Journal of Geoscience and Environment Protection, 2025, 13(5), 60-73
https://www.scirp.org/journal/gep
ISSN Online: 2327-4344
ISSN Print: 2327-4336

Effect of Site Size, Armed Group Presence, Conservation Model and Governance Mode on the Conservation Return on Investment across Selected Conservation Areas in the Grauer's Gorilla (*Gorilla beringei graueri*) Range in Eastern Democratic Republic of the Congo

Urbain Ngobobo[1,2*], Zo Hasina Rabemananjara[1], Bruno Ramamonjisoa[1], Augustin Basabose[3]

[1]Antananarivo University, Antananarivo, Madagascar
[2]The Dian Fossey Gorilla Fund, Goma, Democratic Republic of the Congo
[3]Lwiro Natural Research Center, Lwiro, Democratic Republic of the Congo
Email: *urbainngobobo@gmail.com

How to cite this paper: Ngobobo, U., Rabemananjara, Z. H., Ramamonjisoa, B., & Basabose, A. (2025). Effect of Site Size, Armed Group Presence, Conservation Model and Governance Mode on the Conservation Return on Investment across Selected Conservation Areas in the Grauer's Gorilla (*Gorilla beringei graueri*) Range in Eastern Democratic Republic of the Congo. *Journal of Geoscience and Environment Protection, 13,* 60-73.
https://doi.org/10.4236/gep.2025.135005

Received: February 22, 2025
Accepted: May 13, 2025
Published: May 16, 2025

Abstract

The forests of the eastern Democratic Republic of the Congo are among the most biodiverse in the world. They are home to many endangered and endemic species, such as the Grauer's gorilla (*Gorilla beringei graueri*). Governmentally protected areas (GPAs) in Grauer's gorilla range face challenges to limit or halt poaching and bushmeat extraction, and it is unclear whether alternative community conservation models can overcome some of these challenges. Here, we examine how protected area (PA) size, conservation models (CM), mode of governance (GM), and the presence of armed groups relate to Return On Investment in land (ROIL) across selected PAs. As proxies of ROIL, we solicited information on the site coverage (area patrolled as a percentage of total surface area) and the level, extent, and trend of poaching or hunting from the [ecosystem or conservation] managers of 11 PA sites to Grauer's gorillas, of which five were GPAs and six were community based protected areas (CPAs). We found substantial differences in apparent ROIL across PAs. CPA often had higher ROILs than GPA due to the former's high site coverage, low levels, and decreasing trends in poaching or hunting, and a relatively low presence of armed groups. This suggests that community forests in Grauer's gorilla range in eastern DRC may have the potential to help address and overcome some of the conservation management challenges currently facing the subspecies. However, follow-up studies are needed to explore the extent to which our findings

can be attributed to factors such as the relatively smaller size of community forests, their specific geographical locations, differences in management models or ecosystem attributes (e.g., the presence of other fauna), or aspects related to the involvement of local communities.

Keywords

Return on Investment, Community-Based Conservation, Fortress Style Conservation, Poaching, Bushmeat, Armed Conflict, Grauer's Gorilla Range, Congo Forest

1. Introduction

The loss of biodiversity worldwide has long been recognized as a prominent political and social concern (Lele et al., 2010). A key component of strategies to protect biodiversity has been Protected Areas (PAs), defined as "a clearly defined geographical area, recognized, dedicated and managed, through legal or other effective means, to ensure the long-term maintenance of natural features and the ecosystem services, cultural features and other elements of value to society, whether expressed or not, and the sustainable use of all resources, both natural and cultural, within that area, in harmony with the objectives and purposes of the protected area" (Dudley, 2008). However, there are different PA approaches defined by their objectives and management strategies. Many governments have historically engaged in formal, "fortress conservation model" means of biodiversity conservation, often also called a "fence and fine" approach, through the creation of PAs in which human visitation and resource exploitation are strictly prohibited (Ervin et al., 2010; Doumenge et al., 2015; Jones et al., 2018; Naidoo et al., 2019; Filho et al., 2020; Elleason et al., 2021; Appleton et al., 2022). However, despite these efforts, global biodiversity continues to deteriorate at an alarming rate (Dudley, 2008; Hockings et al., 2008; Poisson, 2009; Butchart et al., 2010; Leverington et al., 2010; Pimm et al., 2014). This has prompted the search for alternative conservation models and the need to explore more effective conservation strategies, possibly combining fortress conservation models with more community-driven approaches (Naughton-Treves, Holland, & Brandon, 2005; Nepstad et al., 2006; Bray et al., 2008).

The continued deterioration of biodiversity and ecosystems has prompted governments and their partners to agree to extend and varied PAs (Venter et al., 2014; Di Minin, 2015), resulting in an increase in the land and sea area covered by governmentally protected areas "GPA" (categories I to IV) and other effective conservation measures (OEMCs), such as community protected area "CPA" (Appleton et al., 2022). Unfortunately, the expansion of GPAs does not always ensure more effective control of poaching, bushmeat extraction, and other extractive activities, which often remain a significant problem (Bruner et al., 2001; Maxwell et al., 2020; Graham et al., 2021). These challenges are often driven by the limited financial and

logistical capacity of many GPAs to provide effective ground patrol coverage (Bruner et al., 2001; Lerner et al., 2007; Graham et al., 2021), issues that are particularly relevant for large PAs (Chardonnet, 2019). High site coverage by patrols is crucial for enforcing conservation measures (e.g., hunting restrictions), as rangers on the ground serve as the primary deterrent that renders higher-level legal policies effective (Moore et al., 2018).

The failure to ensure the effective conservation of GPAs is a reality in the forests of the eastern Democratic Republic of the Congo (DRC). These forests are among the most crucial areas for biodiversity in the world and a priority for conservation (Dagallier et al., 2020; Grantham et al., 2020; Singh et al., 2021; Appleton et al., 2022). For example, they are home to several endemic species, such as the Grauer's gorilla (*Gorilla beringei graueri*), a critically endangered subspecies (Plumptre et al., 2021). Grauer's gorillas face several threats, including poaching, habitat loss and degradation, civil war, and climate change (Plumptre et al., 2021). These threats are exacerbated by the fact that all GPAs that host Grauer's gorillas experience management difficulties (Plumptre et al., 2021) due to financial and logistical (personnel and equipment) constraints (Anthony et al., 2015; Trigg & Tshimanga, 2020) and security issues resulting from recurrent wars and political instability (Mathys, 2017). These constraints, and additional difficulties regarding the inaccessibility of these forests, make it difficult for rangers and management personnel to patrol the full extent of GPAs (Bruner et al., 2001; Graham et al., 2021; Challender & MacMillan, 2014; Persson, Rauset, & Chapron, 2015). Alternative models of community forestry and community-based conservation concessions may overcome some of these issues, as they may require fewer patrolling resources due to higher community support for and adherence to conservation measures (Dawson et al., 2021; Elleason et al., 2021). This is particularly relevant for Grauer's gorillas in DRC, as around 74% of their range is outside formal PAs (Plumptre et al., 2015; Dagallier et al., 2020; Plumptre et al., 2021).

The conservation potential of community-led initiatives could add protection outside existing PAs (Shackleton et al., 2002), though the effectiveness of these models is a subject of debate (De Albuquerque & De Oliveira, 2007; Armenteras, Rodríguez, & Retana, 2009) and can be assessed using several criteria and indicators (Leverington et al., 2010). Here, we opted to compare proxies for a Return On Investment in Land (ROIL) between governmental (fortress) and community-based conservation areas, areas that further varied in surface area (size) and the presence of armed groups. We selected a proxy of patrol cover, the site coverage rate (SCR), to determine the relative capacity at given sites to actively patrol the forests and remove or deter threats (e.g., snares). We further gathered and compared data on poaching/hunting levels and temporal trends therein, under the assumption that range patrol coverage has a direct positive effect on the reduction of poaching activities (Hilborn et al., 2006).

We explored the link between the characteristics of conservation areas (con-

servation model type, area size, presence of armed groups) and proxies of ROIL (SCR and poaching/hunting levels/trends) without setting a priori hypotheses, given inconsistent evidence in the literature. For example, regarding support for various "best practices" for conserving wildlife and forests, there are suggestions by some that community-based initiatives, which often also include social goals such as poverty alleviation in addition to conservation goals, are insufficient by themselves (Hackel, 1999; Sanderson & Redford, 2004), while others find support for community-based conservation or a combination of models (Wilshusen et al., 2002; see Horwich & Lyon, 2007 for an overview of this discussion; Shahabuddin & Rao, 2010). The optimal size of PAs is also a point of contention, with large PAs being effective in ensuring habitat connectivity and conservation of undisturbed habitats (Gaston et al., 2008; Cantú-Salazar & Gaston, 2010; Di Minin et al., 2013; Watson et al., 2014; Saura et al., 2017), while small sites may have a disproportional contribution through their ability to reduce landscape fragmentation (Armsworth et al., 2018). Finally, we did predict that the presence of armed groups would reduce the ROIL, given issues with, for example, illegal resource exploitation that may follow armed conflict or the mere presence of armed groups (Glew & Hudson, 2007).

Our analyses, though preliminary, may give conservation practitioners information to design the most effective approach to protect Grauer's gorillas and their native ecosystems, making clear choices for conservation models that ensure effective protective coverage (Butchart, Di Marco, & Watson, 2016; Armsworth et al., 2018).

2. Methodology

2.1. Study Area

We collected data on 11 sites in the Grauer's gorilla range in eastern DRC (**Figure 1**). Among the 11 sites, five are GPAs of the fortress conservation model and six are CPAs of the community-based conservation model. Of the five GPAs of the fortress, two are directly managed by the state through the Institut Congolais Conservation Nature (ICCN), such as Maiko National Park (PNM) and Itombwe Natural Reserve (INR), two others are managed by conservation organizations through a public-private partnership (PPP) governance mode, including Virunga National Park (PNVi) and Kahuzi Biega National Park (KBNP), and the last one is managed by the communities through another type of partnership between local communities and the Congolese state, the Kisimba Ikobo Primates Reserve (RPKI). Among the six CPAs, five are directly managed by the communities themselves, including the Oku Community Reserve (RCO), Usala Gorilla Reserve (RGU), Utunda and Wassa Gorilla Reserve (REGOUWA), Muhuzi-Buhinda Gorilla Reserve (RGMB), and Lubutu Gorilla Reserve (REGOLU), and the last one, Nkuba Conservation Area (NCA), is managed through a partnership between local communities and a non-governmental conservation organization and designated as a separate management entity (SEM) governance mode (**Figure 1**).

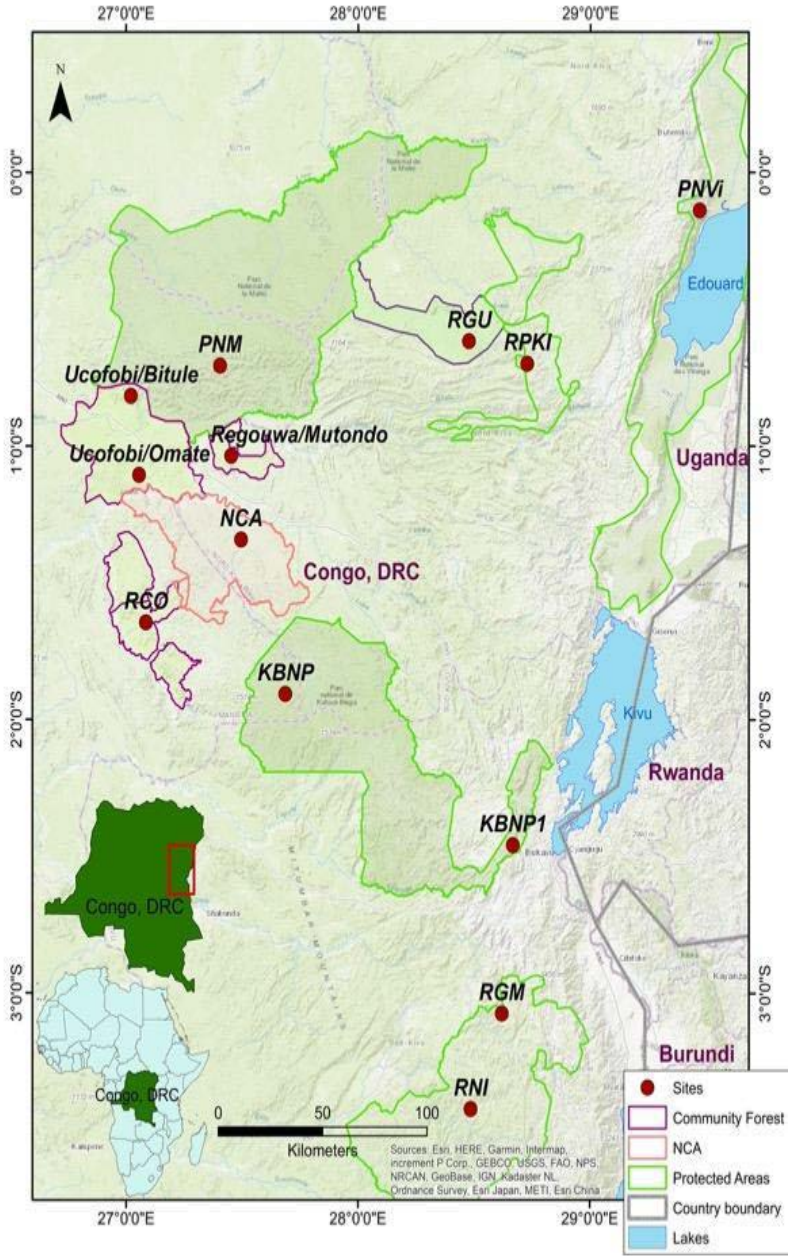


Figure 1. The study area is in the east of the Democratic Republic of the Congo. The green polygons represent the protected areas under the authority of the ICCN, including RNI, PNKB, PNM, PNVi, RGT, and RPKi. The dark red polygons represent community forests located under the fortress (RGMB, RGU, RCO, REGOUWA, UCOFOBI/REGOLU, and NCA).

2.2. Data Collection

In 2023, we solicited, via a questionnaire in French, data from 11 PA managers, in the case of all six CPAs, and chief park wardens for the five GPAs. The questionnaire was mixed with questions that allowed open-ended responses, and others were multiple-choice questions (see questionnaire in the appendix). We requested that respondents report the size (km^2) of the site (a) and the area of the site covered or controlled by the rangers through patrols (b), from which we estimated the site cov-

erage rate as b/a*100. We also solicited data on the level, extent, and trends of poaching/hunting, as well as information on deforestation, wildlife trends, and the presence of armed groups; we classified these responses according to preset categories as described below.

Survey respondents were asked to categorize the level of poaching/hunting as being 1) very low (poses few or no obvious threats and negative impacts on the values and integrity of the site are likely to be minor), 2) low (poses some obvious threats and localized, but reversible negative impacts are anticipated), 3) high (poses a medium but obvious threat to the site, which may have localized negative impacts on the values and integrity of the site, but which may be reversible) or 4) very high (threats to the site are very high and current and/or predicted future impacts are likely to result in the irreversible loss of the majority of the values and integrity of the site). Where site managers could not provide such information, we classified the situation as 5) data deficient.

Survey respondents were asked to estimate the extent of poaching/hunting as occurring 1) everywhere (affecting more than 50% of the surface area), 2) widespread (15% - 50%), 3) dispersed (5% - 15%), or 4) localized (less than 5%). If the distribution of these threats was unknown, we classified this as 5) unknown or 6) not applicable when there was no poaching/hunting.

For the trend of poaching and hunting, survey respondents were asked to indicate whether these threats were positive (increasing), negative (decreasing), or stable over time. Survey respondents were also asked to classify trends in the abundance of wildlife, specifically medium-to-large-sized mammals.

All data for this study were collected from CPA managers and chief park wardens from fortress GPAs of the Grauer's gorilla range. In addition, other resource persons who have worked in conservation in the area and people who know the GG range, gorillas, GPA, and CPA management were also consulted. The information gathered from other resource people was cross-referenced with that from GPA and CPA managers to give us a clearer understanding of the context, or to fill in any missing information.

2.3. Data Analysis

Considering the small size of our sample (n = 11) and large number of varying factors (e.g., conservation model, governance mode, area size, poaching activities, armed group) that could be considered in this study, we focused our analyses primarily on descriptive interpretation of the results rather than quantitative statistical analyses. Nevertheless, we surveyed almost most GPAs of the GG range (n = 5) and almost an equal number of CPA to balance the two categories of conservation models studied. In spatial terms, the sample area covers 41,989.65 km^2 out of 52,000 km^2 (Mehlman et al., 2008) which represents 80.75% of the entire study area.

3. Results

We found that sites varied across parameters (**Table 1**).

Table 1. List of sites surveyed with their conservation model, management entity, total site area (TSA), Patrol covered area in the site (PCA), site coverage/control rate (SCR), presence of armed groups (PAG), percentage area occupied by armed groups (AOAG), Average percentage area occupied by armed groups (AAOAG), threat (poaching/hunting) level, range, and trend; and status of wildlife.

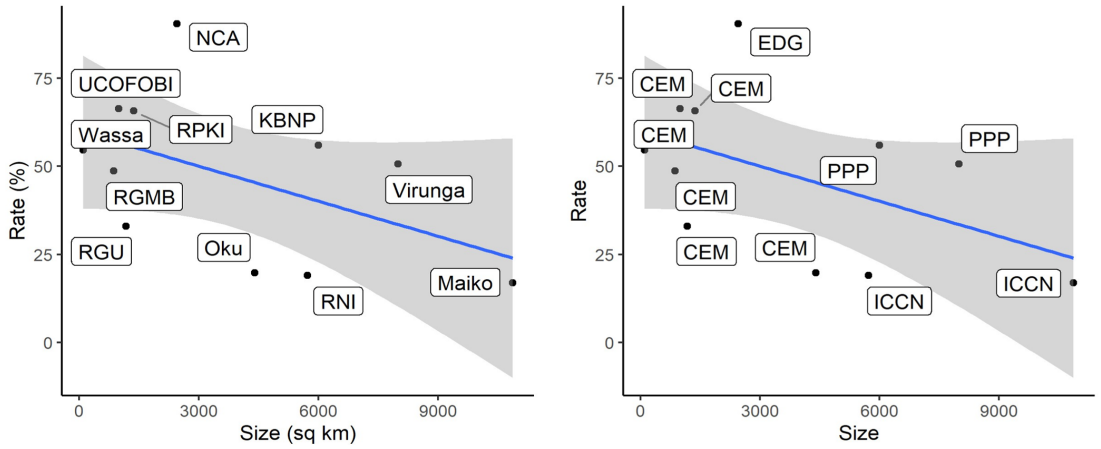
Site[1]	Model	Management entity[2]	TSA (km^2)	PCA (km^2)	SCR (%)	PAG	AOAG	AOAG	Threat level	Threat area	Threat trends	Wildlife status
PNKB	Fortress-GPA	PPP	6000	3360	56.0	Yes	1 - 10	5.5	High	Dispersed	Increase	Stable
PNVi	Fortress-GPA	PPP	8000	4050	50.6	Yes	11 - 20	15.5	High	Dispersed	Increase	Decrease
PNM	Fortress-GPA	ICCN	10,870	1847	17.0	Yes	41 - 50	45.5	Very High	Dispersed	Increase	Increase
RNI	Fortress-GPA	ICCN	5732	1089	19.0	Yes	1 - 10	5.5	Very High	Dispersed	Increase	Decrease
RPKI	Fortress-GPA	CG/ICCN	1370	900	65.7	Yes	11 - 20	15.5	Very High	Dispersed	Decrease	Stable
Mean			6394.4	2249.2	41.6							
NCA	CBC-CPA	SME	2457.9	2222	90.4	No	NA	0.0	Low	Dispersed	Decrease	Increase
RCO	CBC-CPA	CG	4410	870	19.7	No	NA	0.0	High	Dispersed	Decrease	Increase
RGMB	CBC-CPA	CG	870	423	48.6	Yes	21 - 30	25.5	High	Dispersed	Decrease	Decrease
REGOUWA	CBC-CPA	CG	110	60	54.6	Yes	11 - 20	15.5	No data	Dispersed	Stable	Stable
RGU	CBC-CPA	CG	1179.75	389	33.0	Yes	1 - 10	5.5	High	Dispersed	Decrease	Stable
UCOFOBI/REGOLU	CBC-CPA	GCE	990	656	66.3	No	NA	0.0	No data	Dispersed	Decrease	Stable
Mean			1669.6	770.0	52.1							
Overall			3817.2	1442.4	47.4							

Sites: RNI, Itombwe Nature Reserve; PNM, Maiko National Park; NKB, Kahuzi Biega National Park; PNVi, Virunga National Park; NCA, Nkuba Conservation Area; RGU, Usala Gorilla Reserve; RCO, Oku Community Reserve; REGOUWA, UtundaWassa Gorilla Reserve; RPKi, Kisimba Ikobo Primates Reserve; UCOFOBI/REGOLU, Lubutu Gorilla Reserve. Model: Fortress, CBC: Community based conservation; GPA: Governmentally Protected Area, CPA: Community based Protected Area; PPP, Public-Private Partnership; ICCN, Institut Congolais pour la Conservation de la Nature; SEM; Separate Management Entity; CG, Community Governance.

First, we found that specific sites appear to have substantially lower or higher coverage rates than expected for their size, as shown by the visual representation of the (linear) relationship between site size and coverage rate (Figure 2). Notably, NCA, a community conservation model, has a relatively high coverage rate for its size, while sites such as RNI (a site managed by the government) and RGU (a community-managed area) have relatively low coverage rates.

Second, we found that all sites face poaching or hunting at high to very high levels except for the NCA, where this threat was deemed to exist at a "low" level.

Third, whereas these threats were of a dispersed nature at all sites, they were reportedly increasing in prevalence at three out of four GPAs (all but the RPKI where there was a decrease) and decreased at all but one (REGOUWA, where this trend was stable) CPAs. Wildlife increased at some sites and decreased at other sites, without apparent consistency across sites of different characteristics. An exception to this pattern was the reported increase or stability in wildlife at all three sites where no armed groups were in the forest.



For reference only, we provide a visual of the linear relationship (solid blue line and associated confidence interval in grey), although low sample size inhibited the effective use of statistical analyses.

Figure 2. Approximation of the relationship between site coverage rate and site size. This figure is generated from the simple linear regression model. It shows the relationship between site coverage rate and site size. This figure shows the distribution of protected areas according to their surface area and site coverage rate. The hatched area represents the prediction field for the distribution of coverage rate as a function of surface area. RGU, RCO, RNI are below the predicted rate, while NCA is above the predicted rate.

Fourth, armed groups were reportedly present at 72.73% of the sites. Half of the sites (50%) in the CPAs were characterized by armed groups, whereas 27% of these forests did not have armed groups present. Armed groups reportedly were found at all GPAs sites.

4. Discussion

Site coverage rate is low in the Grauer's gorilla range, with park management entities being able to patrol, on average, less than half of their area. However, higher coverage seems to be achieved in some protected areas. The three sites with the highest coverage rates (NCA, RPKI, UCOFOBI/REGOMOKI) are all predominantly managed by, or in close partnership with, communities. We also found indications that community-based conservation areas performed better in reducing threats from poaching/hunting, and wildlife abundance seemed to be less negatively affected by the presence of armed groups, though there is variation between sites. Whether these differences across sites stem from the differences in governance and community involvement, or rather a result of other contributing factors, remains a topic for further study.

Community-based conservation areas seem, at first sight, to be more effective than governmentally governed sites. However, the community-based areas included in this study were also generally smaller than their governmentally protected counterparts, and we also found indications that coverage rates declined with an increase in the extent of PAs. This is in line with earlier findings that large areas can be disproportionately affected by human impacts such as poaching/hunting and deforestation (Lonn et al., 2018), and that an increase in area can negatively affect the capacity to patrol a site in the field (Mcclanahan et al., 2008;

Ervin et al., 2010; Allan et al., 2015). With a limited number of sites to compare, we were unable to statistically separate these two factors that potentially influence conservation effectiveness, though we can derive a few preliminary conclusions.

First, it seems clear that some of the fortress-style governmentally managed PAs are underperforming regarding conservation effectiveness. Partially, this may stem from the fact that they are very large areas that may be challenging to effectively patrol on foot, given the dense forested landscapes, from a few centrally placed control centers or headquarters. The designation of large sites may align with the logic behind some of the guidelines for category II national parks, which specify that these areas must be sufficiently large to maintain ecological functions and processes (Dudley, 2008). Yet, the smaller sizes of community forests, plus a possible higher level of adherence to conservation measures by community members, may make the latter more manageable. This is consistent with the notion that large sites are disproportionately difficult to manage (Chardonnet, 2019).

Second, the presence of armed groups may be a substantial contributing factor to the effectiveness of PAs in the Grauer's gorilla range (Roz & Carr, 1994). The presence of armed groups, along with associated insecurity, hinders patrols in parts of protected areas, rendering these areas effectively "paper parks" (Chardonnet, 2019). This is the case, for example, in Virunga National Park, where a significant portion has remained unpatrolled due to the presence of various armed groups (Plumptre et al., 2015). The same holds for Kahuzi-Biega National Park, which regularly experiences incursions and occupation by various, occasionally armed, groups, and which seemingly lacks the community support to halt deforestation and habitat conversion to agricultural fields (Yamagiwa, 2003; Simpson & Pellegrini, 2023).

The presence of armed group seems to affect the GPAs more than CPAs of ForesCom model. The resilience of the CPA in the community forests can result from involvement of the local communities, and the local communities' ownership of the forest and their collaboration with the CPAs' managers. In contrast, local communities have on various occasions shown hostility to the GPAs where they were previously evicted and denied access (Hockings et al., 2008).

Site logistics represent another factor. Given the poor state of the road infrastructure and the lack of other access routes in Grauer's gorilla range, large sites covering more than 3000 km^2 often have a high number of ranger patrol posts or stations located in very remote, isolated, and disconnected areas far from their headquarters. This may make them easier prey for armed groups. This is the case, for example, in the low-altitude sector of the PNKB (Yamagiwa, 2003; Simpson & Pellegrini, 2023). However, smaller sites with patrol stations located closer to their headquarters facilitate communication and enable site managers to organize patrols and respond more quickly. Also, some CPAs benefit from good relations with local communities, who maintain access to their forests and act as informants to site managers in the event of any suspicious presence on the site, even in remote areas. Therefore, combining small sizes with community support can facilitate effective control and management of the site in combating poaching, hunting, and

other forms of anthropogenic pressures (Kristen, Paul and Bijay, 2019), while contributing to the fight against global landscape fragmentation by connecting existing blocks of PAs (Armsworth et al., 2018). We found substantial differences in apparent conservation ROIL across PAs, although further research is needed to identify and disentangle the contributing factors. For now, it seems promising to invest in a mixed model approach for conservation in eastern DRC, where community-based conservation models may supplement efforts that follow more formal, government-led, approaches to PA management.

Authors' Contributions

- **Urbain NGOBOBO** designed the questionnaire, collected and analyzed the data, and wrote the article;
- **Professor Zo Hasina Rabemananjara** supervised all stages of the article;
- **Professors Augustin Basabose and Bruno Ramamonjisoa** contributed to all stages of the article.

Acknowledgements

We thank the site managers of the Institut Congolais pour la Conservation de la Nature (ICCN) and community forest managers for authorizing and responding to the questionnaire. We also thank the Dian Fossey Gorilla Fund and local communities who helped with data collection. Special thanks to Vainqueur Bulambo for Python data analysis and training.

Declaration of Publication Ethics

We have respected all ethical standards related to a scientific publication.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Allan, E., Manning, P., Alt, F., Binkenstein, J., Blaser, S., Blüthgen, N. et al. (2015). Land Use Intensification Alters Ecosystem Multifunctionality via Loss of Biodiversity and Changes to Functional Composition. *Ecology Letters, 18,* 834-843. https://doi.org/10.1111/ele.12469

Anthony, N. M., Atteke, C., Bruford, M. W., Dallmeier, F., Freedman, A., Hardy, O. et al. (2015). Evolution and Conservation of Central African Biodiversity: Priorities for Future Research and Education in the Congo Basin and Gulf of Guinea. *Biotropica, 47,* 6-17. https://doi.org/10.1111/btp.12188

Appleton, M. R., Courtiol, A., Emerton, L., Slade, J. L., Tilker, A., Warr, L. C. et al. (2022). Protected Area Personnel and Ranger Numbers Are Insufficient to Deliver Global Expectations. *Nature Sustainability, 5,* 1100-1110. https://doi.org/10.1038/s41893-022-00970-0

Armenteras, D., Rodríguez, N., & Retana, J. (2009). Are Conservation Strategies Effective in Avoiding the Deforestation of the Colombian Guyana Shield? *Biological Conservation, 142,* 1411-1419. https://doi.org/10.1016/j.biocon.2009.02.002

Armsworth, P. R., Jackson, H. B., Cho, S., Clark, M., Fargione, J. E., Iacona, G. D. et al. (2018). Is Conservation Right to Go Big? Protected Area Size and Conservation Return-on-Investment. *Biological Conservation, 225,* 229-236. https://doi.org/10.1016/j.biocon.2018.07.005

Bray, D. B., Duran, E., Ramos, V. H., Mas, J., Velazquez, A., McNab, R. B. et al. (2008). Tropical Deforestation, Community Forests, and Protected Areas in the Maya Forest. *Ecology and Society, 13,* Article 56. https://doi.org/10.5751/es-02593-130256

Bruner, A. G., Gullison, R. E., Rice, R. E., & da Fonseca, G. A. B. (2001). Effectiveness of Parks in Protecting Tropical Biodiversity. *Science, 291,* 125-128. https://doi.org/10.1126/science.291.5501.125

Butchart, S. H. M., Di Marco, M., & Watson, J. E. M. (2016). Formulating Smart Commitments on Biodiversity: Lessons from the Aichi Targets. *Conservation Letters, 9,* 457-468. https://doi.org/10.1111/conl.12278

Butchart, S. H. M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J. P. W., Almond, R. E. A. et al. (2010). Global Biodiversity: Indicators of Recent Declines. *Science, 328,* 1164-1168. https://doi.org/10.1126/science.1187512

Cantú-Salazar, L., & Gaston, K. J. (2010). Very Large Protected Areas and Their Contribution to Terrestrial Biological Conservation. *BioScience, 60,* 808-818. https://doi.org/10.1525/bio.2010.60.10.7

Challender, D. W. S., & MacMillan, D. C. (2014). Poaching Is More than an Enforcement Problem. *Conservation Letters, 7,* 484-494. https://doi.org/10.1111/conl.12082

Chardonnet, B. (2019). *L'Afrique Change: Ses aires protégées doivent-elles évoluer? Reconfigurer les aires protégées en Afrique*. International Union for Conservation of Nature.

Dagallier, L. M. J., Janssens, S. B., Dauby, G., Blach-Overgaard, A., Mackinder, B. A., Droissart, V. et al. (2020). Cradles and Museums of Generic Plant Diversity across Tropical Africa. *New Phytologist, 225,* 2196-2213. https://doi.org/10.1111/nph.16293

Dawson, N. M., Coolsaet, B., Sterling, E. J., Loveridge, R., Gross-Camp, N. D., Wongbusarakum, S. et al. (2021). The Role of Indigenous Peoples and Local Communities in Effective and Equitable Conservation. *Ecology and Society, 26,* Article 19. https://doi.org/10.5751/es-12625-260319

De Albuquerque, U. P., & De Oliveira, R. F. (2007). Is the Use-Impact on Native Caatinga Species in Brazil Reduced by the High Species Richness of Medicinal Plants? *Journal of Ethnopharmacology, 113,* 156-170. https://doi.org/10.1016/j.jep.2007.05.025

Di Minin, E., & Toivonen, T. (2015). Global Protected Area Expansion: Creating More than Paper Parks. *BioScience, 65,* 637-638. https://doi.org/10.1093/biosci/biv064

Di Minin, E., Hunter, L. T. B., Balme, G. A., Smith, R. J., Goodman, P. S., & Slotow, R. (2013). Creating Larger and Better Connected Protected Areas Enhances the Persistence of Big Game Species in the Maputaland-Pondoland-Albany Biodiversity Hotspot. *PLOS ONE, 8,* e71788. https://doi.org/10.1371/journal.pone.0071788

Doumenge, C., Palla, F., Scholte, P., Hiol Hiol, F., & Larzillière, A. (2015). *Aires protégées d'Afrique centrale—État 2015*. OFAC.

Dudley, N. (2008). *Lignes directrices pour l'application des catégories de gestion aux aires protégées Conseil Régional pour l'Environnement de la Junta de Andalucia*. http://www.iucn.org/publications

Elleason, M., Guan, Z., Deng, Y., Jiang, A., Goodale, E., & Mammides, C. (2021). Strictly Protected Areas Are Not Necessarily More Effective than Areas in Which Multiple Human Uses Are Permitted. *Ambio, 50,* 1058-1073. https://doi.org/10.1007/s13280-020-01426-5

Ervin, J., K. J., Mulongoy, K., Lawrence, E., Game, D., Sheppard, P., Bridgewater, G. et al. (2010). *Making Protected Areas Relevant: A Guide to Integrating Protected Areas into Wider Landscapes, Seascapes and Sectoral Plans and Strategies.* CBD Technical Series No. 44, Secretariat of the Convention on Biological Diversity.

Filho, L. W., Barbir, J., Sima, M., Kalbus, A., Nagy, G. J., Paletta, A. et al. (2020). Reviewing the Role of Ecosystems Services in the Sustainability of the Urban Environment: A Multi-Country Analysis. *Journal of Cleaner Production, 262,* Article 121338. https://e-space.mmu.ac.uk/626415/ https://doi.org/10.1016/j.jclepro.2020.121338

Gaston, K. J., Jackson, S. F., Cantú-Salazar, L., & Cruz-Piñón, G. (2008). The Ecological Performance of Protected Areas. *Annual Review of Ecology, Evolution, and Systematics, 39,* 93-113. https://doi.org/10.1146/annurev.ecolsys.39.110707.173529

Glew, L., & Hudson, M. D. (2007). Gorillas in the Midst: The Impact of Armed Conflict on the Conservation of Protected Areas in Sub-Saharan Africa. *Oryx, 41,* 140-150. https://doi.org/10.1017/s0030605307001755

Graham, V., Geldmann, J., Adams, V. M., Grech, A., Deinet, S., & Chang, H. (2021). Management Resourcing and Government Transparency Are Key Drivers of Biodiversity Outcomes in Southeast Asian Protected Areas. *Biological Conservation, 253,* Article 108875. https://doi.org/10.1016/j.biocon.2020.108875

Grantham, H. S., Duncan, A., Evans, T. D., Jones, K. R., Beyer, H. L., Schuster, R. et al. (2020). Anthropogenic Modification of Forests Means Only 40% of Remaining Forests Have High Ecosystem Integrity. *Nature Communications, 11,* Article No. 5978. https://doi.org/10.1038/s41467-020-19493-3

Hackel, J. D. (1999). Community Conservation and the Future of Africa's Wildlife. *Conservation Biology, 13,* 726-734. https://doi.org/10.1046/j.1523-1739.1999.98210.x

Hilborn, R., Arcese, P., Borner, M., Hando, J., Hopcraft, G., Loibooki, M. et al. (2006). Effective Enforcement in a Conservation Area. *Science, 314,* 1266-1266. https://doi.org/10.1126/science.1132780

Hockings, M., Stolton, S., Leverington, F., Dudley, N., & Courrau, J. (2008). *Évaluation de l'efficacité: Un cadre pour l'évaluation de l'efficacité de la gestion des aires protégées* (2ème éd.). UICN.

Horwich, R. H., & Lyon, J. (2007). Community Conservation: Practitioners' Answer to Critics. *Oryx, 41,* 376-385. https://doi.org/10.1017/s0030605307001010

Jones, K. R., Venter, O., Fuller, R. A., Allan, J. R., Maxwell, S. L., Negret, P. J. et al. (2018). One-third of Global Protected Land Is under Intense Human Pressure. *Science, 360,* 788-791. https://doi.org/10.1126/science.aap9565

Lele, S., Wilshusen, P., Brockington, D., Seidler, R., & Bawa, K. (2010). Beyond Exclusion: Alternative Approaches to Biodiversity Conservation in the Developing Tropics. *Current Opinion in Environmental Sustainability, 2,* 94-100. https://doi.org/10.1016/j.cosust.2010.03.006

Lerner, J., Mackey, J., & Casey, F. (2007). What's in Noah's Wallet? Land Conservation Spending in the United States. *BioScience, 57,* 419-423. https://doi.org/10.1641/b570507

Leverington, F., Costa, K. L., Pavese, H., Lisle, A., & Hockings, M. (2010). A Global Analysis of Protected Area Management Effectiveness. *Environmental Management, 46,* 685-698. https://doi.org/10.1007/s00267-010-9564-5

Lonn, P., Mizoue, N., Ota, T., Kajisa, T., & Yoshida, S. (2018). Biophysical Factors Affecting Forest Cover Changes in Community Forestry: A Country Scale Analysis in Cambodia. *Forests, 9,* Article 273. https://doi.org/10.3390/f9050273

Mathys, G. (2017). Bringing History Back in: Past, Present, and Conflict in Rwanda and the Eastern Democratic Republic of Congo. *The Journal of African History, 58,* 465-487. https://doi.org/10.1017/s0021853717000391

Maxwell, S. L., Cazalis, V., Dudley, N., Hoffmann, M., Rodrigues, A. S. L., Stolton, S. et al. (2020). Area-Based Conservation in the Twenty-First Century. *Nature, 586,* 217-227. https://doi.org/10.1038/s41586-020-2773-z

Mcclanahan, T. R. et al. (2008). Cover Caption. *Conservation Letters, 1,* i. https://doi.org/10.1111/j.1755-263x.2008.00008.x

Mehlman, P. T. Stoinski, T. S., & Steklis, H. D. (2008). *Conservation in the 21st Century: Gorillas as a Case Study*. Springer. https://doi.org/10.1007/978-0-387-70721-1

Moore, J. F., Mulindahabi, F., Masozera, M. K., Nichols, J. D., Hines, J. E., Turikunkiko, E. et al. (2018). Are Ranger Patrols Effective in Reducing Poaching-Related Threats within Protected Areas? *Journal of Applied Ecology, 55,* 99-107. https://doi.org/10.1111/1365-2664.12965

Naidoo, R., Gerkey, D., Hole, D., Pfaff, A., Ellis, A. M., Golden, C. D. et al. (2019). Evaluating the Impacts of Protected Areas on Human Well-Being across the Developing World. *Science Advances, 5,* eaav3006. https://doi.org/10.1126/sciadv.aav3006

Naughton-Treves, L., Holland, M. B., & Brandon, K. (2005). The Role of Protected Areas in Conserving Biodiversity and Sustaining Local Livelihoods. *Annual Review of Environment and Resources, 30,* 219-252. https://doi.org/10.1146/annurev.energy.30.050504.164507

Nepstad, D., Schwartzman, S., Bamberger, B., Santilli, M., RAY, D., Schlesinger, P. et al. (2006). Inhibition of Amazon Deforestation and Fire by Parks and Indigenous Lands. *Conservation Biology, 20,* 65-73. https://doi.org/10.1111/j.1523-1739.2006.00351.x

Persson, J., Rauset, G. R., & Chapron, G. (2015). Paying for an Endangered Predator Leads to Population Recovery. *Conservation Letters, 8,* 345-350. https://doi.org/10.1111/conl.12171

Pimm, S. L., Jenkins, C. N., Abell, R., Brooks, T. M., Gittleman, J. L., Joppa, L. N. et al. (2014). The Biodiversity of Species and Their Rates of Extinction, Distribution, and Protection. *Science, 344,* Article 1246752. https://doi.org/10.1126/science.1246752

Plumptre, A. J., Kirkby, A., Spira, C., Kivono, J., Mitamba, G., Ngoy, E. et al. (2021). Changes in Grauer's Gorilla (*Gorilla beringei graueri*) and Other Primate Populations in the Kahuzi-Biega National Park and Oku Community Reserve, the Heart of Grauer's Gorilla Global Range. *American Journal of Primatology, 83,* e23288. https://doi.org/10.1002/ajp.23288

Plumptre, A. J., Nixon, S., Critchlow, R., Vieilledent, G., Nishuli, R., Kirkby, A. et al. (2015). *Status of Grauer's Gorilla and Chimpanzees in Eastern Democratic Republic of Congo: Historical and Current Distribution and Abundance*. https://doi.org/10.19121/2015.report.dmx3094100000

Poisson, J. (2009). *Impact de la gestion participative sur l'efficacité de conservation dans les parcs nationaux des pays sous-développés*. Preprint.

Roz, R., & Carr, H. (1994). 'Gorilla Journal'. *Gorilla Journal, 1,* 18.

Sanderson, S., & Redford, K. (2004). The Defence of Conservation Is Not an Attack on the Poor. *Oryx, 38,* 146-147. https://doi.org/10.1017/s0030605304000274

Saura, S., Bastin, L., Battistella, L., Mandrici, A., & Dubois, G. (2017). Protected Areas in the World's Ecoregions: How Well Connected Are They? *Ecological Indicators, 76,* 144-158. https://doi.org/10.1016/j.ecolind.2016.12.047

Shackleton, S., Campbell, B., Wollenberg, E., & Edmunds, D. (2002). Devolution and Com-

munity-Based Natural Resource Management: Creating Space for Local People to Participate and Benefit? *Natural Resource Perspectives, 76,* 1-6.

Shahabuddin, G., & Rao, M. (2010). Do Community-Conserved Areas Effectively Conserve Biological Diversity? Global Insights and the Indian Context. *Biological Conservation, 143,* 2926-2936. https://doi.org/10.1016/j.biocon.2010.04.040

Simpson, F. O., & Pellegrini, L. (2023). Agency and Structure in Militarized Conservation and Armed Mobilization: Evidence from Eastern Drc's Kahuzi-Biega National Park. *Development and Change, 54,* 601-640. https://doi.org/10.1111/dech.12764

Singh, R., Galliers, C., Appleton, M., Hoffmann, M., Long, B., Cary-Elwes, J. et al. (2021). The Vital Role of Rangers in Conservation. *Parks Stewardship Forum, 37,* 128-136. https://doi.org/10.5070/p537151745

Trigg, M. A., & Tshimanga, R. M. (2020). Capacity Building in the Congo Basin: Rich Resources Requiring Sustainable Development. *One Earth, 2,* 207-210. https://doi.org/10.1016/j.oneear.2020.02.008

Venter, O., Fuller, R. A., Segan, D. B., Carwardine, J., Brooks, T., Butchart, S. H. M. et al. (2014). Targeting Global Protected Area Expansion for Imperiled Biodiversity. *PLOS Biology, 12,* e1001891. https://doi.org/10.1371/journal.pbio.1001891

Watson, J. E. M., Dudley, N., Segan, D. B., & Hockings, M. (2014). The Performance and Potential of Protected Areas. *Nature, 515,* 67-73. https://doi.org/10.1038/nature13947

Wilshusen, P. R., Brechin, S. R., Fortwangler, C. L., & West, P. C. (2002). Reinventing a Square Wheel: Critique of a Resurgent "Protection Paradigm" in International Biodiversity Conservation. *Society & Natural Resources, 15,* 17-40. https://doi.org/10.1080/089419202317174002

Yamagiwa, J. (2003). Bushmeat Poaching and the Conservation Crisis in Kahuzi-Biega National Park, Democratic Republic of the Congo. *Journal of Sustainable Forestry, 16,* 111-130. https://doi.org/10.1300/j091v16n03_06