are likely to become genetically unviable in the long term.
- These species occurs at a very low density of less than 1 individual/km^2 of forest on average across much of their range and has a relatively slow reproductive rate, with one infant born every 4-5 years.
- Consequently, they need large areas of habitat to maintain viable populations.

Research Objectives

- To classify, analyze and evaluate the changes in Land use and Land cover types that have occurred at the Lobeke National Park within the course of 5 years (2001-2006).
- To quantify and analyze the changes in occurrence and distribution patterns of Apes species within the identified land cover classes between both years
- To model and evaluate the response of Apes species to the changing land cover classes of both years
- To provide a time series modeling and analysis of changes in species distribution as a result of changing land cover types.
- To make recommendations based on the research results for the sustainable management of the Lobeke national park.

Materials and Methods

The study design (work flow)

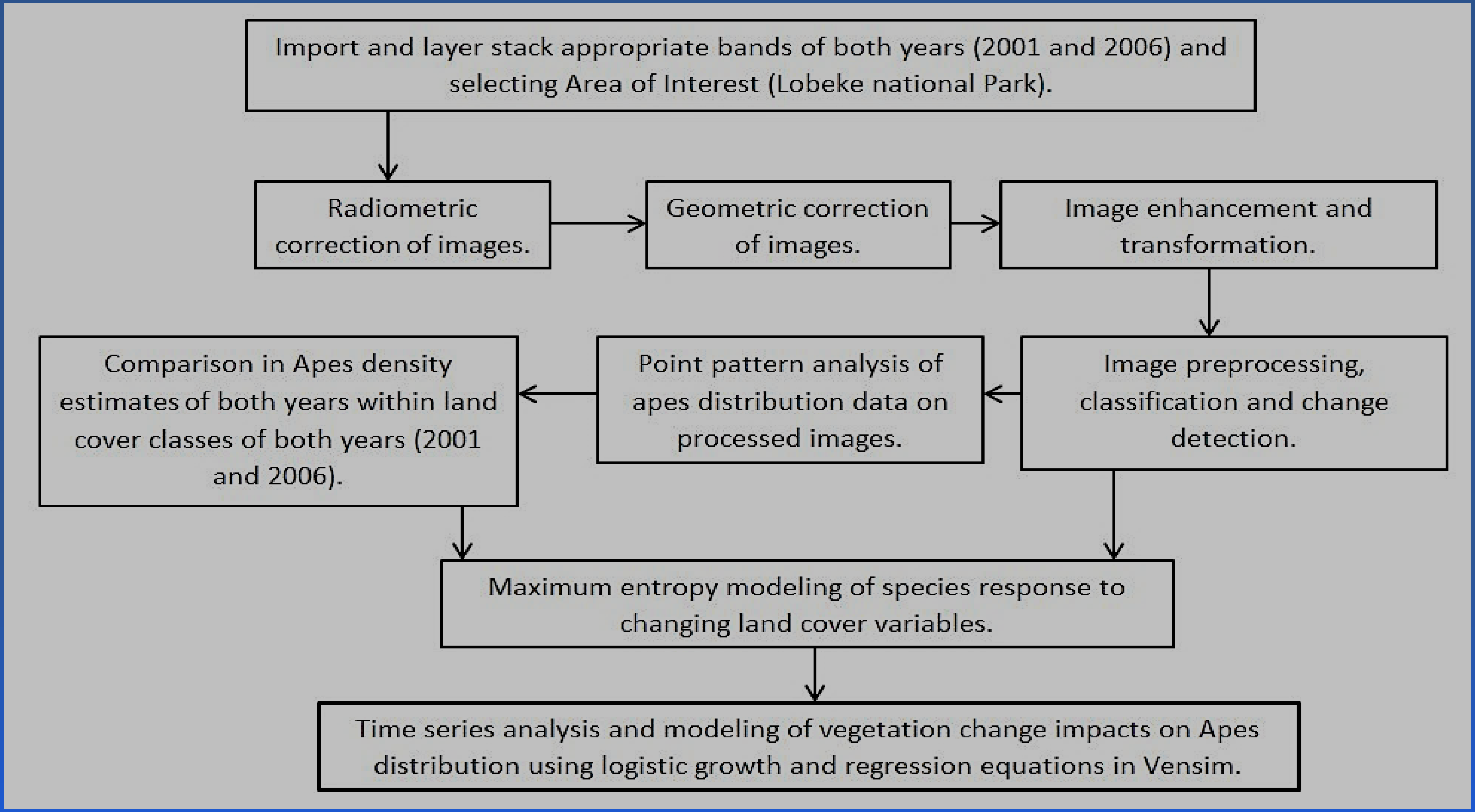


Figure 1 Summarized plan of the research methodology and approach.

Location of Study Site

The Lobeke National Park is a National Park located in South-East Cameroon in the Congo Basin, between latitudes 2º 05' to 2º 30' N and longitudes 15º 33' to 16º 11' E. it is bounded on the east by the Sanaga River which serves as Cameroon's international border with Central African Republic and the Republic of Congo.

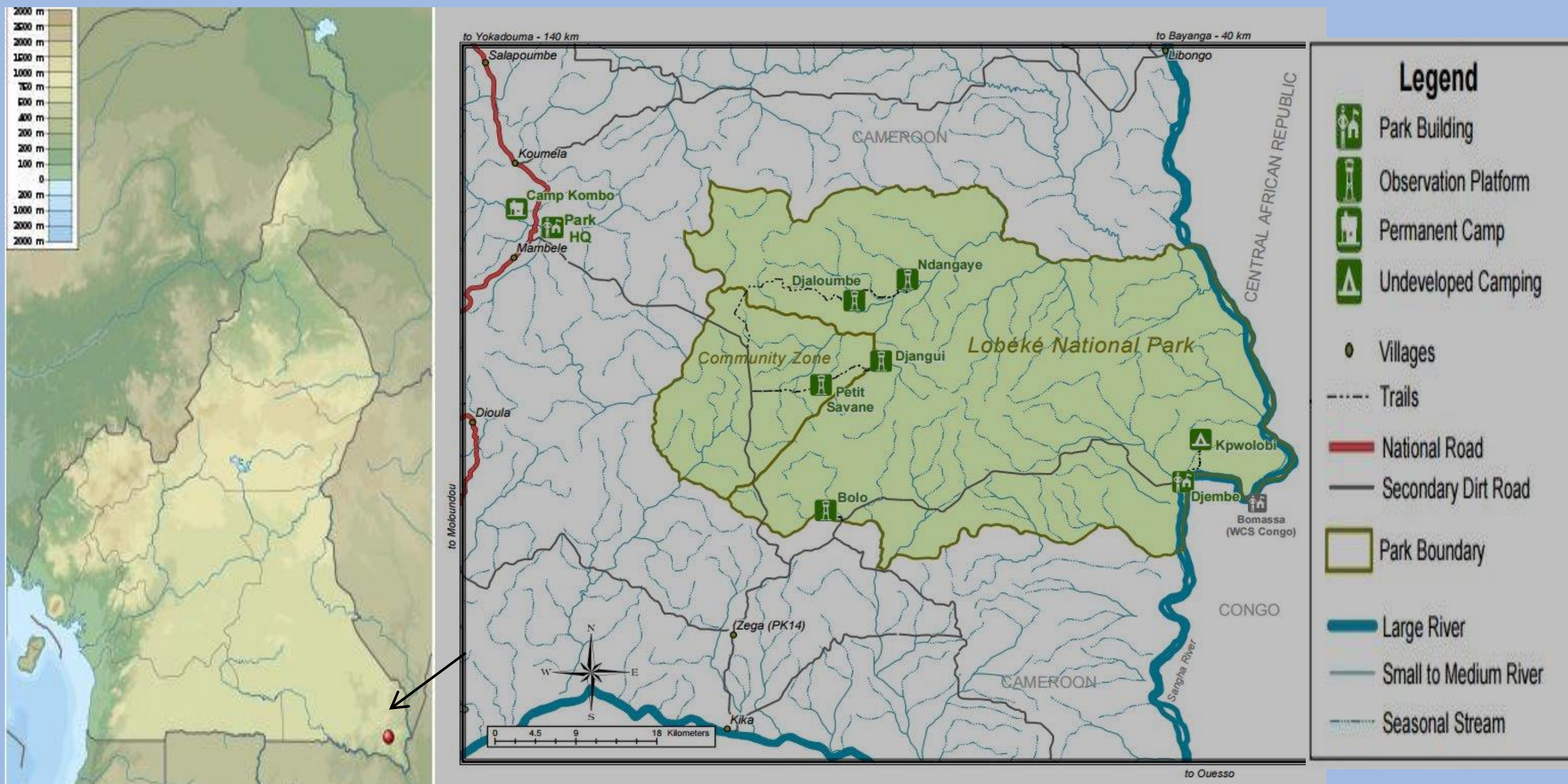


Figure 2. Map of Lobeke national Park and its surrounding Peripheries in South-East Cameroon

Data acquisition and Image pre-processing

- Landsat 7 ETM+ images of South-east Cameroon with acquisition dates of February 2001 and March 2006 were downloaded from USGS.earthexplorer.gov.

- Atmospheric correction was done with landsat surface reflectance in Erdas Imagine inorder to convert remotely sensed DN (digital numbers) to ground surface reflectance.

Image processing (Classification and change detection)

- Supervised classification was done using Maximum likelihood classification in ArcMap and the accuracy results validated.

- The change detection analysis was done done using the formula:
- Area(Class N(m^2)) (2001) = Number_of_pixels(class N) (2001) * pixel_size(m^2)
- Area(Class N(m^2)) (2006) = Number_of_pixels(class N) (2006) * pixel_size(m^2)
- Change in Land cover classes = Area of Land cover classes 2006 – Area of Land cover classes 2001
- Rate of change in Land cover classes = Change in Land cover classes /5years

Surveys and Species distribution Mapping

- Apes distribution data for the years 2001 and 2006 at the Lobeke national park were obtained from the IUCN Pan African Apes database at the Max Planck Institute for evolutionary Anthropology (MPI-EVA), Germany.

- The data were collected in the field by a team of WWF experts using transects and recce surveys which were similarly walked for both years.

- The observations signs recorded were: nest counts, faecal remains, tracks, smell, direct sighting and vocalization.

- Species distribution mapping and modelling was done using MAXENT (Maximum entropy model) and kernel density estimates in ArcGIS in order to test the response of Apes species to changing land cover classes.

- Logistic growth and regression modeling was done with Vensim inorder to simulate the changes in Apes species distribution at the Park within the course of 5 years (2001-2006) as a result of change in vegetation cover.

- The following logistic growth equation was applied in the model:

$$\frac{dN(t)}{dt} = r \cdot \left(1 - \frac{N(t)}{K}\right) \cdot N(t)$$

Where r is the rate of species occurrence/distribution, K is the carrying capacity of the environment (Amount of vegetation cover between 2001 and 2006), and

$$N(t) = \frac{K}{A \cdot e^{-rt} + 1}$$

where A (constant) $= \frac{K}{N_0} - 1$

and N_0 is the initial population at time t_1 (2001).

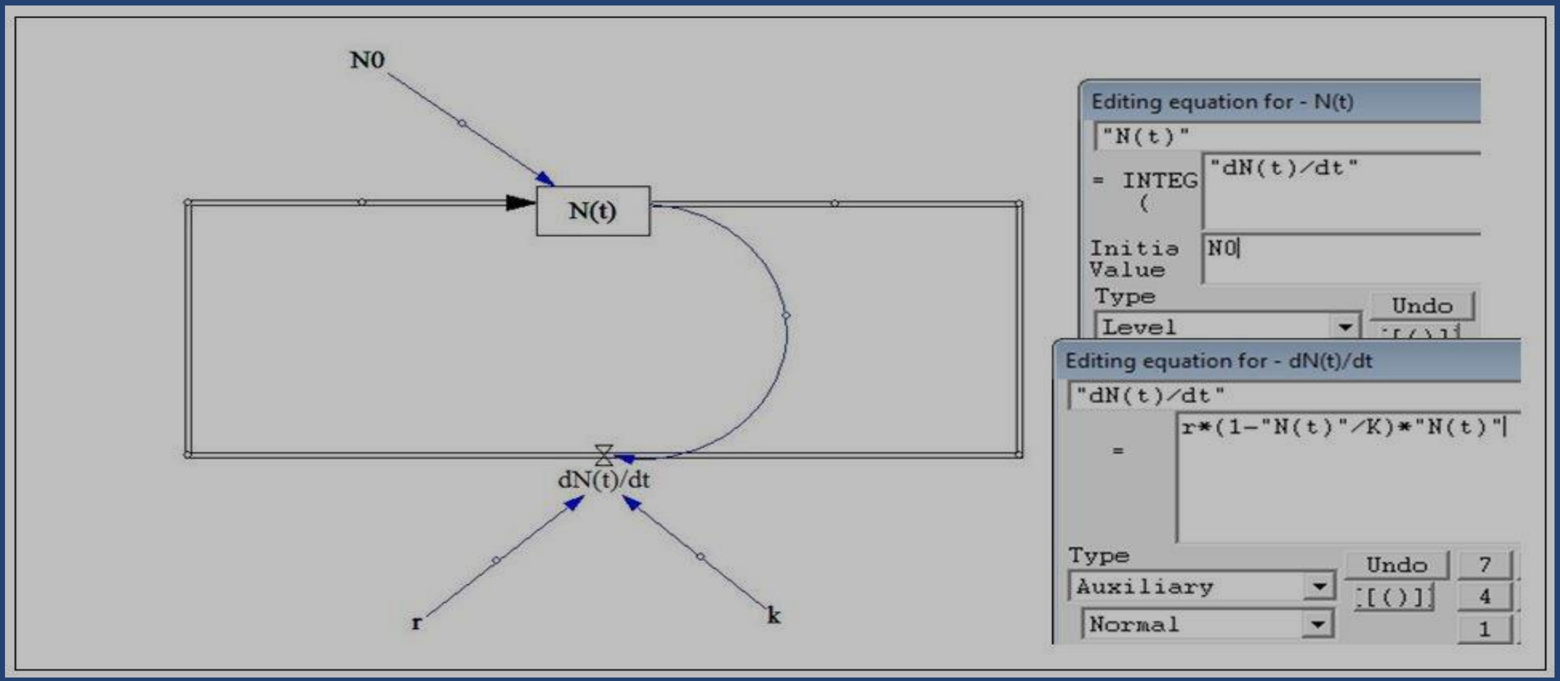
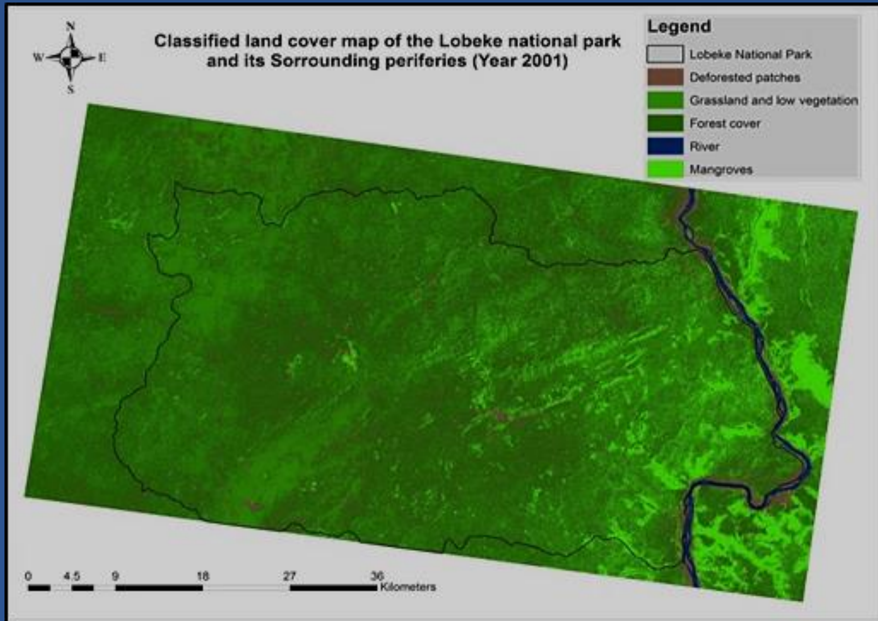
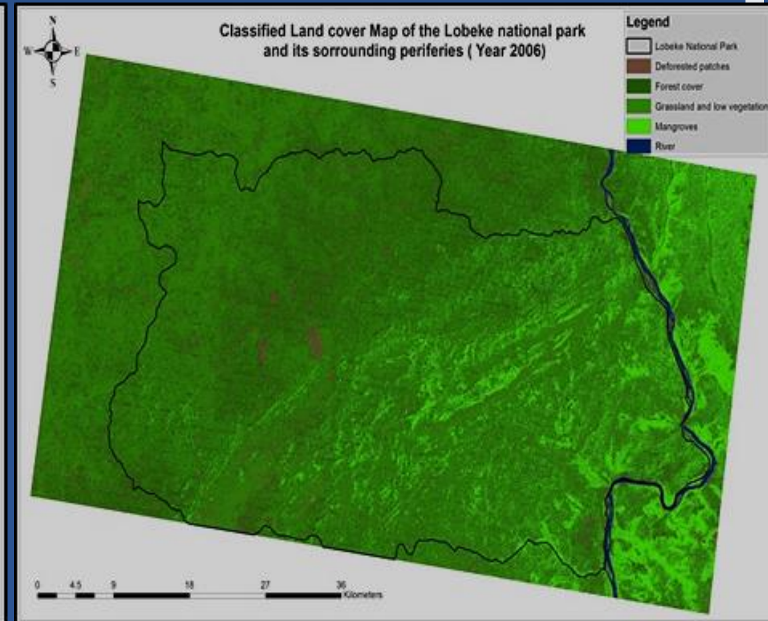


Figure 3. Vensim model applied to simulate rate of change in Apes distribution per time, impacted by rate of change in vegetation cover.

Results





Figures 4. Land cover classification maps for 2001 (left) and 2006 (right).

Table 1a. Accuracy assessment of classified land cover classes (2001).

Classification 2001	Forest cover	Deforested patches	Rivers	Grassland/low vegetation	Mangroves	Total
Forest cover	202	24	0	0	0	226
Deforested patches	0	215	0	4	0	219
Rivers	0	0	182	0	0	182
Grassland/low vegetation	30	4	0	104	0	138
Mangroves	12	0	0	0	198	210
Grand Total	244	243	182	108	198	975

Overall accuracy = 93.52%

Table 1b. Accuracy assessment of classified land cover classes (2006).

Classification 2001	Forest cover	Deforested patches	Rivers	Grassland/low vegetation	Mangroves	Total
Forest cover	214	0	0	0	0	214
Deforested patches	0	102	0	0	0	102
Rivers	0	5	182	0	0	187
Grassland/low vegetation	30	10	2	108	0	148
Mangroves	0	0	0	0	198	198
Grand Total	244	117	182	108	198	849

Overall accuracy = 94.76%

Results cont'd

Table 2a. Computed attribute results of the land cover classifications of the years 2001 and 2006

		2001		2006	
Land cover classes	Pixel size (Ps) (m^2)	N values	Area in km^2 ($N * Ps/10^6$)	N values	Area in km^2 ($N * Ps/10^6$)
Vegetation cover	900	3579202	3221.3	3537433	3183.7
Deforested patches	900	283532	255.2	329816	296.8
Rivers	900	31535	28.4	27695	24.9

Table 2b. Area of classified land cover categories in kilometres

Land cover types	Land cover classes (km^2)	
	2001	**2006**
Vegetation cover	3221.3	3183.7
Deforested patches	255.2	296.8
Rivers	28.4	24.9
Total	3505	3505

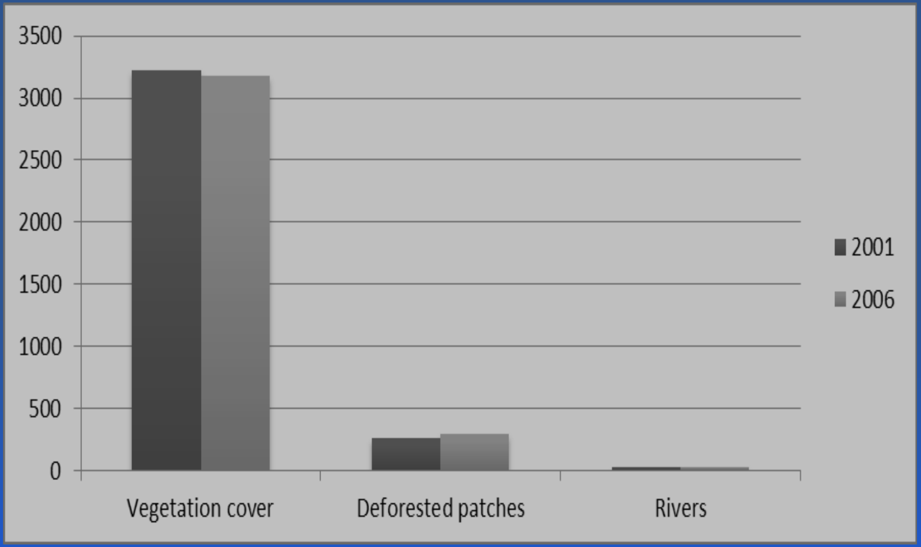


Figure 5: Land use and land cover classification results for 2001 and 2006.

Change detection = Land cover classes 2006 – Land cover classes 2001.

The rate of change was then deduced from this formula as:

Rate of change = Change detection / 5 years.

Table 3. Change detection results

Land cover classes	Change detection (km^2) (2006-2001)	Rate of change (km^2/year) (Change detection/ 5 years)
Vegetation cover	-37.6	-7.52
Deforested patches	41.6	8.32
River	-3.5	-0.7

Results Cont'd

- From our land cover classification results, we further carried out a point pattern analysis and modelling on apes occurrence and distribution within the National park using MAXENT and kernel density estimates.

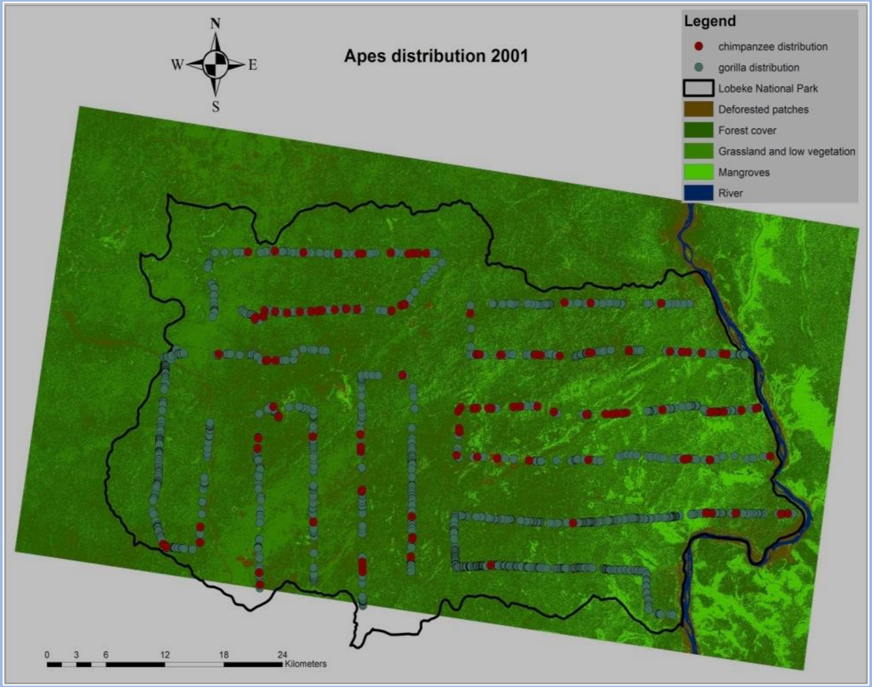


Figure 5a. Pattern distributions in Apes species (chimpanzees and gorillas) for the year 2001 within identified land cover classes.

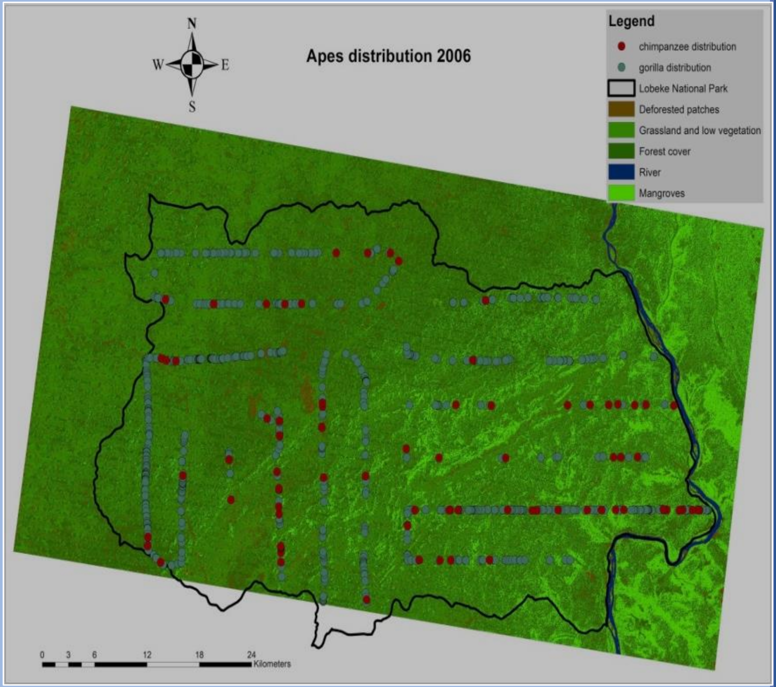


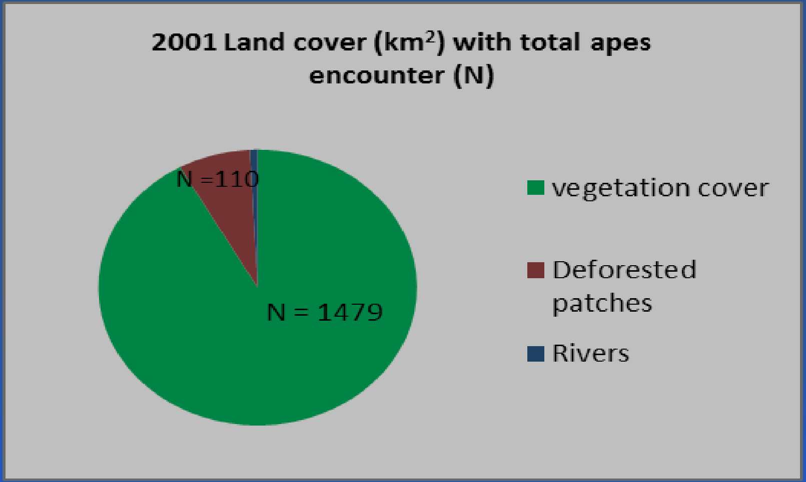
Figure 5b. Pattern distributions in Apes species (chimpanzees and gorillas) for the year 2006 within identified land cover classes.

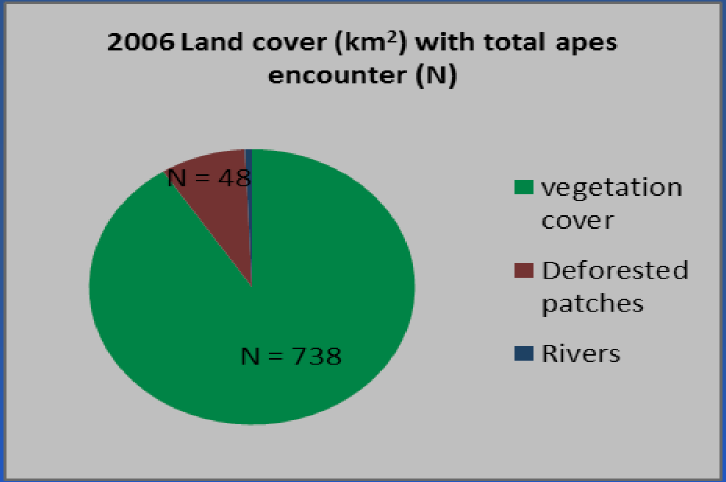
- From our point pattern analysis, we aimed at statistically comparing how many encounter rates of chimpanzees and gorillas where made within each of the land cover classes of both years.

Results Cont'd

Table 4 Comparison in Apes encounter rate within the selected land cover classes of both years.

Land cover classes	Total land cover area (km^2), 2001	Chimpanzee encounters (N), 2001	Gorilla encounters (N), 2001	Total land cover area (km^2), 2006	Chimpanzee encounter (N), 2006	Gorilla encounter (N), 2006
Vegetation Cover	3221.3	139	1340	3183.7	85	653
Deforested patches	255.2	11	99	296.8	5	43
Rivers	28.4	-	-	24.9	-	-
Total	**3504.9**	**150**	**1439**	**3505.4**	**90**	**696**

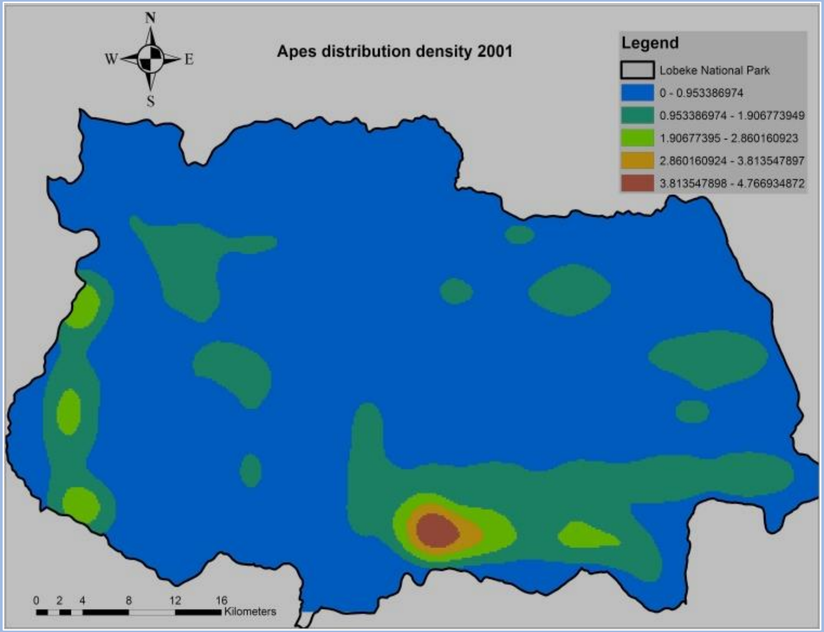


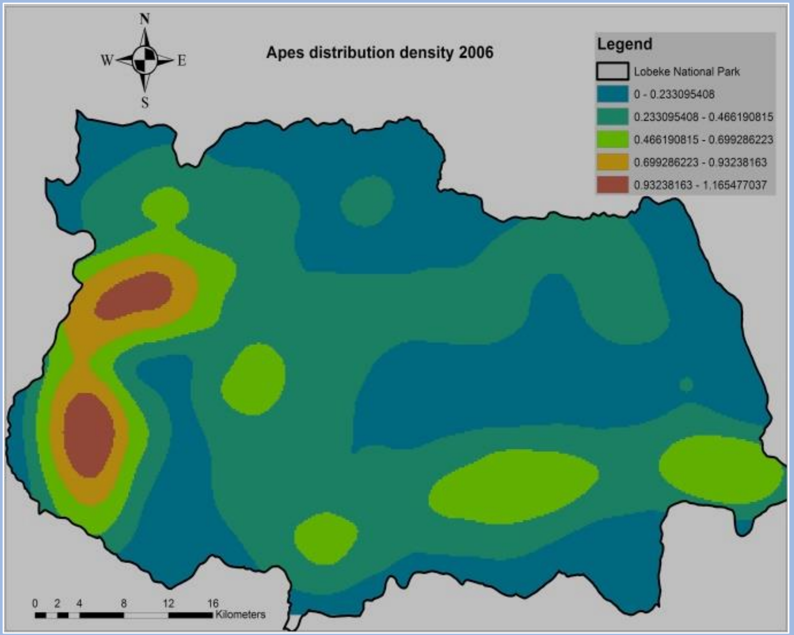


Figures 6. Pie charts showing distribution of Apes encounter within selected land cover classes of both years (2001 and 2006).

Results Cont'd

- Based on this occurrence values, we further applied the one sample Kolmogorov smirnov test (K.S test) to test for statistical significance in normality of species distribution between both years.
- An Asymp. Sig. (2-tailed) value of 0.113c (11.3% significance) was obtained in 2001 and 0.200c (20% significance) obtained in 2006 , thus indicating normality in distribution in apes species between both years, hence null hypothesis accepted for species distribution in both years.
- With these statistical significance results, density maps of species distribution for both years were deduced.

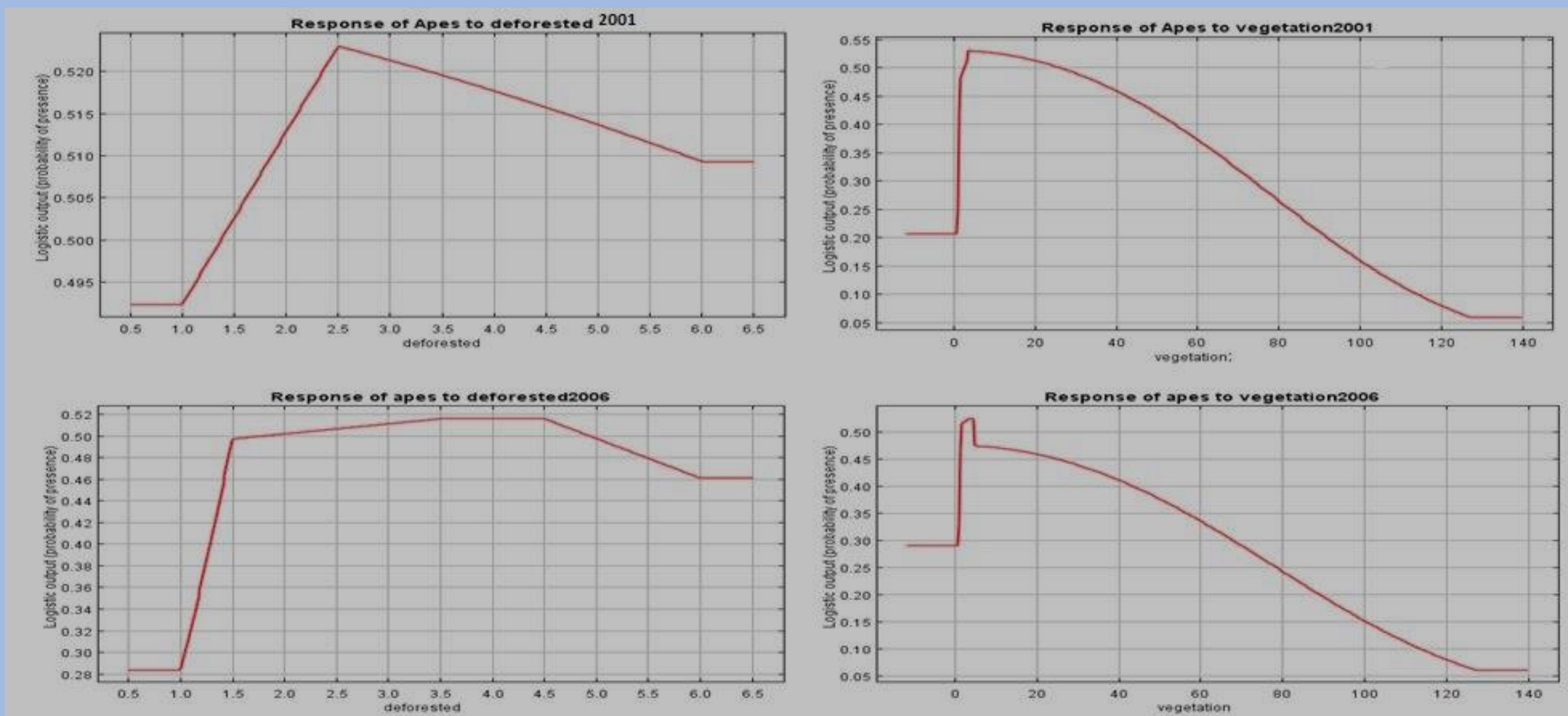




Figures 7. Apes distribution density within selected land cover classes of both years (2001 on the left) and (2006 on the right).

Results Cont'd

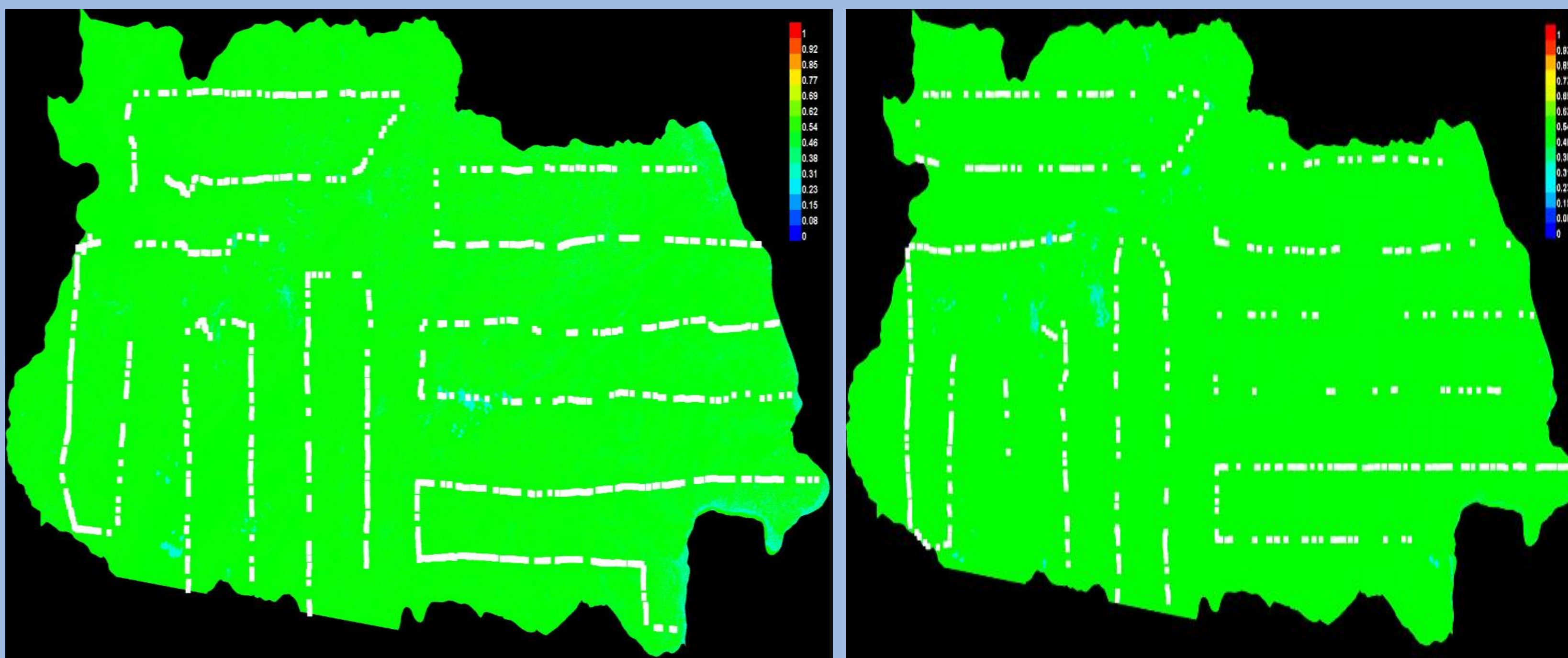
- High density values indicated species occurrence in areas of extreme dense vegetation cover.
- We further applied the Pearson correlation test in R, which gave a correlation value of 0.88, implying that there is a strong correlation in Apes distribution between both years.
- From the density distribution of species, we further applied MAXENT modelling analysis to evaluate and compare the response of Apes species to the different land cover classes between both years. Figures 9 Summarize the obtained results from the MAXENT model.



Figures 8. MAXENT model results for both years. Response of Apes to deforested areas 2001 (upper left), vegetated areas 2001 (upper right), deforested areas 2006 (lower left) and vegetated areas 2006 (lower right).

Results Cont'd

- From the Maxent results, it could be observed that the probability of vegetation pressure to species distribution decreases at an increase vegetation threshold for both years, hence indicating that species are more vulnerable to survival at areas with dense vegetation cover than areas with no vegetation (deforested patches).
- Figures 9a and 9b shows a response map generated by the Maxent model to illustrate a dense distribution of apes species on vegetation cover.



Figures 9. Species distribution maps generated by the MAXENT model (2001 on the left and 2006 on the right).

Results Cont'd

- We further applied the Vensim logistic growth model in order to simulate the rate of change in species distribution within a period of 5 years (2001-2006) influenced by the rate of vegetation change.
- We calculated the value of A and r using the parameters- K (vegetation carrying capacity for 2001) = 3221.3 km^2, N_0 (species encounter (2001)) = 1588 and t (time) = 5 years.
- The deduced value of *r* from the equation was -14 encounters per km^2 per year, which we applied in the Vensim model to simulate dN(t)/dt (rate of change in species encounter (N) at a given period of time (t)).

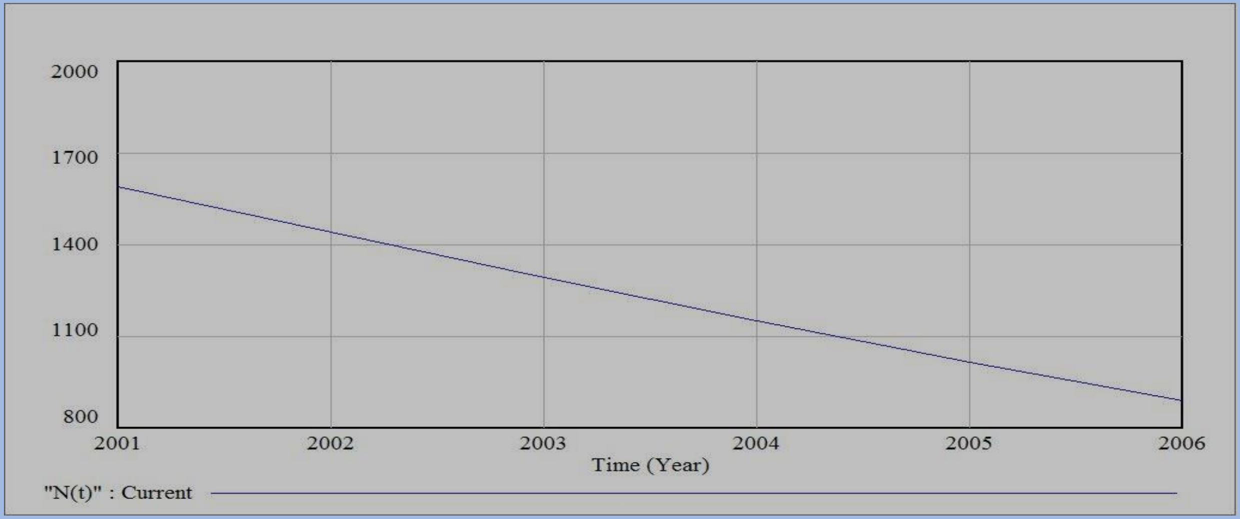


Figure 10. Graph of species distribution change within a 5 years interval impacted by rate of vegetation change as simulated by the Vensim model.

- The Vensim model simulation results as seen in Figure 10 could show that, as time changes (increase from 2001 to 2006), species distribution decreases at a logical regression rate of -14 encounters per sq.km per year.
- This decrease was due to a loss in vegetation cover from 3221.3 km^2 in 2001 to 3183.7 km^2 in 2006, when applied for the value of k (carrying capacity of the environment) in the model.

Discussion

- From our results, we could deduce a change detection with vegetation loss of -37.6 km^2 within the course of 5 years at a rate of -7.52 km^2/year. This loss in vegetation could be accounted for as a result of increase human population around the park as well as large scale, medium size and small size logging companies.
- Point pattern analysis and mapping of Ape species within these land cover classes depicted high encounters of chimpanzees and gorillas within vegetation covers and a very low or less dense occurrence of these species around deforested patches.
- Our results also showed a more dense distribution of gorillas than chimpanzees within the selected land cover classes. This is because chimpanzee and gorilla densities differ in relation to the distribution and quality of habitats (Bermejo, 1999; Morgan et al., 2006; Poulsen & Clark, 2004; Tutin & Fernandez, 1984).
- With a fitness model using MAXENT (Maximum Entropy Model), species response to increase vegetation threshold in both years was quite high as the probability of vegetation pressure to species distribution decreased. These results showed that chimpanzees and gorillas are more vulnerable to survive in areas of extreme dense vegetation cover.
- Our vensim model results also showed a decrease in species distribution at a rate of -14 encounters per km^2 per year from 2001 to 2006 as a result of loss in vegetation cover at a rate of -7.52 km^2/year.
- This model was quite predictive as it uses environmental variables (vegetation cover) as basis of simulating species distribution at a defined time series thus simplifying the responses generated by the MAXENT model.

Conclusions

- The classification results obtained in the study proved to be quite efficient to identify forest land cover changed between both years as a high accuracy of classification results could be deduced (93.52% for the year 2001 and 94.76% for the year 2006).
- A point pattern analysis of ape survey data for the years 2001 and 2006 could properly predict the distribution or occurrence encounters of chimpanzees and gorillas between vegetation cover and deforested areas which made the change comparison easy to deduce.
- Simulation models from MAXENT, Vensim and kernel density estimates could deduce results on species density and response to changing land cover classes of both years.
- With such results, it is possible to further analyse and predict how species will respond to these changing environmental variables by the year 2035.
- We thus concluded from these output scenarios that the vegetation cover of the Lobeke National park is under threat and gradually losing its stand which will affect wildlife occurrence at the park in the long run if mitigative measures are not strictly applied.
- Thus providing a positive conservation measure to this scenario will not only benefit wildlife survival but with contribute to mitigate the devastating effects of climate change at a global level.

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- This research would not have been possible without the constant contribution of ideas and provision of data by the IUCN Apes database management team of the department of Primatology at the Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany.
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Supplementary Material

Picture 1: Pictures of Apes species in their niche: (a) Chimpanzees (b) Gorilla (c) Bonobos.

“Apes” (also called old world primates) are large mammal species originating from the Order: “Primates” and Family: “Hominoidea”, ranging from Africa to Southeast Asia, and are also considered to be the closest relatives to humans. These species include chimpanzees, gorillas and bonobos which live in African forests as well as orangutans which live in South East Asian Forests.

Thank You