

Faunal Composition of Medium- and Large-Sized Mammals in Unclassified Forests along National Highway 4 in Tshopo Province (Democratic Republic of the Congo)

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ABSTRACT

The aim of this study was to assess the composition, diversity, and abundance of mammal communities at the three sites (Baboro/Libombo, Bafwakondima, and Dikwa).

Field data were collected using the “Recce” reconnaissance walk method, and the analyses focused on species richness, diversity indices, Pielou’s evenness index, the kilometer abundance index (KAI), the Morisita index, and the analysis of indicator species (IndVal).

A total of 2,028 indices belonging to several taxonomic groups were recorded, with artiodactyls being the most dominant across all sites. Bafwakondima exhibited the greatest species richness (17 species), the highest diversity ($H' = 2.32$), and the greatest evenness (0.82), indicating a more balanced and ecologically stable community. In contrast, Baboro/Libombo and Dikwa exhibited lower diversity and a more pronounced dominance of certain species.

The Morisita index revealed a high similarity between Baboro/Libombo and Dikwa (0.96), while Bafwakondima stood out (0.71). The analysis of indicator species identified several significant species at Bafwakondima, highlighting its ecological importance.

Human activities, including hunting, logging, and mining, have been observed at all sites and are likely to influence community structure and species distribution.

Key words: faunal composition, unclassified forests, mammals, National Route 4

INTRODUCTION

Background and Rationale

The tropical forests of the Congo Basin constitute one of the most biodiverse ecosystems on the planet (Mayaux et al., 1998; De Wasseige et al., 2012). However, increasing anthropogenic pressures, such as hunting, logging, and mining, are significantly altering these ecosystems (Wilkie et al., 2011; Benitez-Lopez et al., 2017).

Medium- and large-sized mammals play a key role in ecosystem functioning and are widely recognized as indicators of ecological integrity (Ripple et al., 2016). Despite their importance, most ecological studies conducted in Central Africa focus on protected areas, leaving unprotected forests largely unexplored (Kühl et al., 2009).

The Democratic Republic of the Congo plays a central role in the conservation of Africa’s tropical forests. It is home to nearly half of the forests in the Congo Basin and is home to several iconic and endemic species, such as the okapi and Grauer’s gorilla (De Wasseige et al., 2012).

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Problematic

Africa's wildlife, and more specifically that of the Democratic Republic of the Congo, represents a resource whose depletion is accelerating even before we have fully grasped its complexity. These ecosystems are home to communities of large mammals whose diversity field inventories describe as unique (Gaidet and Le Doze, 2004; Nobimé et al., 2008; Dibloni et al., 2011). Yet there is a glaring disparity in biological monitoring, as monitoring efforts are confined solely to Protected Areas, which cover only about 15% of the national territory. The remainder of the forest cover nearly 40% of the country's forest area falls within rural areas where local populations harvest resources without state oversight or prior ecological assessment. Nevertheless, nearly all large mammals dependent on tropical forests persist in these areas. Their survival, however, remains dependent on anthropogenic pressures whose intensity threatens to disrupt the balances necessary for sustainable conservation.

Our work focused on Tshopo Province, specifically along the Kisangani-Ituri road in the village of Bafwakondima and the Kisangani-Buta road in the villages of Dikwa and Baboro/Libombo. The overall objective was to assess the specific composition of large and medium-sized mammals in the three unclassified forest areas along National Road 4. The ideal is to obtain more or less precise estimates of populations of large and medium-sized mammals and to assess threats arising from anthropogenic activities, thereby enabling fully informed decision-making in conservation management.

The constant traffic on the RN4 has a profound impact on the exploitation of biological resources. The ease of travel along this trans-African highway fuels the illegal bushmeat trade by directly linking poaching hotspots to urban consumption centers. We have chosen to focus our attention on medium and large-sized mammals because of their role as sentinel species. Their vulnerability to hunting makes them excellent indicators of the overall integrity of a habitat. Furthermore, this group includes taxa of high conservation value such as the okapi, the chimpanzee, and the elephant, whose detection through signs of presence facilitates monitoring in the field.

METHODOLOGICAL APPROACH

Study Area

Our study focused on unprotected forest areas along National Highway 4 in Tshopo Province, Democratic Republic of the Congo. This strategic selection of our study sites was driven by the predominant influence of this highway. This major trans-African corridor has emerged as the primary route for wildlife movement. Our fieldwork was therefore conducted in three distinct locations spread along this key highway.

a. Kisangani-Ituri Axis

The village of Bafwakondima is located 172 kilometers from the city of Kisangani, on the Ituri Road. Survey data indicate a precise location at 0°48' north latitude and 24°29' east longitude, at an elevation of 505 meters. This area falls entirely within the northern equatorial climate zone of the Democratic Republic of the Congo, between 0 and 2° north latitude. Our investigations focused on the forested area located on the right side of National Highway 4 coming from Kisangani, extending into the vegetation for a distance of approximately 12 kilometers as the crow flies from the center of Bafwakondima.

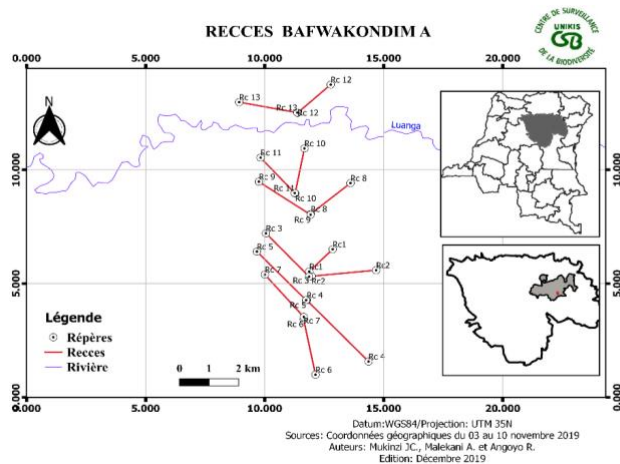


Figure 1. Spatial representation of Recce transect lines in the Bafwakondima locality

b. Kisangani-Buta Axis

Our second site, located in Baboro/Libombo within the Banalia territory in Tshopo Province, is home to the village of Libombo (N01.71244°; E025.33563°; Alt: 424 m). The surrounding forest is characterized by an evergreen tree layer, maintaining a perpetually green canopy.

Finally, our third site, the locality of Dikwa, is located some 175 kilometers from Kisangani on the road leading to Buta (01°9'16.21" North latitude and 025°40'06.0" East longitude, at an elevation of 459 meters).

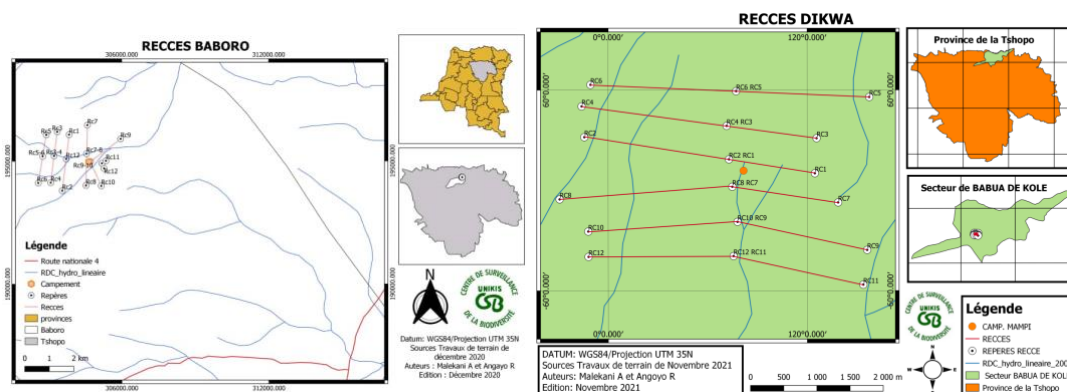


Figure 2. Spatial representation of Recce transect lines in the Baboro/Libombo and Dikwa localities

Sampling

Methodology of the fauna and flora survey

Field surveys were conducted using the reconnaissance (recce) method, which is particularly well-suited for rapid biodiversity assessments in dense tropical forests. This method allows for flexible navigation while recording animal traces, such as footprints, droppings, and direct observations. We adopted the principle of moving through the forest along a compass-determined azimuth, striving to maintain a straight path while taking the “paths of least resistance” to avoid disturbing the vegetation. This strategy, validated by Walsh et al. (2001), allows for the rapid assessment of animal populations and the mapping of habitats in remote and vast areas, where establishing conventional transects would be too costly.

We used a ‘Garmin 64’ GPS device for navigation and positioning and ‘Sunto’ compasses to determine our bearing in the forest. We selected a bearing of 40°, which is parallel to the eastern and western boundaries and perpendicular to the north-south axes of the study sites.

The use of ‘Nikon’ cameras allowed us to document our observations, and the field guides ‘African Mammals’ by Jonathan Kingdon were indispensable for resolving taxonomic uncertainties. The exploration effort resulted in 25.82 km covered in Bafwakondima across 13 survey lines, compared to 23 km across 12 lines in Baboro/Libombo and 25.1 km across 12 lines in Dikwa.

Data Analysis

Statistical environment and software

The composition of medium- and large-sized mammals was assessed using the following indicators: species richness, Shannon diversity index (H'), Simpson’s index ($1-D$), and Pielou’s evenness index (J).

Relative abundance was estimated using the kilometer abundance index (KAI). Although the KAI may be influenced by detectability, it serves as a reliable indicator for making comparisons under similar sampling conditions.

Site similarity was assessed using the Morisita index, and species-habitat associations were evaluated using indicator species analysis (IndVal). We used ArcGIS software (version 10.0) to create a map showing the surveyed sites.

RESULTS

The Major Mammal Groups at the Three Sites

In Table 1 below, we present the specific composition of mammals in terms of abundance and various diversity indices at the three study sites.

Table 1. Composition of mammals

	Bab/Libombo	Bafwako	Dikwa	Total
Artyodactyls	447	720	356	1523
<i>Cephalophus dorsalis</i> (Gray, 1846)	264	209	203	676
<i>Cephalophus leucogaster</i> (Gray, 1873)		1		1
<i>Cephalophus nigrifrons</i> (Gray, 1871)	15	90	3	108
<i>Cephalophus sylvicultor</i> (Afzelius, 1815)	13	156	10	179
<i>Hyemoschus aquaticus</i> (William, 1841)	14	9		23
<i>Okapia johnstoni</i> (Harry Johnston, 1901)		27		27
<i>Philantomba monticola</i> (Peter Thunberg, 1789)	46	130	49	225
<i>Potamochoerus porcus</i> (Carl Linnaeus, 1758)	79	68	91	238
<i>Syncerus caffer</i> (A. Sparrman, 1779)		29		29
<i>Tragelaphus spekei</i> (Sclatter, 1864)	16	1		17
Carnivora	11		5	16
<i>Civettictis civetta</i> (Schreber, 1776)	3			3
<i>Genetta sp</i> (Linnaeus, 1758)	2		2	4
<i>Herpestes sp</i> (Gray, 1837)	2			2
<i>Lutra maculicollis</i> (Lichtenstein, 1835)	4		2	6
<i>Panthera pardus</i> (Linnaeus, 1758)			1	1
Pholidota	40	65	15	120
<i>Phataginus tricuspis</i> (Rafinesque, 1820)	35	3	8	46
<i>Smutsia gigantea</i> (Johannes smuts, 1808)	5	62	2	69
<i>Uromanis tetradactyla</i> (Linnaeus, 1766)			5	5
Primates	13	74	24	111
<i>Cercopithecus sp</i> (Gray, 1845)	12	6	11	29
<i>Papio anubis</i> (René Lesson, 1827)		4		4

<i>Pan troglodytes</i> (Johann Friedrich, 1776)	1	64	13	78
Rodentia	102	53	32	187
<i>Atherurus africanus</i> (Gray 1842)	102	53	32	187
Tubulidentia		64	7	71
<i>Orycteropus afer</i> (Pallas, 1766)		64	7	71
Species richness	16	17	15	
Shannon (H')	1,86	2,32	1,71	
Simpson (1-D)	0,76	0,88	0,72	
Équitability (J)	0,67	0,82	0,63	
Total	613	976	439	2028

Table (1) shows the distribution of species across the orders (Artiodactyla, Carnivora, Pholidota, Primates, Rodentia, and Tubulidentia) in Bab/Libombo, Bafwakondima, and Dikwa. In terms of numbers, Artiodactyla is the most abundant order. The distribution shows a high frequency of these herbivorous species, particularly in the Bafwakondima area, which appears to offer favorable conditions for them. Carnivores are present in smaller numbers in Baboro/Libombo and Dikwa. The Bafwakondima forest exhibits the highest diversity ($H' = 2.32$), the greatest species richness (17 species), and the best evenness (0.82). This indicates a more balanced and rich community.

The Baboro/Libombo and Dikwa forests have lower diversity values. This may indicate lower diversity or the dominance of a few species.

In Table 2, we present the individuals along with their abundance indices.

Table 2. KAI of Taxonomic Groups Observed in Bafwakondima

Family	Species	Number of indices	Distance traveled in km	KAI	ES
Bovidae	<i>C. dorsalis</i>	209	25,82	8,09	0.56
Bovidae	<i>S. caffer</i>	29	25,82	1,12	0.21
Bovidae	<i>T. spekei</i>	1	25,82	0,03	0.04
Bovidae	<i>P. monticola</i>	130	25,82	5,03	0.44
Bovidae	<i>C. leucogaster</i>	1	25,82	0,03	0.04
Bovidae	<i>C. nigrifrons</i>	90	25,82	3,48	0.37
Bovidae	<i>C. sylvicultor</i>	156	25,82	6,04	0.48
Tragulidae	<i>H. aquaticus</i>	9	25,82	0,34	0.12
Giraffidae	<i>O. johnstoni</i>	27	25,82	1,04	0.20
Orycteropodidae	<i>O. afer</i>	64	25,82	2,47	0.31
Suidae	<i>Potamochoerus sp</i>	68	25,82	2,63	0.32
Cercopithecidae	<i>Cercopithecus sp</i>	6	25,82	0,23	0.09
Hominidae	<i>P. troglodytes</i>	64	25,82	2,47	0.31
Cercopithecidae	<i>P. anubis</i>	4	25,82	0,15	0.08
Manidae	<i>P. tricuspis</i>	3	25,82	0,11	0.07
Manidae	<i>S. gigantea</i>	62	25,82	2,4	0.30
Hystricidae	<i>A. africanus</i>	53	25,82	2,05	0.28
	17	976			

Caption: KAI : Kilometers-based abundance index; ES : Standard error

The species *C. dorsalis* and *C. sylvicultor* are more abundant, with a KAI of 8.09 and 6.04, respectively. In contrast, the species *C. leucogaster* and *T. spekei* are less abundant, with a KAI of 0.03 each.

In Table 3, we present the individuals along with their abundance indices.

Table 3. KAI of Taxonomic Groups Observed in Baboro/Libombo

Family	Species	Number of indices	Distance traveled in km	KAI	ES
Bovidae	<i>C. dorsalis</i>	264	23	11,47	0,71
Bovidae	<i>T. spekei</i>	16	23	0,69	0,17
Bovidae	<i>P. monticola</i>	46	23	2	0,29
Bovidae	<i>C. nigrifrons</i>	15	23	0,65	0,17
Tragulidae	<i>H. aquaticus</i>	14	23	0,60	0,16
Suidae	<i>Potamochoerus sp</i>	79	23	3,43	0,39
Bovidae	<i>C. sylvicultor</i>	13	23	0,56	0,16
Viveridae	<i>C. civetta</i>	3	23	0,13	0,08
Mustelidae	<i>L. maculicollis</i>	4	23	0,17	0,09
Mustelidae	<i>Herpestes sp</i>	2	23	0,08	0,07
Viveridae	<i>Genetta sp</i>	2	23	0,08	0,07
Manidae	<i>S. gigantea</i>	5	23	0,21	0,10
Manidae	<i>P. tricuspis</i>	35	23	1,52	0,26
Hominidae	<i>P. troglodytes</i>	1	23	0,04	0,04
Cercopithecidae	<i>Cercopithecus sp</i>	12	23	0,52	0,15
Hystricidae	<i>A. africanus</i>	102	23	4,43	0,43
	16	613			

Over a distance of 23 km, the species *C. dorsalis* is the most abundant, with a KAI of 11.47, while *P. troglodytes* is less abundant, with a KAI of 0.04.

In Table 4, we present the individuals along with their abundance indices in kilometers at Dikwa.

Table 4. KAI of taxonomic groups observed in Dikwa

Family	Species	Number of indices	Distance traveled in km	IKA	ES
Bovidae	<i>C. dorsalis</i>	203	25,1	8,08	0,57
Bovidae	<i>P. monticola</i>	49	25,1	1,95	0,28
Bovidae	<i>C. nigrifrons</i>	3	25,1	0,11	0,07
Bovidae	<i>C. sylvicultor</i>	10	25,1	0,39	0,13
Orycteropodidae	<i>O. afer</i>	7	25,1	0,27	0,10
Suidae	<i>Potamochoerus sp</i>	91	25,1	3,62	0,40
Manidae	<i>P. tricuspis</i>	8	25,1	0,31	0,11
Manidae	<i>U. tetradactyla</i>	5	25,1	0,19	0,08
Manidae	<i>S. gigantea</i>	2	25,1	0,07	0,06
Mustelidae	<i>L. maculicollis</i>	2	25,1	0,07	0,06
Viverridae	<i>Genetta sp</i>	2	25,1	0,07	0,06
Felidae	<i>P. pardus</i>	1	25,1	0,03	0,03
Cercopithecidae	<i>Cercopithecus sp</i>	11	25,1	0,43	0,13
Hominidae	<i>P. troglodytes</i>	13	25,1	0,51	0,14
Hystricidae	<i>A. africanus</i>	32	25,1	1,27	0,22
	15	439			

The species *C. dorsalis* is well represented, with an IKA of 8.08. In contrast, *P. pardus* is less well represented, with an IKA of 0.03.

Equitability of Piélou

Figure 3 below shows the distribution of species across the three study sites.

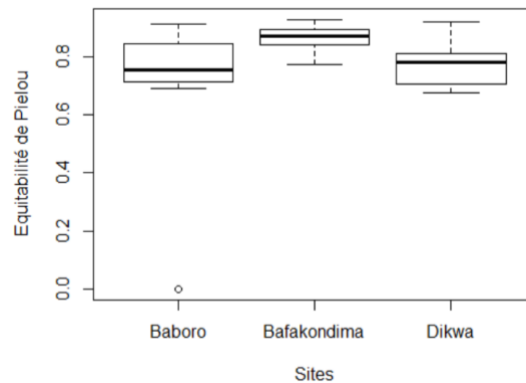


Figure 3. Equitability of Piélou

In Baboro, the average equity index for Piélou is 0.72; in Bafwakondima, it is 0.82; while in Dikwa, it is 0.77. Individuals are not evenly distributed across the three sites.

Index of Morisita (Similarity between Sites)

Table 5 below shows the similarities among the three sites.

	Baboro	Bafwakondima	Dikwa
Baboro	1		
Bafwakondima	0,71	1	
Dikwa	0,96	0,71	1

The similarity between Baboro and Bafwakondima sites is 0.71; between Bafwakondima and Dikwa, it is also 0.71. Meanwhile, Baboro and Dikwa sites are very similar, with a similarity of 0.96.

Characterization of Three Sites

In Table 6, we identify the indicator species for each site based on their occurrence and value indices.

Table 6. Indicator species for each site

Sites	Species	Fidelity	Occurr	Indval	p.value	Threshold
Baboro	<i>Tragspek</i>	0,9455	0,500	0,688	0,003	**
	<i>Phattric</i>	0,7647	0,583	0,668	0,018	*
Bafwakondima	<i>Smutgiga</i>	0,891	1,000	0,944	0,001	***
	<i>Cephsylv</i>	0,8623	1,000	0,929	0,001	***
	<i>Cephnigr</i>	0,8219	0,923	0,871	0,001	***
	<i>Orycafer</i>	0,8941	0,846	0,87	0,001	***
	<i>Pan_trog</i>	0,8084	0,923	0,864	0,001	***
	<i>Okapjohn</i>	1	0,692	0,832	0,001	***
	<i>Synccaff</i>	1	0,615	0,784	0,001	***
Dikwa	<i>Uromtetr</i>	1	0,333	0,577	0,018	*

Tragelaphus spekei is the most characteristic species of Baboro, although *Phataginus tricuspis* is also notably associated with the area.

As for Bafwakondima, this habitat is characterized by several species with very high IndVal scores and strong statistical significance (***), indicating strong associations with this habitat. *Okapia johnstoni* is a good indicator species, but less dominant due to its low occurrence. *Syncerus caffer* is an associated species, but less representative. *Orycteropus afer* and *Pan troglodytes* reinforce this association.

In Dikwa, however, *Uromanis tetradactyla* is endemic to the area, but its low abundance limits its usefulness as a strong indicator. *Syncerus caffer* is an associated species, but less representative. *Orycteropus afer* and *Pan troglodytes* reinforce this association.

Human Activities

Table 7 shows the types of human activities at the three sites

Table 7. Types of human activities at the three sites

	CM	CS	Log	Min	Traps	Clues	Total
Bab/Libombo	13	4	6		10	13	46
Bafwako	14	3	2	5	10	4	38
Dikwa	9	4			7	5	25
Total général	36	11	8	5	27	22	109

Caption: MC : Machet cut ; CS : Cartridge sleeve; Log : Logging; Min : Mining

Table (7) shows the distribution of human activities in Bab/Libombo, Bafwako, and Dikwa. Machete cutting (MC) is the most common activity, with a total of 39 occurrences, distributed among Bab/Libombo (16), Bafwako (14), and Dikwa (9).

Cartridge-based hunting is less common, with only 11 occurrences, distributed among Baboro/Libombo (4), Bafwakondima (3), and Dikwa (4), indicating a relatively similar presence in all three areas. Timber harvesting is more prevalent in Baboro/Libombo with 6 occurrences, followed by Bafwakondima with 2 occurrences. Mining is present only in Bafwakondima with 5 occurrences. Trapping is widespread with a total of 27 occurrences, distributed among Baboro/Libombo (10), Bafwakondima (10), and Dikwa (7). In contrast, the “Trail” activity has a total of 21 occurrences, with a high concentration in Baboro/Libombo (12), followed by Bafwakondima (4) and Dikwa (5). A single occurrence of “Additional Trail” is noted in Baboro/Libombo.

DISCUSSION

Community Structure and the Dominance of Artiodactyls

The results show a clear dominance of artiodactyls at all three sites, with particularly high abundance at Bafwakondima. This dominance is typical of tropical forest ecosystems, where ungulates play a central role in shaping community structure. Studies conducted in the Congo Basin show that duikers (genus *Cephalophus*) often dominate mammal assemblages due to their adaptation to dense forests (Van Vliet & Nasi, 2008).

Relative Abundance (KAI) and Ecological Pressure

The Kilometric Abundance Index (KAI) is highest at Bafwakondima (37.8), compared to 26.7 and 17.5 at the other sites. This suggests that Bafwakondima offers more favorable conditions (resources, habitat, etc.). According to Buckland S.T. et al. (2001), the KAI is a good proxy for comparing relative abundances when sampling conditions are similar.

Indicator Species and Ecological Differentiation

The IndVal analysis identifies Bafwakondima as having several strong indicator species (*S. gigantea*, *C. sylvicultor*, *P. troglodytes*) and Dikwa as having only one weak indicator species. According to Dufrene Marc & Legendre (1997), an indicator species reflects habitat fidelity and ecological specificity. Bafwakondima thus appears to be an ecologically specialized habitat with a well-defined faunal structure.

Similarity between Sites (Morisita Index)

The high similarity between Baboro and Dikwa (0.96) indicates similar ecological conditions. In contrast, the lower similarity with Bafwakondima (0.71) suggests ecological differentiation, likely related to habitat quality. According to Krebs, Charles J. (1999), high similarity indices often reflect biotic homogenization, which is sometimes associated with human disturbances.

Impacts of Human Activity

The results reveal widespread machete clearing, trapping, logging, and mining. According to Wilkie, David S., et al. (2011), these activities lead to a decline in large mammal populations and habitat degradation.

CONCLUSION AND RECOMMENDATIONS

This study on the species composition of medium- and large-sized mammals provides a comprehensive assessment of the structure of this taxon across three forest sites. Artiodactyls dominate at all sites.

Bafwakondima stands out as the most diverse and balanced site, with the highest values in terms of species richness, Shannon diversity, and evenness of the ground vegetation. In contrast, Baboro/Libombo and Dikwa exhibit lower diversity and more pronounced dominance patterns, suggesting ecological simplification.

The high degree of similarity observed between Baboro/Libombo and Dikwa suggests comparable ecological conditions or shared disturbance patterns, whereas Bafwakondima appears more distinct, reflecting habitat heterogeneity.

It is important to note that the widespread presence of human activities, particularly hunting, mining, and logging, poses a major threat to mammal populations and the stability of ecosystems.

Based on the foregoing, we suggest the following:

- Strengthening surveillance and anti-poaching efforts
- Prioritizing the protection of the Bafwakondima site
- Sustainable management of natural resources,
- Long-term ecological monitoring and
- Further scientific research

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REFERENCES

- Benítez-López, A., Alkemade, R., & Verweij, P. A. (2017). The impact of hunting on tropical mammal populations. *Science*, 356(6334), 180–183. <https://doi.org/10.1126/science.aaj1891>
- Buckland, S. T., Anderson, D. R., Burnham, K. P., Laake, J. L., Borchers, D. L., & Thomas, L. (2001). *Introduction to distance sampling*. Oxford University Press.
- Code forestier de la République Démocratique du Congo. (2002).
- De Wasseige, C., Devers, D., de Marcken, P., Eba'a Atyi, R., Nasi, R., & Mayaux, P. (2012). *Les forêts du bassin du Congo : État des forêts 2010*. Office des publications de l'Union européenne / Observatoire des Forêts d'Afrique Centrale (OFAC).
- Dibloni, O. T., Millogo, A. N., Ouedraogo, A. J., Guenda, W., & Vermeulen, C. (2011). Diversité faunique et distribution des activités de braconnage dans la réserve de biosphère de la mare aux hippopotames au Burkina Faso. *International Journal of Biological and Chemical Sciences*, 5(5), 1813–1827. <https://doi.org/10.4314/ijbcs.v5i5.5>
- Dufrêne, M., & Legendre, P. (1997). Species assemblages and indicator species: The need for a flexible asymmetrical approach. *Ecological Monographs*, 67(3), 345–366. <https://doi.org/10.2307/2963459>
- Gaidet, N., & Le Doze, S. (2004). *Indicateurs de pression environnementale selon un degré d'anthropisation croissante : La gestion participative de la faune en zone communale au Zimbabwe*. CIRAD-EMVT.
- Kingdon, J. (2015). *The Kingdon field guide to African mammals* (2nd ed.). Bloomsbury Publishing.
- Krebs, C. J. (1999). *Ecological methodology*. Benjamin Cummings.
- Kühl, S., Strodtholz, P., & Taffertshofer, A. (2009). *Qualitative und quantitative Methoden der Organisationsforschung: Ein Überblick*.
- Mayaux, P., Archard, F., & Malingreau, J. P. (1998). Global tropical forest area measurements derived from coarse resolution satellite imagery: A comparison with other approaches. *Environmental Conservation*, 25(1), 37–52. <https://doi.org/10.1017/S0376892998000054>
- Nobimé, G., Gaoué, O. G., & Sinsin, B. (2008). Distribution des espèces de primates au Bénin et ethnozoologie. *International Journal of Biological and Chemical Sciences*, 2(3), 346–354.
- Ripple, W. J., Newsome, T. M., Wolf, C., Dirzo, R., Everatt, K. T., Galetti, M., Hayward, M. W., Kerley, G. I., Levi, T., Lindsey, P. A., Macdonald, D. W., Malhi, Y., Painter, L. E., Sandom, C. J., Terborgh, J., & Van Valkenburgh, B. (2016). Collapse of the world's largest herbivores. *Science Advances*, 2(4), e1600103. <https://doi.org/10.1126/sciadv.1600103>
- Van Vliet, N., & Nasi, R. (2008). Hunting for livelihood in the Congo Basin: A multidisciplinary perspective. *Biodiversity and Conservation*, 17(11), 2557–2575.
- Walsh, P. D., White, L. J. T., Mbina, C., Mihindou, Y., Groves, T., Lahm, S. A., Tutin, C. E. G., Beyers, R., & Thibault, M. (2001). Estimating the abundance of forest elephants and other large mammals using reconnaissance (recce) surveys and line transects in Central African forests. *Journal of Applied Ecology*.
- Wilkie, D. S., Bennett, E. L., Peres, C. A., & Cunningham, A. A. (2011). The empty forest revisited. *Annual Review of Environment and Resources*, 36, 215–238.