

Long-term research sites as refugia for threatened and over-harvested species

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The presence of researchers, ecotourists or rangers inside protected areas is generally assumed to provide a protective effect for wildlife populations, mainly by reducing poaching pressure. However, this assumption has rarely been empirically tested. Here, we evaluate and quantify the conservation benefits of the presence of a long-term research area in Taï National Park, Côte d'Ivoire. A wildlife survey following 225 km of line transects revealed considerably higher primate and duiker encounter rates within the research area when compared with adjacent areas. This positive effect was particularly pronounced for threatened and over-harvested species, such as the endangered red colobus monkey (*Procolobus badius*). This pattern was clearly mirrored by a reversed gradient in signs of poaching, which decreased towards and inside the research area, a trend that was also supported with park-wide data. This study demonstrates that even relatively simple evidence-based analytical approaches can bridge the gap between conservation theory and practice. In addition, it emphasizes the value of establishing long-term research sites as an integral part of protected area management.

Keywords: conservation; research; line transect; threatened species; protected area

1. INTRODUCTION

It is generally stated that protected areas are more efficient for wildlife conservation than unprotected ones [1,2]. However, many areas, especially in Africa, are referred to as 'paper parks', meaning that their management is weak or non-existent and with poor law enforcement [3]. This has led to the 'empty forest syndrome', which refers to forested areas that have been depleted of their animal populations through uncontrolled poaching [4,5]. In an extreme case, local human populations completely invaded a protected area, leading to the disappearance of its wildlife and their habitat [6].

The presence of researchers, ecotourists and/or rangers may help discourage the local human population from trespassing into protected areas. Previous studies

have demonstrated the importance of ecotourism and ranger patrols for the preservation of wildlife populations and their habitats [7]. Similar benefits have also been suggested to arise from the presence of researchers, but this has never been empirically tested [8]. Although researchers have encouraged the application of evidence-based theory to validate existing conservation strategies [9], accurate quantification of conservation success is still rarely undertaken [10].

Using Taï National Park, Côte d'Ivoire, as an example, we use an evidence-based approach to evaluate the direct conservation benefits to wildlife populations resulting from long-term research presence inside protected areas.

2. MATERIAL AND METHODS

(a) Study site

Data were collected in the Taï National Park (TNP), Côte d'Ivoire (figure 1a). The TNP, covering an area of 5400 km², is the largest protected remnant of primary forest belonging to the Upper Guinean Forest Block. The research area within the TNP comprises two long-term research projects, the Taï Chimpanzee Project and the Taï Monkey Project, that are spatially adjacent and overlapping (figure 1b). The Taï Monkey Project was established in 1989, and behavioural research is conducted here on four primate species within a 4 km² area [11]. The Taï Chimpanzee Project was initiated in 1979 and encompasses four chimpanzee communities that are followed daily within a ca 83 km² area [12,13].

(b) Survey design and data collection

Using the DISTANCE v. 5.0 software [14], we systematically placed seventy-five 1 km equidistant and 1 km long transects, within a 200 km² study area (figure 1b). This area comprises ca 60 km² of the research area and ca 140 km² of its neighbouring areas. We walked each transect three times between September 2008 and July 2009, for a total survey effort of 225 km. We recorded direct and indirect observations of primates and duikers along each transect, and entered their geographical positions using a GPS Garmin 60 CSx. We focused our surveys on duikers and primates as they are the two groups most affected by poaching within the study area [15]. For each primate species encountered along each transect, we recorded the number of individuals observed and the perpendicular distance from the transect line to the first individual seen. Indirect observations consisted of chimpanzee nests and duiker faeces. For each chimpanzee nest, we measured its perpendicular distance to the transect line. Duiker dung piles were recorded within a 1 m strip on both sides of each transect. Signs of poaching were also recorded along each transect and consisted of poachers' trails and camps, snares and empty cartridges. Every time signs of poaching were recorded, these were either removed (e.g. empty cartridges) or marked (e.g. poachers' trails) to avoid double counting.

(c) Spatial distribution of poaching signs and *Procolobus badius* groups

We derived interpolated maps from encounter rates with signs of poaching and groups of red colobus monkeys (*Procolobus badius*) observed with data collected for this study within a 200 km² area, and data collected throughout the park from 2005 to 2008 (see the electronic supplementary material, figure S2). To produce these maps, we used the inverse distance-weighted function (IDW) in the program ARCMAP v. 9.2 (ESRI, Redlands, CA, USA). Encounter rates were collected along the 225 km of line transects walked in this study and along 1065 km of line transects surveyed throughout the park (see the electronic supplementary material for further details).

(d) Statistical analyses

To identify species more vulnerable to hunting pressures within the study area, we investigated density variation as a proxy for hunting pressure in the frequently encountered primate and duiker species (see the electronic supplementary material, table S1 and figure S1 for further details). Based on these results, we singled out three over-harvested species (i.e. *P. badius*, *Cercopithecus diana* and *Phlancomba maxwellii*) which were included as response variables in subsequent analyses. These species are also commonly found in local bushmeat markets and two of them are classified as endangered according to the IUCN Red List of Threatened Species [15,16].

We tested for an effect of the long-term presence of a research area on animal and poaching sign encounter rates by fitting generalized linear models (GLMs) using the statistical software environment

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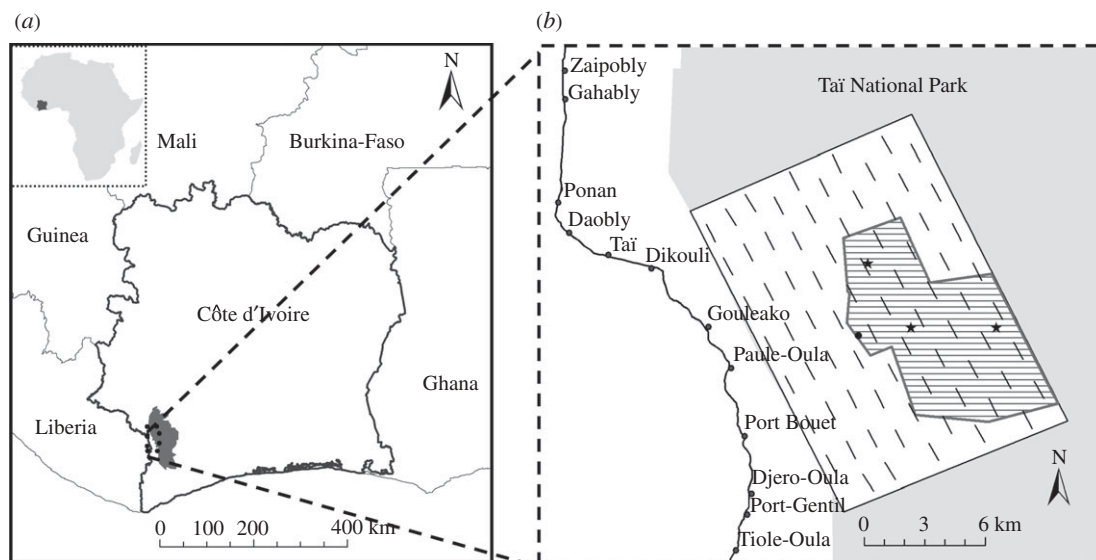


Figure 1. (a) Location of the study area within Tai National Park, Côte d'Ivoire. (b) The location of the 75 transects are shown within the survey area, with the research area represented by dashed lines. Within the research area, the location of the Tai Monkey Project's camp is indicated by a circle and the three Tai Chimpanzee Project's camps by stars.

Table 1. Results for the full GLMs. (The predictor variables, which significantly influenced the response variables, are indicated in bold.)

response variables (count data)	intercept		predictor variables (slope, with <i>p</i> -value in parentheses)			
	estimate (StError)	<i>p</i> -value	human density	distance to research area	forest type	distance to the border of the park
duikers	4.24 (0.14)	<0.001	0.36 (0.22)	-0.41 (<0.05)	-0.03 (0.10)	1.05 (<0.001)
primates	0.98 (0.07)	<0.001	0.25 (0.14)	-0.55 (<0.001)	-0.08 (0.38)	-0.01 (0.98)
poaching signs	-1.04 ^E -16 (0.07)	1.00	0.04 (0.76)	0.66 (<0.001)	-0.05 (0.51)	-0.16 (0.28)
<i>C. diana</i>	-0.22 (0.14)	0.11	-0.14 (0.59)	-0.46 (0.01)	0.14 (0.55)	-0.22 (0.44)
<i>P. badius</i>	-0.34 (0.18)	0.06	0.21 (0.48)	-0.65 (<0.001)	0.49 (0.25)	0.09 (0.78)
<i>P. maxwellii</i>	2.25 (0.04)	<0.001	0.32 (<0.001)	-0.16 (<0.001)	-0.03 (0.58)	0.55 (<0.001)

R v. 2.8.1 [17]. We evaluated the significance of four variables (i.e. human density, distance to research area, forest type and distance to the border of the park) in predicting the response of six dependant variables (i.e. count data of: duikers, primates, poaching signs, *P. badius*, *C. diana* and *P. maxwellii*). Analyses of residuals revealed no spatial autocorrelation based both on an eigenvector and Gaussian modelling techniques (see the electronic supplementary material, table S2 for further details).

3. RESULTS

The results of the full GLMs, including all predictor variables, demonstrated that proximity to the research area had a significant positive influence on the presence of duikers and primates, and for all three over-harvested species (table 1). These results are further supported by the cumulative weighted Akaike information criterion for the variable 'distance to research area', which was close to 1 for all of these species (see the electronic supplementary material, table S3). By contrast, we observed a significant decline in signs of poaching with increasing proximity to the research area (table 1 and the electronic supplementary material, table S3). This trend also emerges from data collected for a wildlife monitoring programme that was conducted throughout the TNP from 2005 to 2008 (figure 2).

4. DISCUSSION

Our results strongly suggest that the long-term presence of a research area is an effective way to protect wildlife populations. Its presence was found to be a strong predictor of wildlife population densities, especially for threatened or over-harvested species. Although we cannot control for all influential factors (e.g. total annual budget and conservation activities), it still appears that the mere presence of researchers is sufficient to generate a positive impact on wildlife populations in the vicinity.

It could be argued that our results may be an artefact of placing research stations in areas of high wildlife abundance. The initial choice of the location of the first research project within TNP was made after confirmation of the presence of a healthy chimpanzee population, but selected mainly for logistical reasons (e.g. access to roads and existing infrastructure; [13]). Furthermore, analyses by Hoppe-Dominik *et al.* [18] of long-term data on wildlife density and distribution for four areas of the TNP indicate that another area of the park (the southeast) also contained high large mammal density at the time the first research project was established (see the electronic supplementary material, figure S3). Moreover, their results demonstrate that only two areas of the park did

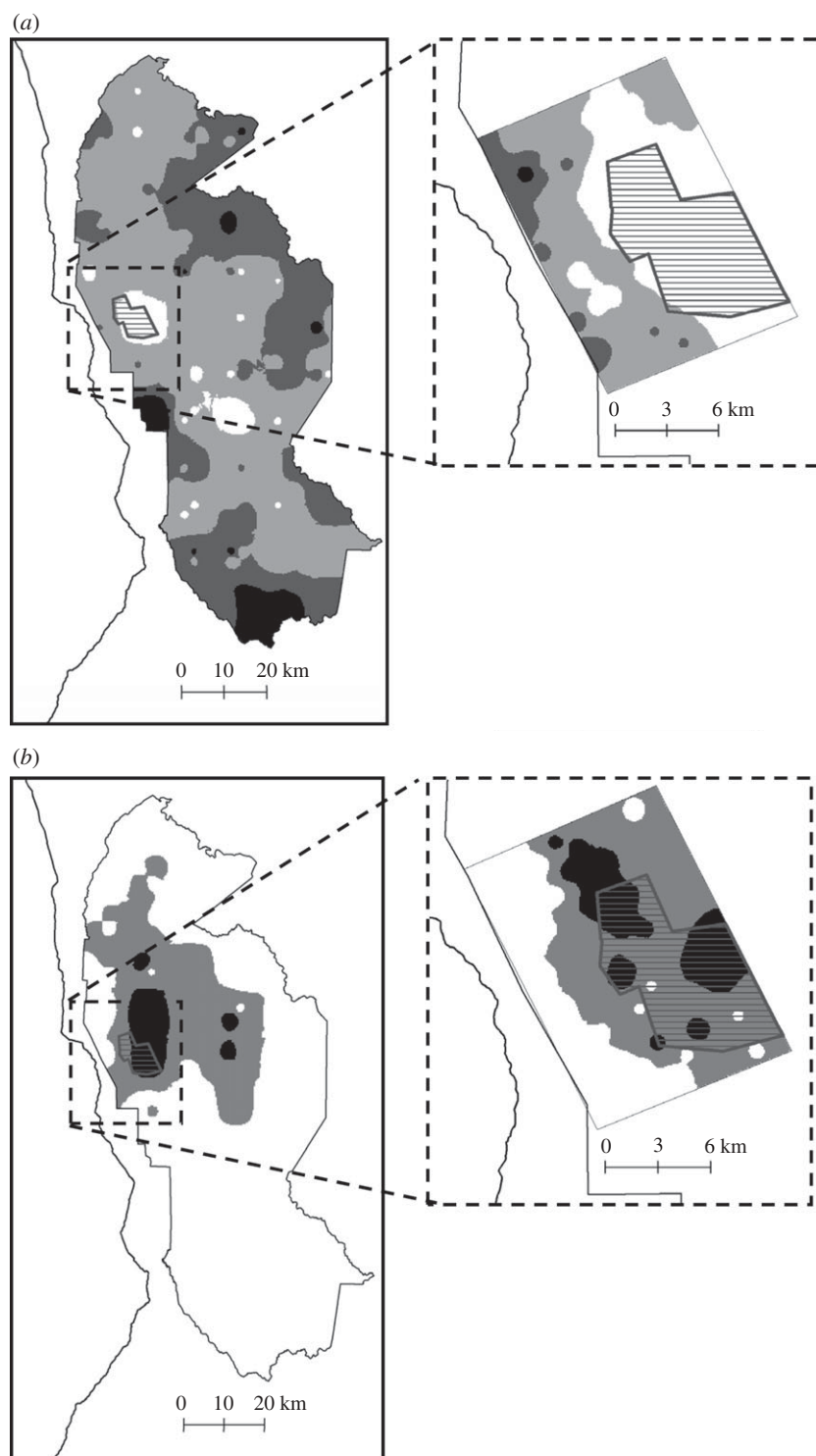


Figure 2. Interpolated maps from encounter rates with (a) poaching signs (sign km^{-1}) and (b) groups of *P. badius* observed (group km^{-1}). For each panel, the maps derived from data collected for this study are shown to the right, and from data collected throughout the Tai National Park to the left. Both maps share the same shading legend. (a) White regions, 0–1; light grey regions, 2–4; dark grey regions, 5–7; black regions, 8–15. (b) White regions, 0–0.49; grey regions, 0.5–1.49; black regions, 1.50–3.00.

not suffer a decrease in their animal density between 1977 and 2004, areas where there was a research and tourist presence. This further corroborates our results that demonstrate the positive influence of the presence of a research area on wildlife protection.

Researchers can also have negative effects on wildlife within protected areas, notably by increasing the likelihood of disease transmission between humans and wildlife, which applies especially to apes [19].

These problems should be addressed to the best of our abilities in order to reduce the potential negative impact of our presence [20,21]. Nonetheless, the positive impacts still appear to outweigh the negative ones [19]. Regular monitoring of wildlife populations and their threats can help conservationists to respond rapidly to population declines. Unfortunately, such a programme is currently being implemented in only a few African national parks [2].

We demonstrate that in addition to obtaining information on population status, wildlife monitoring can also be a simple means by which to measure the success of conservation actions. As such, systematic evidence-based methods should be put into use more widely, in particular to evaluate park management efficiency, as well as conservation activities of individual practitioners.

Finally, it should be emphasized that the positive effect of the presence of researchers or conservationists will only be a temporary one, unless sustained over a long period of time. For instance, a conservation organization was present at Marahoué National Park (Côte d'Ivoire) between 1998 and 2002, during which time the park was well-preserved. Shortly after the departure of the organization, this park suffered major human encroachment, resulting in a 93 per cent decrease in forest cover [6]. This exemplifies the importance of long-term commitment by research and conservation projects to ensure the continuous beneficial effect of their presence for wildlife populations and their habitats.

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