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Comparing law enforcement monitoring data and research data suggests an underestimation of bushmeat poaching through snaring in a Kenyan World Heritage Site

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Abstract

Rangers collect law enforcement monitoring (LEM) data during their patrols in protected areas. These data are increasingly used to interpret patrolling effectiveness and to predict poaching activity. However, LEM data can contain biases that may weaken the conclusions derived from such analyses. Research data, collected from 82 km of desnaring transects and interviews with 31 rangers, were compared with recorded LEM data. The latter included a logbook in which poacher sightings were documented, desnaring reports containing the locations of known snaring hotspots, and patrol strategies, containing the allocation of ranger patrols within the conservancy. Our findings suggest that the poaching prevalence reported through the LEM data is likely to constitute an underestimation of the true prevalence. Patrolling strategies were found to be predictable, allowing poachers to evade detection. One-third of the interviewed rangers admitted to not reporting sighted poachers. We conclude that the use of LEM data for analysis or poaching prediction by managers of protected areas or researchers requires careful consideration of patrol predictability, possible displacement of poaching activity, and ranger culture and morale in order to avoid underestimation of true poaching prevalence.

KEYWORDS
bushmeat, Kenya, poaching, protected areas, rangers, snaring

Résumé

Les gardes forestiers collectent des données de surveillance de l'application des lois lors de leurs patrouilles dans les zones protégées. Ces données sont de plus en plus utilisées pour interpréter l'efficacité des patrouilles et prédire les activités de braconnage. Cependant, les données de surveillance de l'application des lois peuvent contenir des biais susceptibles d'affaiblir les conclusions pouvant être tirées de telles analyses. Les données de recherche, recueillies sur 82 km de transects de retrait de pièges et lors d'entretiens avec 31 gardes forestiers, ont été comparées aux données de surveillance de l'application des lois enregistrées. Ces dernières comprenaient un registre dans lequel les observations de braconniers étaient répertoriées, des rapports de retraits de pièges contenant les emplacements des points de piégeage connus et les stratégies de patrouille, indiquant l'affectation des patrouilles de garde forestiers au sein de la zone conservation. Nos résultats suggèrent que la prévalence du braconnage rapportée par les données de surveillance de l'application des lois est susceptible de constituer une sous-estimation de la prévalence réelle. Les stratégies de patrouille se sont avérées prévisibles, permettant aux braconniers d'échapper à la détection. Un tiers des gardes interrogés ont admis ne pas avoir signalé des braconniers qu'ils avaient observés. Nous concluons que l'utilisation des données de surveillance de l'application des lois dans le cadre de l'analyse ou de la prédiction du braconnage par les gestionnaires de zones protégées ou les chercheurs nécessite un examen attentif de la prévisibilité des patrouilles, du déplacement possible des activités de braconnage, et de la culture et de l'état d'esprit des gardes forestiers afin d'éviter de sous-estimer la véritable prévalence du braconnage.

1 | INTRODUCTION

Protected areas, which currently cover approximately 15% of the earth's terrestrial area (IUCN, 2018; UNEP-WCMC, 2020), play a major role in the conservation of biological diversity. Unsustainable hunting is among the main threats to continued protection of biodiversity in these areas (Schulze et al., 2018), and wildlife populations within them have diminished as a result of bushmeat hunting (Craigie et al., 2010; Rija et al., 2020; Ripple et al., 2015, 2016). Hunting of this nature is often conducted using snares (Gray et al., 2018), which are cheap to make, hard to detect (Ibbett et al., 2020; O'Kelly et al., 2018b) and non-selective (Becker et al., 2013; Campbell et al., 2019; Loveridge et al., 2020). Patrolling is an essential but costly method of deterring poachers (Critchlow et al., 2016; Moore et al., 2018; Plumptre, 2019). Therefore, researchers are eager to understand and improve patrolling effectiveness in protected areas. Ranger-based law enforcement monitoring (LEM) data are increasingly used in the analysis and prediction of poaching activities to assess patrol coverage and chart trends in observed illegal activities (Hötte et al., 2016; Jachmann, 2007; Stokes, 2010). This usage has extended to the prediction of illegal activities using techniques such as Bayesian hierarchical models (Critchlow et al., 2016) and machine learning (Xu et al., 2020; Kar et al., 2017).

Ranger-generated LEM data have several methodological limitations. For example, not all illegal activities are detected or have equal detection rates (Keane et al., 2011), patrol data do not constitute a representative sample of the entire protected area (Keane et al., 2011; Stokes, 2010), and rangers may not register all activities, with some turning a blind eye to poaching activities or becoming involved in poaching themselves (Lindsey et al., 2011; Robinson et al., 2010).

Decreasing trends in the observation of illegal activities during patrols in protected areas are nevertheless often interpreted as an indication that such activities have been deterred (Gandiwa et al., 2014; Hilborn et al., 2006; Moore et al., 2018) and that greater patrol efforts result in a higher encounter rate with respect to illegal

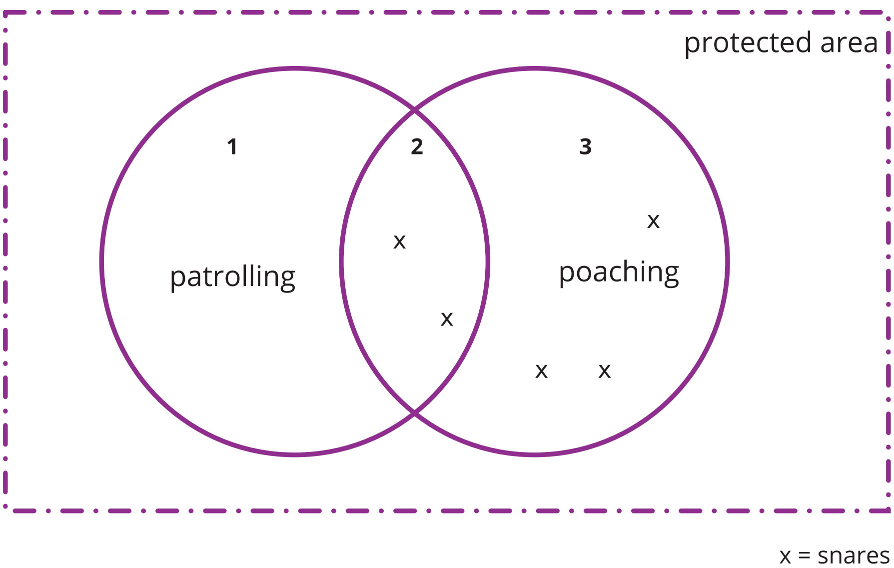

FIGURE 1 Interaction of patrolling and poaching activities in a protected area where snaring takes place. Ranger-patrolled areas (1) and poached areas (3) overlap in an intersection of unknown size (2), as it is not known whether the poaching level in area (1) is truly zero (as shown in this figure) or whether there may be an alternative explanation (refer Table 1). Poaching observations (detection of snares and sightings of poachers) originate from intersection (2)

activities (Gholami & Walk, 2018; Jachmann, 2008). The conclusion that poachers have been deterred by patrolling rangers requires two assumptions: that displacement of poaching activities to other parts of the protected area or to other times of the day is unlikely (Dobson et al., 2018) and that the methodological limitations of LEM data have been overcome (Gholami et al., 2017; Linkie et al., 2015; Rashidi et al., 2018).

However, the use of LEM data under these assumptions poses the risk that the input data will be incomplete and biased as a result of under-reporting due to the low detectability of poaching activity, incompleteness of reporting, and temporal or spatial displacement of poaching activities. These terms are elaborated in Figure 1 and Table 1.

The use of ranger-generated LEM data for the analysis and prediction of poaching activity thus requires that the biases listed in Table 1 did not play a significant role in the generation thereof. In other words, both managers of protected areas and researchers must determine what the poaching incidence would have been in the absence of ranger patrols. Such counter-factual thinking is essential for the evaluation of environmental management outcomes (Ferraro, 2009) but is unfortunately not implementable for individual protected areas (Rodrigues & Cazalis, 2020). Isolating the deterrent effect of patrols is complicated by the multiple processes that interact and occur simultaneously, as outlined in Table 1. Moreover, the level of patrolling in protected areas worldwide is insufficient for monitoring (Dancer, 2019), while the sampling effort to detect even large changes in the level of illegal activities is prohibitive (Jones et al., 2017). Finally, any bias in reported poaching prevalence cannot be calibrated, estimated, or triangulated, as no unbiased independent data, covariate data associated with the bias, or alternative data sources are available for poaching events (Dobson et al., 2020). It has taken decades to disentangle deterrence from displacement in more controlled and better-funded urban environments (Braga et al., 2019; Chalfin & McCrary, 2017). In the absence of such clarity, LEM data users must consider the possibility that the reported data underestimate the true prevalence of poaching.

Here, we examine whether ranger-reported LEM data are likely to underestimate true poaching levels, using a Kenyan protected area in which bushmeat poaching occurs as a case study.

Specifically, we compared LEM data with research data with the aim of finding indications of (1) snaring in areas where rangers did not expect snares and which were not or hardly patrolled (patrol bias or displacement); (2) predictable patrolling patterns, which allow poachers to evade detection (displacement); and (3) incomplete or no reporting of detected snares or sighted poachers (under-reporting).

2 | METHODS

2.1 | Study area

The Soysambu estate is a 190 km^2 ranch and conservancy situated at the western shore of Lake Elementaita (Figure 2), a shallow alkaline lake in Kenya's Great Rift Valley (S0°28.122′ E36°11.408′) that is

TABLE 1 Biases and uncertainties in the interpretation of LEM data

Name	Observation of poachers or snares	Biases and uncertainties
Patrolled area, no poaching activity (1)	No poachers or snares are detected	*Deterrence*: Previous patrolling activity deters poachers from entering the conservancy (Hilborn et al., 2006; Moore et al., 2018). However, evidence of deterrence has hitherto been inconsistent, even in heavily patrolled areas (Dancer, 2019) An alternative explanation for the lack of observed poaching signs is the displacement of poaching to other locations in the protected area (Kuiper, Kavhu, Ngwenya, Mandisodza-Chikerema, & Milner-Gulland, 2020)
Patrolled area, poaching activity detected (2)	Poachers and/or snares were detected	*Detectability*: Snaring prevalence may be under-reported owing to the low detectability of snares. The estimated detectability ranges from ±3–4% in savannahs (Rija, 2017) to ±20% in forests (Ibbett et al., 2020; O'Kelly et al., 2018b). Poachers have become harder to detect through the introduction of mobile phones. They can warn other poachers of approaching rangers, or be informed of patrol plans by compromised rangers (Rija & Kidegesho, 2020) *Temporal displacement*: Poachers may displace their activities, for example by hunting at night when ranger patrol activity is reduced (Hötte et al., 2016; Ouko, 2018). *Under-reporting*: Snares may be removed by rangers but not reported Poachers may be sighted but not reported, for example, due to collusion with rangers (Moreto et al., 2015)
Unpatrolled area, poaching takes place (3)	Poachers and snares are not detected by rangers	*Spatial displacement*: Poachers may displace poaching activity to other parts of the protected area, in response to patrolling (Denninger Snyder et al., 2019; Kuiper et al., 2020), predictability of patrol patterns (timing and location of patrols) (Hötte et al., 2016; Rija, 2017), or inside knowledge of patrolling strategy (Herbig & Warchol, 2011; Rija & Kidegesho, 2020) *Patrol bias*: The area was not patrolled, for example, due to ranger preferences (Moreto & Matusiak, 2016), logistical problems (Keane et al., 2011; Rotich et al., 2014), or safety issues (Nolte, 2016)

Note: The parenthetical numbers in the 'Name' field refer to Figure 1.

located at approximately 1776 m above sea level. The annual mean temperature ranges between 18.5°C and 19.4°C, and the annual rainfall is between 600 and 700 mm (Ongalo, 2019).

The Lake Elementaita ecosystem, which includes Soysambu, is recognised as a World Heritage Site (UNESCO, 2011), a wetland of international importance under the Ramsar Convention (Ramsar Sites Information Service, 2019), and a Key Biodiversity Area (KBA Partnership, 2020). The conservancy is considered to be of critical importance in allowing movement of wildlife between Lake Naivasha, Lake Elementaita and Lake Nakuru, and the neighbouring Eburu Forest (Ojwang et al. 2017). The migration routes lead through Soysambu in a southeastern direction through the former Utut conservation area, which has now been sold, parcelled and fenced to be developed as real estate holiday homes (Mutwiri et al., 2017; Ongalo, 2019). The Soysambu Conservancy is dissected by three public roads and separated from the neighbouring Lake Nakuru National Park by an electric fence.

The conservancy carries out biannual animal censuses since 1990. Over 25 mammal species are counted, consisting mainly of Burchell's zebras, African buffaloes, impalas, Thomson's gazelles, Grant's gazelles, waterbucks and (near-threatened) Rothschild giraffes.

The estate employs 65 unarmed rangers who are responsible for providing security to residents, visitors and livestock in the estate. They also protect the conservancy against poaching, illegal firewood collection and illegal grazing. No specialised internal or external training is required from or provided for the rangers. The rangers work in shifts (6 a.m.–6 p.m., n = 37; 6 p.m. to 6 a.m., n = 24). The patrol plan allocates rangers to mobile patrolling in areas within the conservancy or to static objects, such as park gates, offices and stores. Foot patrols are conducted during the day by groups of two to four rangers (n = 23). At night, two vehicles patrol the estate, each staffed with a driver and a supervisor (n = 4). The remaining rangers of the night shift (n = 20) are allocated to park infrastructure objects. The conservancy has limited contact with the surrounding

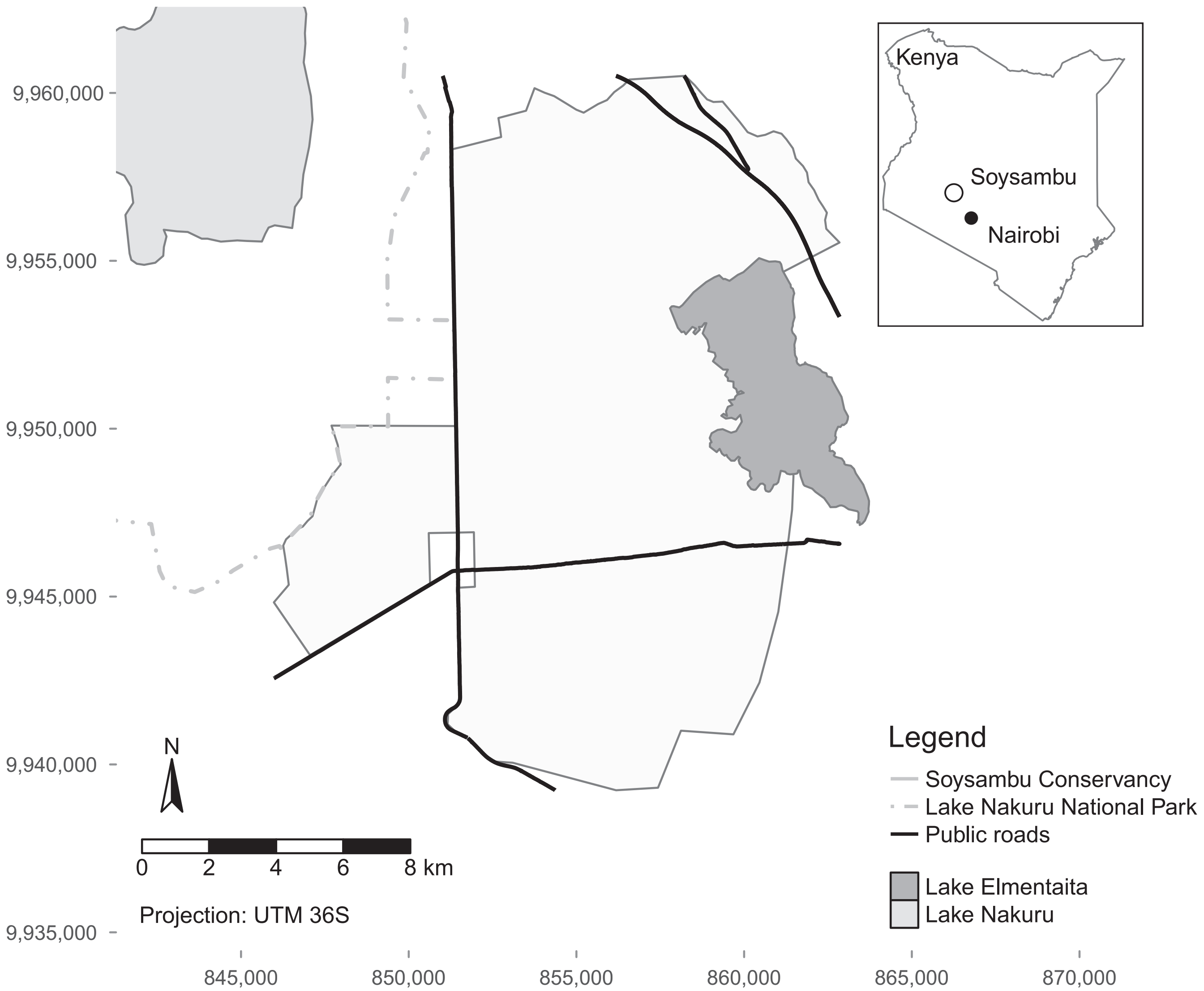

FIGURE 2 Location of Soysambu Conservancy. Inset: location of conservancy in Kenya

TABLE 2 Overview of data sources used (LEM data and research data)

Dataset	Details
Law enforcement monitoring data reported by conservancy (LEM data): 1. Desnaring reports: reports of desnaring exercises organised by the conservancy 2. Observation book: records of observed poachers as reported by rangers 3. Patrol allocation plan: patrolling strategy	1. The conservancy organises regular desnaring exercises, often assisted by third parties (NGOs, KWS). The number and type of snares and the general GPS locations of snaring hotspots were registered during desnaring. The GPS positions of individual snares were not registered. Desnaring reports for the calendar years 2017 and 2018 were made available by the conservancy. No desnaring reports are available for snares removed by rangers during patrols 2. Rangers who observe poachers are required to report this to the control room located at the estate's headquarters. Observations are handwritten in an observation book. These records are not inserted in any database system or further processed. Entries between the period 30 November 2018 and 30 March 2019 were examined 3. Rangers are allocated to static duties (park gates and infrastructure) and mobile duties (patrolling of assigned areas). The locations visited and routes followed by ranger patrols (patrolling patterns) are not monitored or registered
Independent data collected during study (research data): 1. Desnaring transects: collection of snares' GPS positions 2. Ranger interviews: stated frequency of poacher observations 3. Ranger interviews: ranger morale and perceived deterrence capacity	1. Twenty-seven desnaring transects were carried out in the period December 2018–April 2019. The trajectory of transects, GPS positions of detected snares, and snare type were recorded 2. The interviews with rangers took place in the period January 2019—April 2019

communities, and few informers are available to help rangers pre-empt poaching activities or identify poachers.

Bushmeat poaching through the use of snares poses a considerable threat to wildlife in Soysambu and the wider Lake Elementaita ecosystem (Government of Kenya, 2010; Ongalo, 2019). Rangers regularly remove snares from known poaching hotspots, at times assisted by armed rangers from the Kenya Wildlife Service (KWS) and third-party volunteers. The more frequently encountered snare types are either neck snares (designed to strangle the animal) or foot snares (designed to immobilise the animal). Known neck snare hotspots are located along roads dissecting the conservancy in the northeastern and southwestern sections. The main foot snare hotspot is located immediately east of Elementeita village in the southwestern section of the conservancy. Foot snares are placed on animal trails in open areas and mainly trap zebras. Neck snares are placed in bushes and catch a wide range of animals, such as zebras, impalas, waterbucks, Thompson's gazelles and Grant's gazelles.

2.2 | Methodology

Our approach aimed to detect indications of under-reporting of poaching by comparing independent data collected during the study (hereafter: research data) with LEM data reported by the rangers. An overview of the data sources used is presented in Table 2.

Specifically, we first compared the locations of snaring hotspots reported by the conservancy (LEM data) with those that we found during desnaring transects (research data). Detection of snares at unexpected locations during desnaring transects (research data) may indicate patrol bias or spatial displacement. Second, we compared the conservancy's patrol strategy (LEM data) with rangers' perceptions of the predictability thereof for poachers (research data). Predictable patrol strategies allow poachers to evade detection and therefore give an indication of under-reporting of poacher sightings. Third, we compared the frequency of poacher sightings in the conservancy's observation book (LEM data) with ranger-reported frequency of such sightings during interviews (research data). A mismatch between LEM data and research data may indicate inaccurate reporting of poaching prevalence. We explored such mismatches further by interviewing rangers about their perceived capacity to deter poachers.

We position our findings in the context of the relationship between snaring intensity as indicated by both the LEM and research data and expected poacher sightings. Snaring entails frequent visits by poachers who install snares and replace those that have been broken by animals or removed by rangers (Watson et al., 2013). Each incursion into the protected area reduces the probability that the poacher will not be sighted by rangers. Such sightings can occur during patrols that focus on known snaring locations, during routine patrols, or from locations with a consistently high ranger presence, such as park gates. The latter two cases require no previous knowledge of snaring locations. The combination of heavy snaring activity in patrolled areas and a low count of reported poacher sightings will, therefore, become increasingly unlikely over time and may indicate systematic under-reporting of true poaching prevalence in the LEM data.

2.3 | Data collection

Documents established by the conservancy were collected and assessed (LEM data: desnaring reports, observation book and patrol allocation plan) and compared with research data (desnaring transects and ranger interviews), as outlined in Table 2.

During our desnaring transects (research data), we obtained GPS coordinates of both detected snares and transect trajectories. Each transect team comprised at least four rangers with experience in desnaring. Transects were carried out by walking in line with a distance of 20 m between each person. Snares were classified as neck or foot snare. The average snare transect length was 3 km, and the average width was 80 m.

We interviewed 31 of the 65 rangers employed by the conservancy. The interviewees were randomly sampled from the list of employed rangers. The interviewed rangers each had, on average, 7 years of field experience. Three of the interviewees were women; the male/female ratio of the ranger force is 60/5. Each interview took approximately one hour. All interviews were conducted face-to-face on the basis of anonymity and informed consent procedures. The interviews consisted of 23 closed questions that were scored on a five-point Likert scale and 10 open questions. We asked the interviewees to evaluate their perceptions of the predictability of patrolling patterns; spatial and temporal aspects of poaching practices; and bottlenecks that occur when rangers attempt to deter poachers from entering the conservancy. The rangers were also asked to estimate the frequency with which they observed poachers in the conservancy. These frequencies (research data) were compared with the reported poacher sightings (LEM data). Research data and LEM data were compared for overlapping time periods.

Our interview protocol complied with the British Sociological Association (BSA) Statement of Ethical Practice (British Sociological Association, 2017). Our research was authorised under Research Licence A21280 of the Kenyan National Commission for Science, Technology and Innovation.

2.4 | Data analysis

The conservancy's vegetation type was classified as either "open" or "bushy" using a k-means classification in R using the raster library (Hijmans, 2019), utilising a Sentinel-2 L1C satellite image as input (European Space Agency, 2018). The obtained classification raster was continuously checked during the fieldwork.

The detected snare positions were superimposed on the classification raster, and a road layer was added. The distances of detected snares to park borders and gates, water points, lodges, roads and human settlements were extracted from this raster using the R raster library (Hijmans, 2019).

The Hopkins-Skellam test, as implemented in the R spatstat library (Baddeley & Turner, 2005), was used to assess the degree of clustering of the snaring pattern.

The R data.table library (Dowle & Srinivasan, 2017) was used to split Likert scale interview questions into "agree" and "disagree" groups, after which the result was plotted using the R ggplot2 library (Wickham, 2009).

3 | RESULTS

3.1 | Spatial prevalence of snaring

During transect walks that covered 82 km, we found and removed 325 snares (Figure 3).

Most snares found were neck snares (n = 308), often placed just metres apart (median nearest neighbour distance = 12 m) in a clustered pattern (Hopkins-Skellam test: A = 0.042, p-value < 2.2e−16). Foot snares (n = 17) were placed on trails in open areas and were found near the conservancy's mid-western boundary in the immediate vicinity of Elementeita village.

We detected snaring hotspots in locations that were known to the conservancy and that had been documented in desnaring reports (LEM data). The conservancy regularly desnares these hotspots, as rangers found that poachers often replace removed snares. Repeat transects were implemented in five locations (research data, Figure 3) and showed that such re-snaring occurred within 1 day to 1 month after desnaring. Snaring hotspots were also found in unexpected locations: rangers anticipated that snares would be placed close to park borders and settlements around the conservancy (Figure 4). However, we also detected poaching hotspots close to a tourist lodge, park gates and a farm workers' settlement inside the conservancy.

3.2 | Predictability of patrolling strategy

Poachers are often seen entering the conservancy from 4 p.m. onward and are thought to be most active between 6 p.m. and 6 a.m. During this time, the number of rangers on mobile duties decreases sharply from 23 rangers (foot patrol) to 4 (vehicle patrol).

Rangers believe that poachers can easily evade detection at night. At this time, ranger density is low, no foot patrols are conducted, and patrolling vehicles can be heard and seen from afar. Moreover, the rangers in the two patrolling vehicles have no night vision equipment and will likely be outnumbered by poaching gangs should they attempt to confront them. Overall, rangers believe that the patrolling strategies are predictable for poachers (n = 19, Figure 5).

3.3 | Poacher observation frequency and reporting

Rangers reported eight sightings of suspected poachers over the period 28 November 2018–30 March 2019 as per observation books (LEM data). These observations occurred on 8, 9, 12, 23 and 28 December 2018; 12 and 20 January 2019; and 12 and 28 March 2019. No instances of poacher sightings or calls for reinforcement during night patrols were documented during this period. The frequency of poacher observations as reported by rangers during interviews (research data) is summarised in Tables 3 and 4.

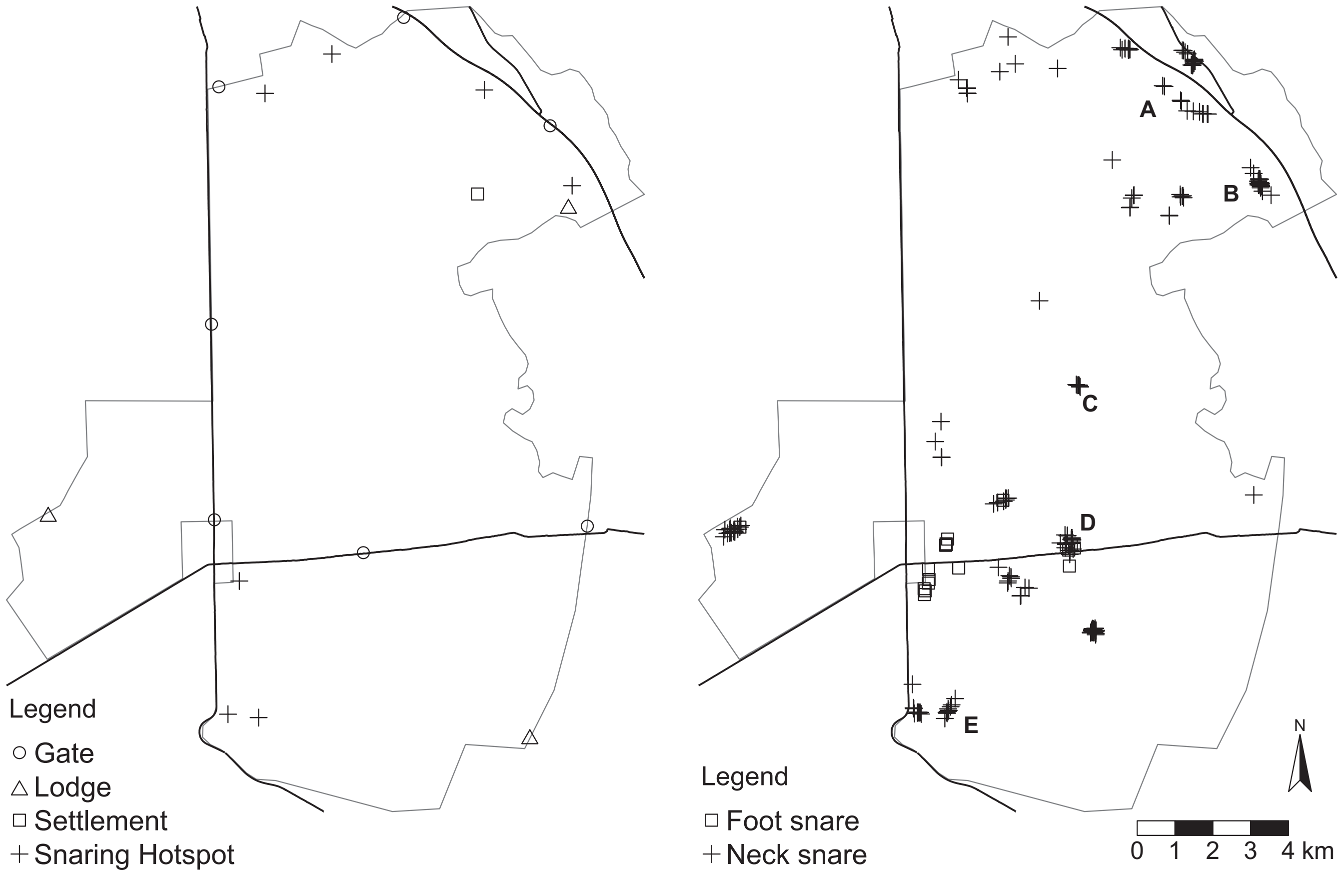

FIGURE 3 Locations of detected foot and neck snares. Left plot: snaring hotspots known to the conservancy. Right plot: snaring hotspots found during the research. The letters A–E (right plot) refer to hotspots that were found to be resnared by poachers during the study period. Locations of transects, park infrastructure and vegetation classification are shown in Figure S.1

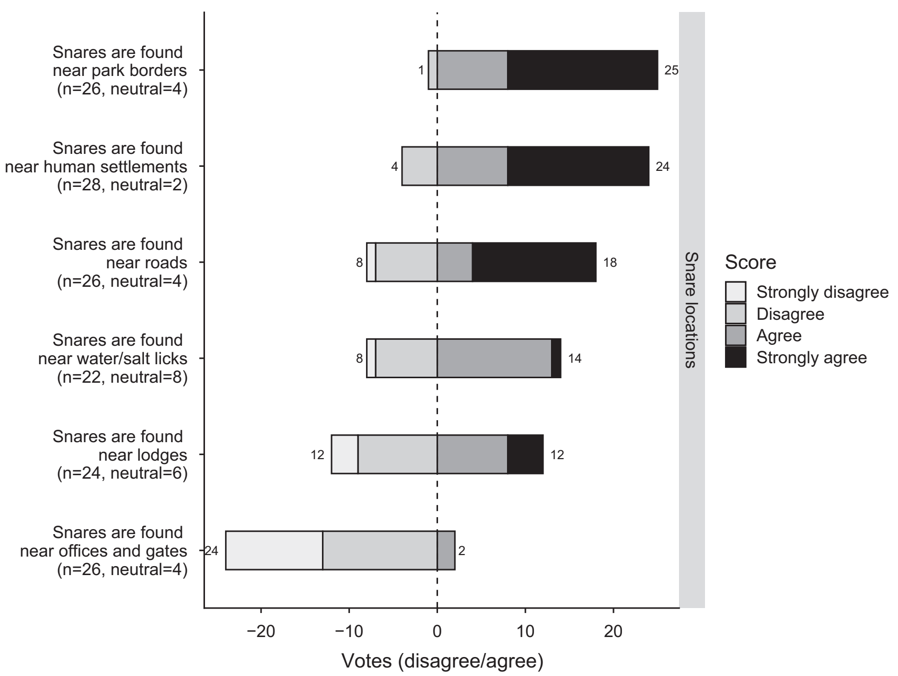

FIGURE 4 Expected locations of snaring hotspots from ranger interviews

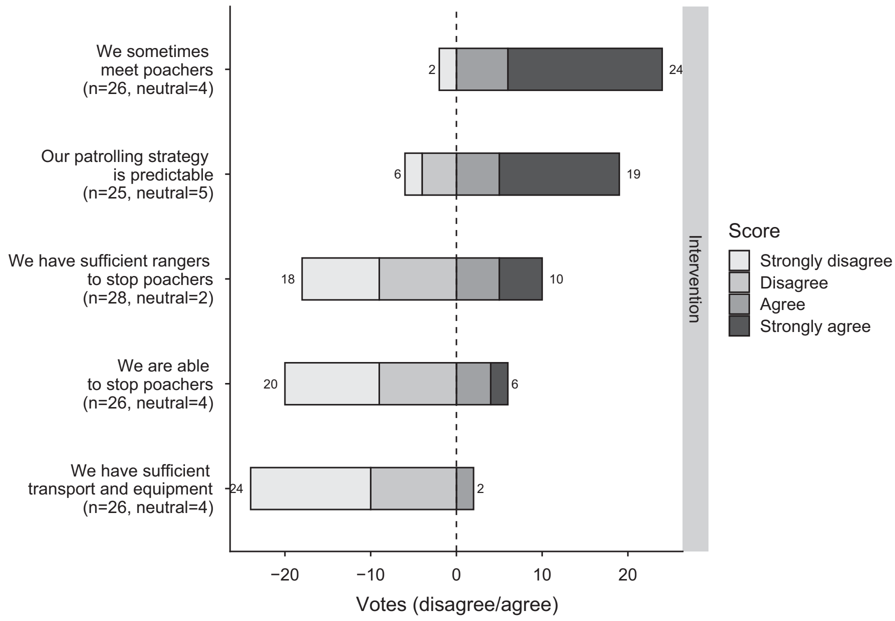

FIGURE 5 Poacher sightings, deterrence as stated by rangers during interviews

TABLE 3 Poacher observations per ranger per month (interviews, research data)

Frequency of observing poachers	n rangers	Frequency per month[a]
Twice per week	3	8.67
Weekly	7	4.33
Twice per month	6	2.00
Monthly	7	1.00
Quarterly	3	0.33
Yearly	1	0.08
Never	2	0
No opinion	2	n.d.
Total/weighted average	31	2.64

[a]The reported observation frequencies are normalised over months (e.g. weekly observation of poachers = 52 observations per year/12 months = 4.33 observations per month on average).

The majority of the interviewed rangers indicated that they occasionally sighted poachers (*n* = 24) but that they were unable to intervene (*n* = 20) (Figure 5). The stated reasons included under-staffing (*n* = 18) and inadequate equipment (*n* = 24). Some rangers admitted that they did not intend to stop poachers or call for reinforcement ("We pretend not to see them") (*n* = 5). Others implicitly indicated the same ("You could see them every day, if you want to") (*n* = 4).

Attempts to arrest sighted poachers were considered risky because poachers may know the rangers' identities and the locations of their homes (*n* = 25). Furthermore, rangers pointed out that they deemed their salaries too low to warrant the physical risks inherent in confrontations with armed poachers (*n* = 15). However, rangers indicated that direct confrontations between them and poachers were rare. When seen, poachers generally move away from the rangers, often covering their faces. Nevertheless, some rangers reported having been threatened by poachers (*n* = 5) and having experienced violence at the hands of poachers at home and during attempted arrest (*n* = 6).

TABLE 4 Observed frequency of poacher sightings in LEM data (observation book) and research data (interviews) in average sightings per month for the period 30 November 2018–30 March 2019

	LEM data	Research data	Remarks
n rangers	65	31	The LEM data were reported by the entire ranger force, and the research data were reported by 31 interviewed rangers
Average number of observations per month	2	2.64	LEM data: 8 observations in 4 months Research data: weighted average (Table 3)
Maximum observations per month	5	8.67	Research data: maximum from frequency per month (Table 3) LEM data: maximum from observation book (5 observations in December 2018)

Rangers clarified that lack of arms is the most challenging, because the poachers that they have to confront are usually armed with crude weapons (e.g., machetes, spears) and operate in groups of three or more persons. Transportation was also seen as important in view of reinforcement response times (n = 13). Rangers can call for reinforcement if they see a group of poachers that outnumbers them. Response times are perceived to be slow because of the poor availability of vehicles; frequently, by the time reinforcement arrives, the poachers have disappeared. Slow response times were also cited as a reason for non-reporting of poacher sightings.

4 | DISCUSSION

Our findings suggest that the LEM data provided by the conservancy underestimate the true prevalence of poaching. Three possible explanations for this may be offered: under-reporting of snaring, predictability of patrolling strategies, and under-reporting of poacher sightings by rangers.

The reported prevalence of snaring is arguably always an underestimation, because the estimated detectability of snares is in the 3–20% range (Ibbett et al., 2020; O'Kelly et al., 2018b; Rija, 2017). The probability that rangers will miss a snare is, therefore, greater than the likelihood that they will find it. Additionally, snares that rangers remove as part of their daily patrols are not reported; desnaring reports are only established after desnaring events that have been specifically organised for that purpose. Finally, desnaring by the conservancy tends to concentrate on known poaching hotspots. However, we identified snaring hotspots in areas that the rangers did not anticipate, namely near park infrastructure. The placement of snares or traps near park infrastructure has been observed in other protected areas (Jenks et al., 2012; O'Kelly et al., 2018a; Watson et al., 2013). Possible explanations offered are park staff involvement (Jenks et al., 2012) and the attraction of animals to the relative safety provided by the proximity of ranger stations (O'Kelly et al., 2018a), which in turn makes the area more attractive to poachers. Watson et al., (2013) recommend further research in this area.

The patrol timing is predictable for poachers, who can avoid rangers by hunting at night. During this time, ranger presence is considerably reduced and patrol vehicles can be seen and heard from afar. Poachers' exploitation of predictable patrolling patterns is widely reported (Herbig & Warchol, 2011; Hötte et al., 2016; Moreto & Lemieux, 2015; Robinson et al., 2010). Nocturnal poaching is not restricted to this conservancy. Kenya's Auditor General found, after interviewing staff of the KWS, that 90% of poaching is likely to occur at night but that rangers lack sufficient night vision equipment to detect it (Ouko, 2018). Furthermore, we found that removed snares were rapidly replaced by poachers, possibly under the assumption that it would be some time before rangers would revisit the desnared area.

Several indications suggest that not all sightings of poachers are reported. First, one-third of the interviewed rangers admitted, either implicitly or explicitly, that they did not report sighted poachers. Second, the ranger force reported on average two poacher sightings per month (LEM data), whereas one-third of the interviewed rangers claimed to see at least four poachers per month on average; three rangers reported seeing eight poachers per month. The apparent under-reporting of poacher sightings by rangers seems to be related to low ranger morale and low perceived capacity to deter poachers from entering the conservancy. Rangers feel that the potential for violence during encounters with groups of armed poachers is not worth the risk, because they are unarmed and consider themselves underpaid. Violence was perpetrated against rangers but was rare. However, violence need not be frequent to be an effective deterrent (Rapoport & Chammah, 1966). The undermining of ranger morale through poacher violence, underpayment, and equipment problems is widespread and well documented. For example, recent studies found that nearly 73% of African rangers have been threatened by poachers (Singh et al., 2020) and that 65% consider themselves underpaid (Belecky et al., 2019).

The presence of the discussed biases results in survivorship bias (Shermer, 2014; Zabawski, 2019). Poaching incidents are only eligible for detection and registration if areas in the conservancy were patrolled or available for patrolling, poachers did not displace their activities or managed to evade detection, and all snares or poachers were both detected and reported. This form of bias is insidious, because LEM data may suggest low poaching prevalence in areas that may in fact be poached.

Our study is not without its limitations. First, we provide indications of survivorship bias rather than firm, quantified proof. This is due to the nature of multiple and interacting sources of possible bias and is not specific to this study. The disentanglement of deterrence and displacement is complex and has only recently been established in urban environments. Second, we studied a single site, and this may lead to concerns regarding the generalisation of conclusions. We have endeavoured to support our findings with references to similar situations and processes elsewhere. Both displacement of poaching and undermined ranger morale have been documented elsewhere, and therefore we have no reason to believe that our findings are restricted to this particular protected area.

Third, the rangers working in our study area are unarmed. This may influence the observed difference between stated and reported frequencies of poacher sightings. Indeed, Nahonyo (2005) found that unarmed rangers observed less poaching activity than their armed counterparts. We argue that rangers and community scouts are often unarmed (Holmern et al., 2007; Ihwagi et al., 2015; Roe et al., 2015), and therefore representative of our study's context. Furthermore, displacement and ranger intimidation have been observed even when rangers are armed (Herbig & Warchol, 2011; Ouko, 2018).

Fourth, while we conducted interviews on the basis of anonymity, rangers may nevertheless have avoided giving full disclosure to sensitive questions for fear of identification and possible negative consequences. We observed, however, considerable consent to the key issues studied, as Figure 5 illustrates.

In summary, our findings suggest that ranger-collected data must be interpreted in the context in which they were generated. Unarmed rangers who perceive themselves as underpaid, underequipped and threatened are unlikely to report all sightings of illegal activities. Patrolling patterns may be predictable or leave areas within the protected area unpatrolled. This allows poachers to evade detection or displace their activities elsewhere. A low prevalence of reported poacher sightings may, therefore, indicate either actual low poaching levels or high poaching levels that go unreported.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

AUTHOR CONTRIBUTIONS

HH conceived the research concept and methodology, collected and analysed the data, and led the writing of the manuscript. NJM, JSM and VWW provided critical feedback and contributions to the manuscript drafts and gave final approval for publication.

DATA AVAILABILITY STATEMENT

The dataset for desnaring (removed number and type of snares, coordinates, snare status) is available on Figshare: https://doi.org/10.6084/m9.figshare.12936752.v1 (Harmsen, 2020a). The questionnaires for the interviews with rangers and communities are available on Figshare: https://doi.org/10.6084/m9.figshare.12513098.v1 (Harmsen, 2020b).

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REFERENCES

Baddeley, A., & Turner, R. (2005). spatstat: An R package for analyzing spatial point patterns. *Journal of Statistical Software*, *12*(6), 1–42.

Becker, M., McRobb, R., Watson, F., Droge, E., Kanyembo, B., Murdoch, J., & Kakumbi, C. (2013). Evaluating wire-snare poaching trends and the impacts of by-catch on elephants and large carnivores. *Biological Conservation*, *158*, 26–36. https://doi.org/10.1016/j.biocon.2012.08.017

Belecky, M., Singh, R., & Moreto, W. D. (2019). Life on the Frontline 2019: A Global Survey of the Working Conditions of Rangers. WWF.

Braga, A. A., Turchan, B. S., Papachristos, A. V., & Hureau, D. M. (2019). Hot spots policing and crime reduction: An update of an ongoing systematic review and meta-analysis. *Journal of Experimental Criminology*, *15*(3), 289–311. https://doi.org/10.1007/s11292-019-09372-3

British Sociological Association. (2017). BSA Statement of Ethical Practice. British Sociological Association. Durham: BSA Publications.

Campbell, K., Martyr, D., Risdianto, D., & Clemente, C. J. (2019). Two species, one snare: Analysing snare usage and the impacts of tiger poaching on a non-target species, the Malayan tapir. *Biological Conservation*, *231*, 161–166. https://doi.org/10.1016/j.biocon.2019.01.009

Chalfin, A., & McCrary, J. (2017). Criminal deterrence: A review of the literature. *Journal of Economic Literature*, *55*(1), 5–48.

Craigie, I. D., Baillie, J. E. M., Balmford, A., Carbone, C., Collen, B., Green, R. E., & Hutton, J. M. (2010). Large mammal population declines in Africa's protected areas. *Biological Conservation*, *143*(9), 2221–2228. https://doi.org/10.1016/j.biocon.2010.06.007

Critchlow, R., Plumptre, A. J., Alidria, B., Nsubuga, M., Driciru, M., Rwetsiba, A., Wanyama, F., & Beale, C. M. (2016). Improving law-enforcement effectiveness and efficiency in protected areas using ranger-collected monitoring data. *Conservation Letters*, *10*(5), 572–580. https://doi.org/10.1111/conl.12288

Dancer, A. (2019). *On the evaluation, monitoring and management of law enforcement patrols in protected areas*. UCL (University College London).

Denninger Snyder, K., Mneney, P. B., & Wittemyer, G. (2019). Predicting the risk of illegal activity and evaluating law enforcement interventions in the western Serengeti. *Conservation Science and Practice*, *1*(9), 1–13. https://doi.org/10.1111/csp2.81

Dobson, A., Milner-Gulland, E. J., Aebischer, N. J., Beale, C. M., Brozovic, R., Coals, P., Critchlow, R., Dancer, A., Greve, M., Hinsley, A., Ibbett, H., Johnston, A., Kuiper, T., Le Comber, S., Mahood, S. P., Moore, J. F., Nilsen, E. B., Pocock, M. J. O., Quinn, A., … Keane, A. (2020). Making messy data work for conservation. *One Earth*, *2*(5), 455–465. https://doi.org/10.1016/j.oneear.2020.04.012

Dobson, A. D. M., Milner-Gulland, E. J., Beale, C. M., Ibbett, H., & Keane, A. (2018). Detecting deterrence from patrol data. *Conservation Biology*, *33*(3), 1–11. https://doi.org/10.1111/cobi.13222

Dowle, M., Srinivasan, A., Gorecki, J., Chirico, M., Stetsenko, P., Short, T., & Tan, X. (2019). Package 'data. table'. Extension of 'data. frame'.

European Space Agency (2018). *SENTINEL-2B image L1C_T36MZE_A008841_20181115T0750*. European Space Agency.

Ferraro, P. J. (2009). Counterfactual thinking and impact evaluation in environmental policy. *New Directions for Evaluation*, *2009*(122), 75–84. https://doi.org/10.1002/ev.297

Gandiwa, E., Zisadza-Gandiwa, P., Mango, L., & Jakarasi, J. (2014). Law enforcement staff perceptions of illegal hunting and wildlife conservation in Gonarezhou National Park, southeastern Zimbabwe. *Tropical Ecology*, *55*(1), 119–127.

Gholami, S., Ford, B., Fang, F., Plumptre, A., Tambe, M., Driciru, M., & Mabonga, J. (2017). Taking It for a test drive: A hybrid spatio-temporal model for wildlife poaching prediction evaluated through a controlled field test. In M. Ceci, J. Hollmén, L. Todorovski, C. Vens, & S. Džeroski (Eds.), *Machine learning and knowledge discovery in databases* (pp. 292–304). Springer International Publishing. https://doi.org/10.1007/978-3-319-71273-4_24

Gholami, S. (2018). Spatio-Temporal Model for Wildlife Poaching Prediction Evaluated Through a Controlled Field Test in Uganda. In *Proceedings of the AAAI Conference on Artificial Intelligence*, *32*(1).

Government of Kenya (2010). *Nomination Proposal Kenya Lakes System in the Great Rift Valley (Elementaita, Nakuru and Bogoria)*. Nairobi.

Gray, T. N. E., Hughes, A. C., Laurance, W. F., Long, B., Lynam, A. J., O'Kelly, H., Ripple, W. J., Seng, T., Scotson, L., & Wilkinson, N. M. (2018). The wildlife snaring crisis: An insidious and pervasive threat to biodiversity in Southeast Asia. *Biodiversity and Conservation*, *27*(4), 1031–1037. https://doi.org/10.1007/s10531-017-1450-5

Harmsen, H. (2020a). Questionnaires and interview protocol. Figshare. https://doi.org/10.6084/m9.figshare.12513098.v1

Harmsen, H. (2020b). Snares in Soysambu Conservancy. *Nairobi*. https://doi.org/10.6084/m9.figshare.12936752.v1

Herbig, F. J. W., & Warchol, G. (2011). South African conservation crime and routine activities theory: A causal nexus? *Acta Criminologica: Southern African Journal of Criminology*, *24*(2), 1–16.

Hijmans, R. J. (2019). raster: Geographic Data Analysis and Modeling. https://cran.r-project.org/package=raster

Hilborn, R., Arcese, P., Borner, M., Hando, J., Hopcraft, G., Loibooki, M., Mduma, S., & Sinclair, A. R. E. (2006). Effective enforcement in a conservation area. *Science*, *314*(5803), 2006. https://doi.org/10.1126/science.1132780.

Holmern, T., Muya, J., & Røskaft, E. (2007). Local law enforcement and illegal bushmeat hunting outside the Serengeti National Park, Tanzania. *Environmental Conservation*, *34*(1), 55–63. https://doi.org/10.1017/S0376892907003712

Hötte, M. H. H., Kolodin, I. A., Bereznuk, S. L., Slaght, J. C., Kerley, L. L., Soutyrina, S. V., Salkina, G. P., Zaumyslova, O. Y., Stokes, E. J., & Miquelle, D. G. (2016). Indicators of success for smart law enforcement in protected areas: A case study for Russian Amur tiger (*Panthera tigris altaica*) reserves. *Integrative Zoology*, *11*(1), 2–15. https://doi.org/10.1111/1749-4877.12168

Ibbett, H., Milner-Gulland, E. J., Beale, C., Dobson, A. D. M., Griffin, O., O'Kelly, H., & Keane, A. (2020). Experimentally assessing the effect of search effort on snare detectability. *Biological Conservation*, *247*(April), 108581. https://doi.org/10.1016/j.biocon.2020.108581

Ihwagi, F. W., Wang, T., Wittemyer, G., Skidmore, A. K., Toxopeus, A. G., Ngene, S., King, J., Worden, J., Omondi, P., & Douglas-Hamilton, I. (2015). Using poaching levels and elephant distribution to assess the conservation efficacy of private, communal and government land in northern Kenya. *PLoS One*, *10*(9), 1–17. https://doi.org/10.1371/journal.pone.0139079

IUCN (2018). *Protected planet*. IUCN. https://protectedplanet.net/country/KEN

Jachmann, H. (2007). Monitoring law-enforcement performance in nine protected areas in Ghana. *Biological Conservation*, *141*(1), 89–99. https://doi.org/10.1016/j.biocon.2007.09.012

Jachmann, H. (2008). Illegal wildlife use and protected area management in Ghana. *Biological Conservation*, *141*(7), 1906–1918. https://doi.org/10.1016/j.biocon.2008.05.009

Jenks, K. E., Howard, J., & Leimgruber, P. (2012). Do ranger stations deter poaching activity in National Parks in Thailand? *Biotropica*, *44*(6), 826–833. https://doi.org/10.1111/j.1744-7429.2012.00869.x

Jones, S., Burgess, M. D., Sinclair, F., Lindsell, J., & Vickery, J. (2017). Optimal monitoring strategy to detect rule-breaking: A power and simulation approach parameterised with field data from Gola Rainforest National Park, Sierra Leone. *Conservation and Society*, *15*(3), 334–343.

Kar, D., Ford, B., Gholami, S., Fang, F., Plumptre, A., Tambe, M., & Rwetsiba, A. (2017). Cloudy with a chance of Poaching: Adversary behavior modeling and forecasting with real-world poaching data. In *AAMAS '17: Proceedings of the 16th conference on autonomous agents and multiagent systems* (pp. 159–167). Richland, SC: International Foundation for Autonomous Agents and Multiagent Systems.

KBA Partnership (2020). *World database on key biodiversity areas*. http://www.keybiodiversityareas.org/home

Keane, A., Jones, J. P. G., & Milner-Gulland, E. J. (2011). Encounter data in resource management and ecology: Pitfalls and possibilities. *Journal of Applied Ecology*, *48*(5), 1164–1173. https://doi.org/10.1111/j.1365-2664.2011.02034.x

Kuiper, T., Kavhu, B., Ngwenya, N. A., Mandisodza-Chikerema, R., & Milner-Gulland, E. J. (2020). Rangers and modellers collaborate to build and evaluate spatial models of African elephant poaching. *Biological Conservation*, *243*, 108486. https://doi.org/10.1016/j.biocon.2020.108486

Lindsey, P. A., Romañach, S. S., Matema, S., Matema, C., Mupamhadzi, I., & Muvengwi, J. (2011). Dynamics and underlying causes of illegal bushmeat trade in Zimbabwe. *Oryx*, *45*(1), 84–95. https://doi.org/10.1017/S0030605310001274

Linkie, M., Martyr, D. J., Harihar, A., Risdianto, D., Nugraha, R. T., Maryati, M., Leader-Williams, N., Wong, W.-M. (2015). Safeguarding Sumatran tigers: Evaluating effectiveness of law enforcement patrols and local informant networks. *Journal of Applied Ecology*, *52*(4), 851–860. https://doi.org/10.1111/1365-2664.12461

Loveridge, A. J., Sousa, L. L., Seymour-Smith, J., Hunt, J., Coals, P., O'Donnell, H., Lindsey, P. A., Mandisodza-Chikerema, R., & Macdonald, D. W. (2020). Evaluating the spatial intensity and demographic impacts of wire-snare bush-meat poaching on large carnivores. *Biological Conservation*, *244*, 108504. https://doi.org/10.1016/j.biocon.2020.108504

Moore, J. F., Mulindahabi, F., Masozera, M. K., Nichols, J. D., Hines, J. E., Turikunkiko, E., & Oli, M. K. (2018). Are ranger patrols effective in reducing poaching-related threats within protected areas? *Journal of Applied Ecology*, *55*(1), 99–107. https://doi.org/10.1111/1365-2664.12965

Moreto, W. D., Brunson, R. K., & Braga, A. A. (2015). "Such misconducts don't make a good ranger": Examining law enforcement ranger wrongdoing in Uganda. *British Journal of Criminology*, *55*(2), 359–380. https://doi.org/10.1093/bjc/azu079

Moreto, W. D., & Lemieux, A. M. (2015). Poaching in Uganda: Perspectives of law enforcement rangers. *Deviant Behavior*, *36*(11), 853–873. https://doi.org/10.1080/01639625.2014.977184

Moreto, W. D., & Matusiak, M. C. (2016). "We Fight against Wrong Doers": Law enforcement rangers' roles, responsibilities, and patrol operations in Uganda. *Deviant Behavior*, *38*(4), 426–447. https://doi.org/10.1080/01639625.2016.1197015

Mutwiri, J., Makau, I., & Makosi, L. (2017). *Lake Elementaita Wildlife Sanctuary Ecosystem Management Planning*. In KWS-L.Elementaita Land Owners Consultative Meeting, at Zeituni Lodge, L. Elementaita. KWS.

Nahonyo, C. (2009). Assessment of anti-poaching effort in Ruaha National Park, Tanzania. *Tanzania Journal of Science*, *31*(2), 13–21. https://doi.org/10.4314/tjs.v31i2.18416

Nolte, C. (2016). Identifying challenges to enforcement in protected areas: Empirical insights from 15 Colombian parks. *Oryx*, *50*(02), 317–322. https://doi.org/10.1017/S0030605314000891

Ojwang, G. O., Wargute, P. W., Said, M. Y., Worden, J. S., Davidson, Z., Muruthi, P., Okita-Ouma, B. (2017). Wildlife Migratory Corridors and Dispersal Areas: Kenya Rangelands and Coastal Terrestrial Ecosystems. Kenya Vision 2030. Nairobi.

O'Kelly, H. J., Rowcliffe, J. M., Durant, S. M., & Milner-Gulland, E. J. J. (2018a). Robust estimation of snare prevalence within a tropical forest context using N-mixture models. *Biological Conservation*, *217*, 75–82. https://doi.org/10.1016/j.biocon.2017.10.007

O'Kelly, H. J., Rowcliffe, J. M., Durant, S., & Milner-Gulland, E. J. (2018b). Experimental estimation of snare detectability for robust threat monitoring. *Ecology and Evolution*, *8*(3), 1778–1785. https://doi.org/10.1002/ece3.3655

Ongalo, S. (2019). *SOC report for 41 COM 7B.21 Kenya Lake System in the Great Rift Valley (Kenya) (N 1060REV)*. Nairobi.

Ouko, E. R. O. (2018). *Performance audit report on effectiveness of measures put in place by Kenya Wildlife Services in Protecting Wildlife*. Nairobi, Kenya.

Plumptre, A. J. (2019). Law enforcement for wildlife conservation. In F. Fang, M. Tambe, B. Dilkina, & A. J. Plumptre (Eds.), *Artificial intelligence and conservation* (pp. 17–28). Cambridge University Press. https://doi.org/10.1017/9781108587792.002

Ramsar Sites Information Service (2019). *Annotated list of wetlands of international importance*. Ramsar Sites Information Service (RSIS).

Rapoport, A., & Chammah, A. M. (1966). The game of chicken. *American Behavioral Scientist*, *10*(10), 10–28. https://doi.org/10.1177/000276426601000303

Rashidi, P., Skidmore, A., Wang, T., Darvishzadeh, R., Ngene, S., & Vrieling, A. (2018). Assessing trends and seasonal changes in elephant poaching risk at the small area level using spatio-temporal Bayesian modeling. *International Journal of Geographical Information Science*, *32*(3), 622–636. https://doi.org/10.1080/13658816.2017.1404605

Rija, A. A. (2017). *Spatial pattern of illegal activities and the impact on wildlife populations in protected areas in the Serengeti ecosystem*. University of York.

Rija, A. A., Critchlow, R., Thomas, C. D., & Beale, C. M. (2020). Global extent and drivers of mammal population declines in protected areas under illegal hunting pressure. *PLoS One*, *15*(8), e0227163. https://doi.org/10.1371/journal.pone.0227163

Rija, A. A., & Kidegesho, J. R. (2020). Poachers' strategies to surmount anti-poaching efforts in Western Serengeti, Tanzania. In J. O. Durrant, K. Melubo, L. A. Hadfield, L. Weisler, E. H. Martin, R. R. Jensen, & P. J. Hardin (Eds.), *Protected areas in Northern Tanzania* (pp. 91–112). Springer Nature Switzerland AG.

Ripple, W. J., Abernethy, K., Betts, M. G., Chapron, G., Dirzo, R., Galetti, M., Levi, T., Lindsey, P. A., Macdonald, D. W., Machovina, B., Newsome, T. M., Peres, C. A., Wallach, A. D., Wolf, C., & Young, H. (2016). Bushmeat hunting and extinction risk to the world's mammals. *Royal Society Open Science*, *3*(10), 160498. https://doi.org/10.1098/rsos.160498

Ripple, W. J., Newsome, T. M., Wolf, C., Dirzo, R., Everatt, K. T., Galetti, M., Hayward, M. W., Kerley, G. I. H., Levi, T., Lindsey, P. A., Macdonald, D. W., Malhi, Y., Painter, L. E., Sandom, C. J., Terborgh, J., & Van Valkenburgh, B. (2015). Collapse of the world's largest herbivores. *Science Advances*, *1*(4), e1400103. https://doi.org/10.1126/sciadv.1400103

Robinson, E. J. Z., Kumar, A. M., & Albers, H. J. (2010). Protecting developing countries' forests: Enforcement in theory and practice. *Journal of Natural Resources Policy Research*, *2*(1), 25–38. https://doi.org/10.1080/19390450903350820

Rodrigues, A. S. L., & Cazalis, V. (2020). The multifaceted challenge of evaluating protected area effectiveness. *Nature Communications*, *11*(1), 5147. https://doi.org/10.1038/s41467-020-18989-2

Roe, D., Booker, F., Day, M., Zhou, W., Allebone-Webb, S., Hill, N. A. O., Kumpel, N., Petrokofsky, G., Redford, K., Russell, D., Shepherd, G., Wright, J., & Sunderland, T. C. H. (2015). Are alternative livelihood projects effective at reducing local threats to specified elements of biodiversity and/or improving or maintaining the conservation status of those elements? *Environmental Evidence*, *4*(1), 22. https://doi.org/10.1186/s13750-015-0048-1

Rotich, N., Manegene, S., Musanga Pamba, P., Lalampaa, T., Muraya Kariuki, S., Boit, P., & Nzainga, H. (2014). *Lifting the siege: Securing Kenya's Wildlife*. Nairobi, Kenya.

Schulze, K., Knights, K., Coad, L., Geldmann, J., Leverington, F., Eassom, A., Marr, M., Butchart, S. H. M., Hockings, M., & Burgess, N. D. (2018). An assessment of threats to terrestrial protected areas. *Conservation Letters*, *11*(3), e12435. https://doi.org/10.1111/conl.12435

Shermer, M. (2014). Surviving statistics. *Scientific American*, *311*(3), 94. https://doi.org/10.1038/scientificamerican0914-94

Singh, R., Gan, M., Barlow, C., Long, B., Mcvey, D., Kock, R. D., & Avino, F. S. (2020). What do rangers feel? Perceptions from Asia, Africa and Latin America. *Parks*, *26*(10), 63–76.

Stokes, E. J. (2010). Improving effectiveness of protection efforts in tiger source sites: Developing a framework for law enforcement monitoring using MIST. *Integrative Zoology*. https://doi.org/10.1111/j.1749-4877.2010.00223.x

UNEP-WCMC (2020). *World database on protected areas*. UNEP-WCMC. https://www.protectedplanet.net/c/world-database-on-protected-areas

UNESCO (2011). *Kenya Lake System in the Great Rift Valley – Inscribed property*. UNESCO.

Watson, F., Becker, M. S., McRobb, R., & Kanyembo, B. (2013). Spatial patterns of wire-snare poaching: Implications for community conservation in buffer zones around National Parks. *Biological Conservation*, *168*, 1–9. https://doi.org/10.1016/j.biocon.2013.09.003

Wickham, H. (2009). *ggplot2: Elegant graphics for data analysis*. Springer-Verlag New York.

Xu, L., Gholami, S., McCarthy, S., Dilkina, B., Plumptre, A., Tambe, M., & Enyel, E. (2020). Stay ahead of Poachers: Illegal wildlife poaching prediction and patrol planning under uncertainty with field test evaluations (Short Version). In *2020 IEEE 36th International Conference on Data Engineering (ICDE)* (pp. 1898–1901). Los Alamitos: IEEE Computer Society. https://doi.org/10.1109/ICDE48307.2020.00198

Zabawski, E. (2019). Holes in the data. *Tribology & Lubrication Technology*, *75*(5), 2019.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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