Surveying Primates in Northeastern Korup National Park, Cameroon: A Longitudinal Comparison

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Abstract: This study provides a 26-year comparison of relative primate abundance and community composition in northeastern Korup National Park (KNP), South West, Cameroon. We present survey data from ecological line transects collected in 2014 and 2016 that are contextualized with previous surveys (1990, 2004/2005), allowing for comparative analysis of primate assemblages in KNP. Our data indicate a variation in sighting frequency and changes in the representation of primate species along transects between 1990 and 2016 as a result of gun hunting. The results here contribute to regional understandings of primate responses to hunting pressure and support earlier studies, documenting continued significant declines in sightings of the Critically Endangered Preuss's red colobus *Piliocolobus preussi*. Rapid expansion of wildlife economies and increased hunting pressure in Afrotropical forest zones make longitudinal ecological datasets critical to the effectiveness of primate conservation and management. We recommend the implementation of long-term monitoring protocols that utilize a variety of detection methods (e.g., cameras, acoustic sensors, human observers) and sustained community engagement, rather than ad-hoc short-term surveys.

Key words: bushmeat, Cameroon, red colobus, surveys, protected areas

INTRODUCTION

Anthropogenic pressures, particularly hunting for the bushmeat trade, are driving wildlife species toward extinction in west and central African forests (Fa & Brown 2009; Rovero *et al.* 2012; Abernethy *et al.* 2013). Diurnal primates are among the most hunted faunal groups in west and central Africa (Fa & Brown 2009). Primate species have been shown to vary in their vulnerability to hunting, with guenons (*Cercopithecus* spp.) being relatively more tolerant than, for example, the larger bodied colobines (*Colobus* spp., *Piliocolobus* spp.), which tend to be among the first species to disappear from heavily hunted forests (Kümpel *et al.* 2008; Linder & Oates 2011; Cronin *et al.* 2016). From an ecological standpoint, declining primate populations can result in the loss of frugivorous, seed-dispersing, pollinator species, which can directly impact the growth and reproduction of sympatric species of flora and fauna and, consequently, have significant effects on forest structure (Abernethy *et al.* 2013; Estrada *et al.* 2017).

In and around Cameroon's Korup National Park (KNP), bushmeat hunting is intense and widespread (MacDonald *et al.* 2012). Results from passive acoustic monitoring of gunshots in southern KNP suggest that over 39,000 animals are killed by guns alone each year (Astaras *et al.* 2017). Gun hunting in the KNP landscape has led to declines in primate sighting frequency and has most severely affected the relative abundance of drills (*Mandrillus leucophaeus*) and Preuss's red colobus (*Piliocolobus*

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preussi) (Waltert *et al.* 2002; Linder & Oates 2011) (Figure 1).

Wildlife monitoring, especially over long periods of time, is a fundamental component of conservation and management programs in protected areas (Hoppe-Dominik *et al.* 2011). Here, we contribute to an existing longitudinal data set (1992–2004) on primate relative abundance from northeastern Korup National Park (Waltert *et al.* 2002; Linder & Oates 2011) through the addition of data from two subsequent surveys, also from the northeast part of the Park, in 2014 and 2016. Expanding on long-term data sets can help regional conservation practitioners to better assess the effectiveness of management activities and the conservation status of primate species.

METHODS

Site

Designated as a national park in 1986, KNP (1260 km^2) lies within the Ndian and Manyu divisions of Cameroon's South West Region, adjacent to the Nigerian border, near the center of the Cross–Sanaga–Bioko coastal forests ecoregion (Figure 2). KNP is made up of primarily lowland evergreen forest, characterized by a low to moderate elevation with undulating surfaces and a south-to-north gradient of steeper slopes and increasing elevation. It has one annual wet (June–October) and dry season (December–February). As part of a Pleistocene refugium, KNP is recognized for having high levels of species richness, diversity, and endemism across a variety of taxa (Oates *et al.* 2004), including 14 species of primates, eight of which are diurnal (Table 1). Artisanal farms surround each of the villages located inside the park; however, its nutrient-poor soils and designated conservation status have largely protected KNP from widespread cultivation and logging (MINEF 2003). Nonetheless, the protected flora and fauna of KNP remain threatened by hunting due to the bushmeat trade and regional insecurity (Baya & Storch 2010; MacDonald *et al.* 2012; Greengrass 2018).

Data collection

We surveyed line transects in the northeast of KNP for primates in June–July 2014 (CJR/ESH) and June–July 2016 (ANH). In 2014, CJR/ESH re-surveyed three transects used in earlier studies by Edwards (1992) in 1990 and Linder (2008) in 2004–2005 averaging 3.95 km in length (2.98–4.98 km) (Figure 1), as a follow up study to the previous work (see Chapman *et al.* 2000, 2018). Each of the three

Figure 1. Adult female and infant Preuss's red colobus monkey (*Piliocolobus preussi*) in Korup National Park, Cameroon. Photograph by A.N. Hofner.

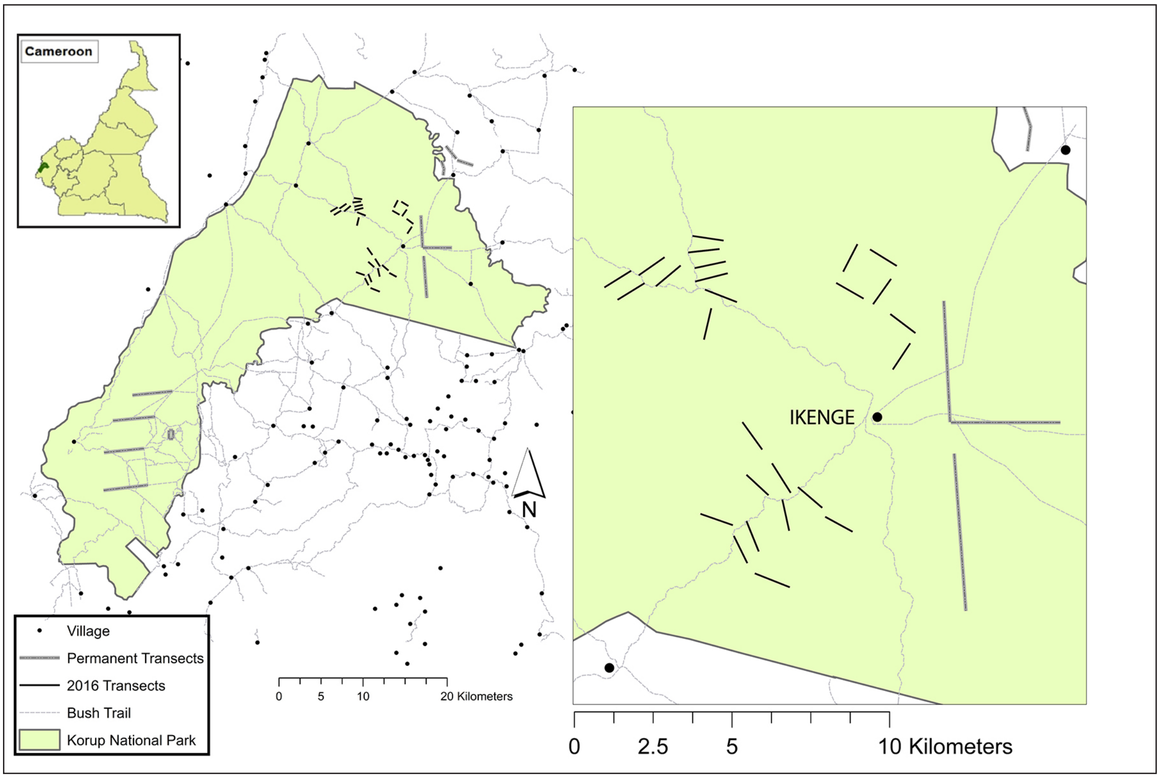

Figure 2. Map of Korup National Park showing the transects used in surveys. The three long transects in the northern region were used in 1990–2014 and the smaller transects were used in 2016. The four long transects in the southern portion of the park were surveyed by Linder (2004–2005) and have been resurveyed through collaborations with park management programs in recent years.

transects was walked five times over the course of the survey.

In the 2016 survey, ANH cut 30 1-km transects (total of 30.07 km) perpendicular to three main bush paths throughout the forest surrounding the village of Ikenge-Bakoko (hereafter Ikenge). Each transect was surveyed twice. The 1990, 2004–2005, and 2014 surveys aimed to assess primate group sighting frequency, whereas the 2016 survey was designed specifically to assess the presence and relative abundance of red colobus in the area surrounding Ikenge. Initially, we planned to use multiple 1-km transects located in 2 by 2 km grids and to analyze the results using multi-scale occupancy modeling. However, low detection rates of *P. preussi* combined with a shortened field season led us to adjust the location of the transects *in-situ* for maximum survey effort in the time available, while maintaining the original number of transects. Survey locations were clustered to reduce travel time between transects during each field trip. Vegetation along transects was cut only when movement was obstructed completely. When cutting was necessary, care was taken to cut primarily vegetation less than 2 cm diameter and to avoid cutting anything over 10 cm diameter. The transects were surveyed at least 7 days after opening, to allow the disturbance to wildlife to subside.

In both 2014 and 2016, we walked transects in teams of 2–3 trained observers between 0700–1300h at a pace of 1 km/hr. All data were collected by ANH, ESH, CJR, and trained Cameroonian field assistants. Given high hunting pressure in the study area and the potential for cryptic behavior by the study animals, we completed a one-minute visual scan every 50 m to screen all forest strata carefully for signs of movement or calls (Fashing & Cords 2000; Remis & Jost Robinson 2012).

While on transects we collected data from visual and acoustic encounters. Upon sighting a primate group, we recorded species, animal-observer distance, perpendicular distance from the transect, height in the tree, and estimated group size where possible. In the case of polyspecific associations, we recorded each species separately. Upon hearing a primate vocalization, we recorded the species and estimated the distance to the call.

Table 1. Diurnal primates found in Korup National Park and their conservation status according to the IUCN Red List of Threatened Species.

Species	Subspecies in Korup National Park	Common Name	Redlist Category*
Cercopithecus nictitans	*Cercopithecus nictitans ludio*	Red-rumped putty nosed monkey	Vulnerable[a]
Cercopithecus mona	*C. mona*	Mona monkey	Near Threatened[b]
Cercopithecus erythrotis	*C. erythrotis camerunensis*	Cameroon red-eared monkey	Vulnerable[c]
Cercopithecus pogonias	*C. pogonias pogonias*	Yellow-crowned monkey	Vulnerable[d]
Piliocolobus preussi	*Piliocolobus preussi*	Preuss's red colobus	Critically Endangered[e]
Cercocebus torquatus	*Cercocebus torquatus*	Red-capped mangabey	Endangered[f]
Mandrillus leucophaeus	*Mandrillus leucophaeus leucophaeus*	Mainland drill	Endangered[g]
Pan troglodytes	*Pan troglodytes ellioti*	Nigeria-Cameroon chimpanzee	Endangered[h]

*IUCN Red List Assessments: [a]Gadsby *et al.* 2020a; [b]Matsuda Goodwin *et al.* 2020; [c]Etiendem *et al.* 2020; [d]Cronin *et al.* 2019; [e]Linder *et al.* 2019; [f]Maisels *et al.* 2019; [g]Gadsby *et al.* 2020b; [h]Oates *et al.* 2020.

Data Analysis

We calculated the sighting frequency (also referred to as "encounter rate" in literature) of all diurnal primate groups for the 2014 and 2016 forest surveys, defined as the number of social groups (including solitary individuals) sighted per km walked (Marshall *et al.* 2008; Linder & Oates 2011). We considered all individuals of the same species as being of the same social group if within 50 m of each other as per previous primate surveys in KNP (McGraw & Bshary 2002; Astaras *et al.* 2011). Where hunting pressure is high, sighting frequency or encounter rate has been used as a measure of relative density because of the difficult nature of standard observational procedures for hunted wildlife (Linder & Oates 2011). Previous surveys of primates in KNP also report group sighting frequency, making the results more comparable across years (Edwards 1992; Waltert *et al.* 2002; Linder 2008). A limitation of sighting frequency is that it may not detect changes through time in group size. This is an important limitation to consider if, for example, sighting frequencies appear stable over time, but group size is actually declining, the data might suggest the species populations have remained stable when they are in fact declining. Estimating primate group size in hunted forests during transect surveys can also be unreliable because most primates tend to hide or quickly flee upon encountering a human (Ferrari *et al.* 2010).

We report group sighting frequency as our estimate of species-specific relative abundance, as has been done in previous surveys in KNP. There were not enough visual encounters with primates to calculate absolute density. Given the known diversity of call types, rates, and frequencies for Korup primates (Linder & Oates 2011) and heavy regional hunting potentially influencing species behavior (Remis & Jost Robinson 2012), we also did not analyze acoustic encounters. However, we do provide data on off-transect encounters and acoustic observations to note species presence in the area, as rare species were detected outside of data collection periods.

We compared our group sighting frequency for each diurnal primate species to those derived from the surveys in the northeast of the Park conducted in 1990 (Edwards 1992) and 2004–2005 (Linder & Oates 2011). Edwards (1992) completed 153.3 km of walks along three permanent transects (approx. 1m wide) varying in length from 3.5 to 4.1 km at the Ikenge site in 1990 (3 km from the village of Ikenge) (Figure 2). Linder and Oates (2011) reported results from a 73.7 km survey effort conducted between December 2004 to April 2005 along three transects, two of which were the same as Edwards' original transects. Differences in methods limit statistical analysis; however, we report the results of all studies to make these regional, longitudinal data available to other researchers and practitioners.

Table 2. Temporal changes in sighting frequency of monkey groups between surveys+:1990 (Edwards 1992), 2004–2005 (Linder & Oates 2011), 2014 and 2016 (this study) at Ikenge.

Species	1990		2004-2005		2014		2016		chi-squared	*p*
	N	Sighting frequency grps/km	N	Sighting Frequency grps/km	N	Sighting Frequency grps/km	N	Sighting Frequency grps/km		
Cercopithecus nictitans	8	0.07 (0.03)	17	0.22 (0.08)	9	0.15 (0.08)	16	0.27 (0.06)	5.48	0.14
C. mona	9	0.08 (0.03)	7	0.09 (0.04)	6	0.10 (0.05)	9	0.15 (0.05)	1.89	0.6
C. erythrotis	4	0.04 (0.02)	4	0.05 (0.03)	6	0.10 (0.05)	6	0.10 (0.04)	4.53	0.21
C. pogonias	6	0.06 (0.02)	3	0.04 (0.02)	2	0.03 (0.03)	9	0.15 (0.05)	0.42	0.94
Piliocolobus preussi	8	0.07 (0.03)	4	0.05 (0.03)	2	0.03 (0.02)	1	0.02 (0.02)	11.46	0.01*
Cercocebus torquatus	0	0.00	0	0.00	0	0.00	1	0.02 (0.02)	1.05	0.79
Mandrillus leucophaeus	3	0.03 (0.02)	0	0.00	0	0.00	0	0.00	NA	NA
Total	**38**	**0.34 (0.08)**	**35**	**0.47 (0.11)**	**25**	**0.42 (0.14)**	**42**	**0.7 (0.15)**	**1.62**	**0.66**

*N is the number of group sightings. Values in parentheses are standard errors. Significant changes in sighting frequency through time were determined using Kruskal-Wallis tests. Values in italic are significant at $p < 0.05$. Survey effort across years: 1990 = 153.3 km; 2004-2005 = 73.7 km; 2014 = 59.2 km; 2016 = 60.1 km).

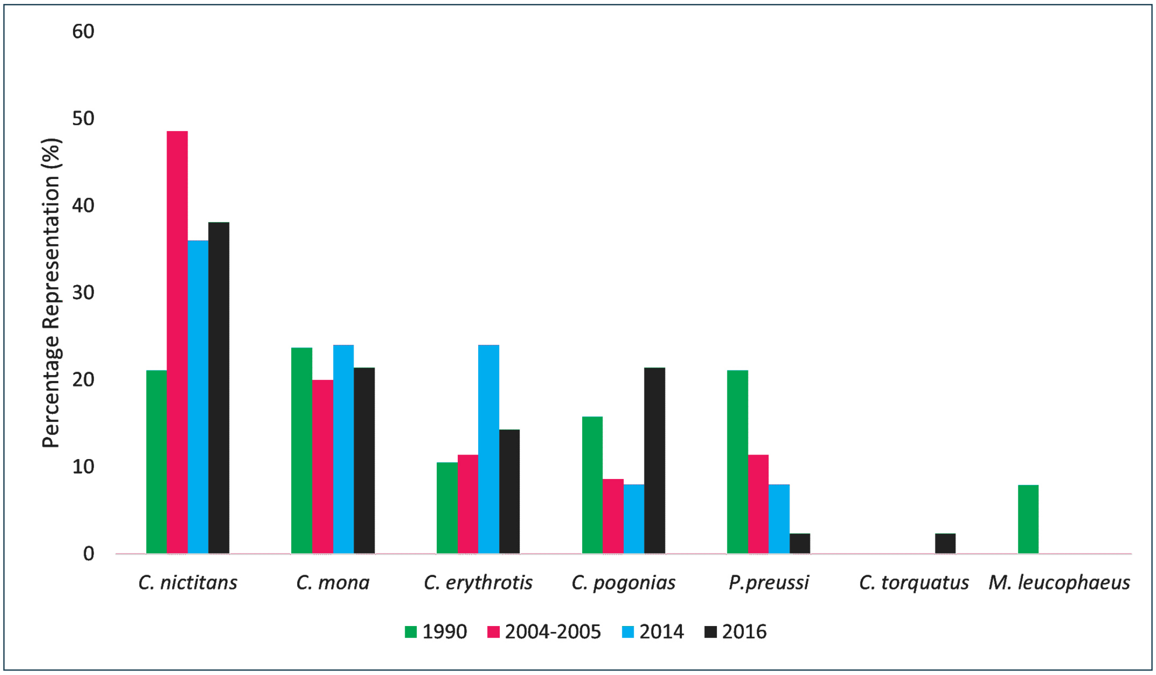

Figure 3. Proportional representation of primate species sighted in 1990 (Edwards 1992), 2004–2005 (Linder & Oates 2011), 2014 (this study), and 2016 (this study).

We tested the data for normality using a Shapiro test and determined that nonparametric tests were most appropriate for the analysis. We examined differences in sighting frequencies across periods with a Kruskal–Wallis test (significance > 0.05) in R (version 3.6.1). For significant results, we then performed a post hoc Dunn's Test (package "FSA"). To assess changes in overall primate community composition at KNP between 1990 and 2016, we compared the proportion of each primate species observed along line transects across multiple study periods.

RESULTS

There was a non-significant increase in overall sighting frequency of primate groups across years (Table 2). At the species level, there was a steady decline in the sighting frequency of *Piliocolobus preussi* from 1990 to 2016, with the difference being significant between 1990 and 2016 (Dunn test Z = 3.05, p = 0.01). Variations in sighting frequency for all other species were not statistically significant. Sightings of *Mandrillus leucophaeus* were reported only on transects in 1990 and *Cercocebus torquatus* was seen only in 2016, but calls were reported in the 1990 and 2004–2005 surveys. Researcher reports of animal presence outside of survey results include the presence of *M. leucophaeus* in hunter surveys (Linder 2008) and a single visual encounter of *M. leucophaeus* in 2014. Further, the Nigeria-Cameroon chimpanzee (*Pan troglodytes ellioti*) has a well-documented range in the central-southern areas of KNP and known presence in the park's steeper northeastern hills. In 2016, both acoustic and visual encounters of the Nigeria-Cameroon chimpanzee were noted by researchers off transects.

The proportional representation of primate species sighted has changed considerably since 1990. *Cercopithecus* species, which accounted for 71% of the sightings in 1990, accounted for 92% and 95% of total sightings in 2014 and 2016, respectively. Most of this change can be attributed to an increase in the proportional representation of *C. nictitans*, which accounted for nearly half of the total primate sightings in 2004–2005 and over a third of the sightings in 2014 and 2016 (Figure 3). In contrast, the percentage of sightings of red colobus monkeys has steadily declined from 21% of the sightings in 1990 to 8% and 2.4% in 2014 and 2016, respectively. The proportional representation of *C. mona* changed little over the 26-year period (20–24%). We also see non-significant shifts in the representation of *C. erythrotis* and *C. pogonias* between the latter two surveys (Table 2).

DISCUSSION

Our analyses of primate sighting frequency across a 26-year period support trends in primate abundance observed by Linder and Oates (2011). Sighting frequency, coupled with records of animal presence (visual and acoustic observations), documented outside of survey data indicate that, while primate species richness has likely not changed at this site, the primate community structure has changed. Guenons had a higher sighting frequency than the larger-bodied species, especially the Critically Endangered *Piliocolobus preussi*, which have continued to decline in both group sighting frequency and proportional representation of all group sightings. Without group size estimates, we cannot determine the full extent of population change.

These results are consistent with the restructuring of primate communities as a result of hunting that Struhsaker (1999) first proposed, and which has been subsequently corroborated in KNP (Waltert *et al.* 2002; Linder & Oates 2011). Red colobus monkeys and drills are known to be especially vulnerable to hunting due to their large body size (i.e., providing more meat per hunting effort than smaller species) and poorly adapted behaviors in response to human hunting (Struhsaker 2010; Morgan *et al.* 2013). Our results provide further evidence that red colobus monkeys are among the most vulnerable primate species to hunting and are usually among the first primate species to disappear in a hunted forest (Struhsaker 2010; Linder *et al*. unpublished data). It has been previously suggested that the increase in the mean sighting frequency of *Cercopithecus nictitans* is reflective of competitive release and the species' ecological flexibility and niche overlap with species that have become rarer (Linder & Oates 2011). In effect, the theory is that the increase in *C. nictitans* observations is due to the decline in abundance of *P. preussi* and *M. leucophaeus* caused by high hunting pressure. Research in southern Nigeria similarly documents the persistence of Sclater's monkey (*Cercopithecus sclateri*) coupled with declines of larger-bodied primate species in heavily hunted forests (Baker & Olubode 2007; see also Peres & Dolman 2000 for Neotropical data). If these trends in primate relative abundance continue, we can expect *P. preussi*, and possibly also *M. leucophaeus*, to disappear from northeastern KNP in the near future.

It is necessary to highlight some limitations of our study. Differences in study design and observer sighting ability among the survey periods (1990, 2004–2005, 2014, 2016) are important to consider. The 2016 survey period differed from the earlier periods in that it surveyed primates along new 1-km transects at varied locations in the forests surrounding Ikenge. Furthermore, sighting frequencies should be interpreted with caution, as they may reflect differential detection probabilities of species among observers and under varying human disturbance levels, as many primate species may avoid areas or become cryptic where there is high human activity (Croes *et al.* 2006; Remis & Jost Robinson 2012). For example, the increase in sighting frequency of *C. pogonias* in 2016 could be due to the survey of new transects, where hunting presence was lower compared to the earlier study transects that are maintained and frequented by hunters (Linder & Oates 2011; Hofner 2016; Jost Robinson unpublished data). The initial transects used in the 1990 and 2004–2005 surveys were still visible in 2014 and were actively used by communities for hunting or ease of movement (Jost Robinson unpublished data). The relatively low primate sighting frequency reported here may also be a result of limited survey effort (due to budgetary and time constraints), which hindered our ability to detect rare species, and/or the proximity of our transects to a human settlement.

Encounter-based methods, though cost-effective, often fail to detect animals confirmed to be present through indirect signs or casual observations, which leads to underestimates of animal abundance (Fragoso *et al.* 2016). This is exacerbated in situations where hunting and other human activity cause behavioral shifts such as decreased calling rates or increased cryptic behaviors (Kumpel *et al.* 2008; Carter *et al.* 2012). For instance, *Pan troglodytes ellioti* were not observed or heard on transects across survey years, but the species was heard – and field signs observed – by the 2016 field teams outside transect survey periods.

Despite these limitations, our results suggest that hunting in northeastern KNP, a stronghold for *Piliocolobus preussi*, continues to threaten some of Cameroon's most iconic primate species. Unfortunately, the situation is unlikely to change soon as conservation interventions in KNP have been hampered since 2016 by a socio-political crisis in South West and North West regions. When conservation activities can safely resume, we recommend the immediate implementation of a Korup-wide program that systematically monitors populations of key wildlife species, hunting, other illegal extractive activities, and the effectiveness of law enforcement strategies. The monitoring of wildlife and anthropogenic activities in KNP and other African forests should employ a variety of methods (e.g., camera traps, autonomous acoustic sensors, line transects) so that even rare species or events can be detected. These protocols must include strategies for the reduction of hunting pressure, otherwise species most vulnerable will continue to decline. We suggest active engagement with local communities including the training of a new generation of local conservationists, to offer much needed employment opportunities to disenfranchised youth (Canney & Ganame 2014). Given continued increases in hunting for global wildlife economies and pressures on the forest related to civil conflict, the establishment of intentional and consistent monitoring protocols, coupled with culturally relevant community engagement and alternative livelihood opportunities, must be a priority in protected areas like KNP.

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