Driven by data: Improved protected area effectiveness in Royal Manas National Park, Bhutan

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Abstract
The necessity of rangers and other frontline staff for ensuring the protection and effective management of protected areas is well documented. The Spatial Monitoring and Reporting Tool (SMART) was developed as a law enforcement monitoring tool with the aim of assisting management in the allocation of resources and strategic deployment of ranger patrols. The ability of SMART to contribute to improved protection depends heavily on effective application through an adaptive management framework. Royal Manas National Park (RMNP), Bhutan, presents an opportunity to review the use of a protected area law enforcement monitoring tool for improving the detection and reduction of illegal activities within a protected area through effective ranger patrols. Results from the analysis of 5 years of monitoring data collected by rangers indicates a marked improvement in patrol effort in RMNP and suggests that the effective deployment of law enforcement monitoring tools, when used as part of an adaptive management framework, can improve the detectability of poaching related threats, potentially resulting in an overall reduction of poaching threats through enabling the informed and targeted allocation of staff and resources.

KEYWORDS
adaptive management, Bhutan, monitoring tools, patrol, ranger, SMART

1 | INTRODUCTION

Protected areas are an essential mechanism for the conservation of biodiversity (Geldmann et al., 2013; Gray et al., 2016) providing a lifeline to threatened species around the world (Brooks, Wright, & Sheil, 2009; Margules & Pressey, 2000) and acting to reverse species declines and prevent extinctions (Hoffmann et al., 2010). Despite the important legal protections afforded to these landscapes, a large proportion of the world's protected areas are not considered to be under sound management, with many lacking the basic requirements to operate effectively (Leverington, Costa, Pavese, Lisle, & Hockings, 2010). Protected areas, particularly in developing tropical regions where biodiversity is generally high, are commonly underfunded (Bruner, Gullison, & Balmford, 2004) and under threat from rapid population growth and poverty (Cincotta, Wisnewski, & Engelman, 2000) which are often drivers of illegal wildlife crimes (Butchart et al., 2010; Challender & MacMillan, 2014; Craigie et al., 2010). In addition to these
pressures the natural resources of protected areas are also threatened by the international illegal wildlife trade in flora and fauna, which is estimated to be worth $7–23 billion annually (UNEP, 2014) and many countries across the world are caught in the grip of an unprecedented rise in wildlife poaching which can negate decades of conservation gains (Dutton, Gratwicke, Hepburn, Herrera, & Macdonald, 2013; Linkie et al., 2018). The world’s wildlife seizure database currently contains over 164,000 seizures involving nearly 7,000 species (UNODC, 2016) emphasizing the scale of the illegal wildlife trade. The spatial and temporal patterns of the poaching that feeds this trade are largely unknown and provide a great challenge for conserving protected areas (Moore et al., 2018).

Significant resources have been directed to conserving protected areas in recent years (Gratwicke, Seidensticker, Shrestha, Vermilye, & Birnbaum, 2007; Hickey & Pimm, 2011). Despite this, given the scale of the issue of effectively protecting great swathes of land, protected area management is tasked with utilizing these resources as effectively as possible. However, the scarcity of information regarding threats and how to best utilize resources, make the duty of securing protected areas extremely difficult. The situation is exacerbated by the fact that rigorous assessments of the impact of conservation interventions are thin on the ground (Ferraro & Pattanayak, 2006); however, the importance of law enforcement for successful protected area management is widely documented (Byers & Noonburg, 2007; Dobson & Lynes, 2008; Hilborn et al., 2006; Leader-Williams & Milner-Gulland, 1993). Therefore, in order to adapt and respond effectively to increasing conservation threats, it is of utmost importance to understand and enhance the effectiveness of law enforcement efforts over space and time. It is also essential that protected area managers and their frontline staff have the best possible information and guidance as to how to address the threats on the ground (Stokes, 2010). Effective management of protected areas and improved law enforcement approaches to mitigate these threats are vitally important for global biodiversity conservation (Brandon, Redford, & Sanderson, 1998; Leverington et al., 2010). Adaptive management can be defined as the systematic acquisition and application of reliable information to improve management over time whereby management becomes an adaptive learning process in which management activities themselves are viewed as the primary tools for experimentation (Walters, 1986). Adaptive management approaches have been applied to various aspects of conservation and protected area management (Agrawal, 2000; Prato, 2009). Law enforcement monitoring (LEM) tools such as SMART, in order to be effective in improving protection and management, need to be considered as an additive and key part of a holistic approach to adaptive management (Stokes, 2010) through which management decisions are adaptively made through the acquisition and analysis of patrol data.

In an attempt to plug the information gaps in protected areas, reduce the reliance on ad hoc and incidental reporting of threats for deploying ranger patrols and enabling adaptive management, protected area and LEM tools have been developed and deployed around the world (SMART, 2018). Ranger-based LEM is the collection of data on illegal activities and other data, such as wildlife and patrol effort by rangers, on wildlife protection patrols (Gray & Kalpers, 2005) providing a cheap source of data, requiring minimal skills and equipment (Stokes, 2010). The need for increasingly effective monitoring tools has been known for some time and a number of tools have been developed throughout recent years (Stokes, 2010). Today, the most utilized of these tools is the Spatial Monitoring and Reporting Tool (SMART) which is actively deployed in ~800 sites and 60 countries worldwide (SMART, 2018). SMART was, and continues to be, developed by the SMART Partnership, a consortium of nine conservation organizations. The consortium aims to improve the performance of protected areas through LEM, assisting protected area managers and conservation practitioners, in making better use of their available resources through an adaptive management approach. SMART is defined as a holistic approach encompassing desktop software, in both online and offline environments, and mobile data collection in order to help protected area managers and rangers through monitoring of ranger patrols and observations. From here data are analyzed, visualized and mapped within the software (SMART, 2018). In order to generate data that is useful to management, and in particular to patrol allocation, the process requires good quality data, an ability to effectively analyze these data and to respond with appropriate management decisions. This requires sufficient training at various levels of implementation, from data collectors to protected area managers. The process also requires careful consideration to management objectives of a protected area, ensuring that the design of the SMART data model, the means through which information is stored, fully encapsulates these information requirements. For effective deployment of SMART, or any other LEM tool, the data needs to be feeding into an adaptive management approach utilizing the data made available through ranger data collection procedures (Stokes, 2010). The protected areas of Bhutan, which cover 51% of Bhutan’s total land area, are becoming increasingly at risk of illegal activities providing a significant challenge for protected area management and law enforcement. In an effort to address these challenges, SMART was introduced to six protected areas and three Forest Divisions in Bhutan in 2013, including
Royal Manas National Park (RMNP), and has since been rolled out to all the country’s protected areas and Forest Divisions indicating national support for SMART, an important component in the effective deployment of LEM tools (Stokes, 2010).

Due to the duration of implementation and the adherence to adaptive management principles, also referred to as the “SMART patrol” approach (Stokes, 2010) at the site, RMNP provides a useful case study to test the effectiveness of LEM under an adaptive management framework in improving patrol efficiency and effectiveness. Previous studies have demonstrated that SMART can render positive results in terms of patrol effort within a protected area (Hötte et al., 2016) and as a result assist in reducing poaching threats (Duangchantrasiri et al., 2016). It is expected that the effective use of SMART will result in improved patrol effort, threat detection and a reduction in overall threat occurrence in RMNP, Bhutan. This will provide further evidence for the hypothesis that, when used as part of an adaptive management framework, LEM tools, such as SMART, can assist in the improvement of patrol effectiveness and the reduction of threats within a protected area.

2 | STUDY AREA

RMNP is Bhutan’s oldest national park, established in 1966, and located in the south-central foothills of Bhutan (90°35’ E to 91°13’ E; 26°46’ N to 27°08’ N). Spanning an area of 1,057 km², the national park falls within the political jurisdiction of three districts (Dzongkhag)—Zhemgang, Sarpang, and Pemagatshel (Figure 1). The national park poses unique challenges to patrol teams due to variable altitudes and terrain ruggedness. Much of the central areas of the national park are not reachable on foot and are therefore not patrolled. RMNP is subdivided into three sections or ranges, Manas Range, Umling Range, and Gomphu Range (Figure 2) and the park itself is connected via forest corridors to Phibsuo Wildlife Sanctuary in the southwest, Phrumshengla National Park in the northern center and Jomotsangkha Wildlife Sanctuary in the southeast (Figure 1). The southern boundary of RMNP runs along the national border with India and abuts Manas National Park, India, forming the Transboundary Manas Conservation Area resulting in specific enforcement and management requirements in order to mitigate threats from across the national border with India. The park is home to 558 recorded plant species, 65 species of...
mammal, 486 species of birds, 69 species of fishes, and more than 180 species of butterfly (RMNP, 2015). RMNP is considered a stronghold for tigers (*Panthera tigris*) in Bhutan and harbors the highest felid diversity of any protected area in the country. In addition, a number of other endangered and charismatic species occupy RMNP including golden langur (*Trachypithecus geei*), clouded leopard (*Neofelis nebulosa*), Asian elephant (*Elephas maximus*), Asiatic water buffalo (*Bubalus bubalis*), Asiatic wild dog (*Cuon alpinus*), and Asiatic gaur (*Bos gaurus*). The national park is also home to globally threatened and endangered floral species such as *Aquilaria malaccensis* and fish species such as mahseer (*Tor spp.*).

RMNP is currently patrolled by 102 wildlife rangers of various positions each adhering to standard operating procedures for the implementation of SMART patrolling. These rangers operate within standard foot patrol teams as well as making up two to three mobile units. Each staff member is mandated to patrol 15 times per month. Central areas of RMNP are generally patrolled on foot as roads are mostly absent from the interior. Vehicle patrols are deployed on the roads found around the park’s boundary. All data are collected using handheld devices which transmit directly to a cloud server when network coverage permits. Each of RMNP’s three ranges has a patrol plan set at monthly patrol planning meetings which draw upon SMART data from the previous month documented in regular monthly SMART reports produced at the range level. Monthly patrol targets and plans are led by the SMART core team which includes the Park Manager, Range Officers, and various SMART focal people. Planning takes into account wildlife observations, threat observations, patrol effort, and allows for the setting of numeric and spatial targets such as distance and area coverage.

### 3 MATERIALS AND METHODS

The patrolling system in RMNP is based on an adaptive management feedback loop, or a “SMART Patrol” approach, as previously outlined by Stokes (2010), through which data are collected by the frontline staff and applied to management decisions regarding patrol deployment. The structure of the data model was determined during initial consultation meetings prior to the implementation of SMART and aims to effectively represent the reality on the ground, allowing for the recording of relevant observations in the field. Initially, these observations were recorded using data forms but the site has since transitioned to the use of mobile devices. Rangers are regularly trained in what observations they should record and how to record these observations. This
includes direct and indirect observations of wildlife, natural features, illegal activities, and any other human encounters. Concurrently, the system records patrol information such as number of patrols, patrol length, patrol days, patrol nights, transport type and others, and allows for spatial analysis. These data are collected on preconfigured devices through a dedicated application which then feeds into the SMART software via a server. The software is administered at park headquarters and the data within is then used for adaptive patrol planning in response to key wildlife and illegal activity patterns within the data. Through the evaluation of SMART patrol data, patrol effort in these areas are planned based on setting numeric targets such as the total number of patrols, number of patrol days, number of patrol nights, number of patrol hours and total distance a patrol team must cover. In addition, spatial targets (e.g., area coverage) and administrative targets are also set based on the patrol data. Ranger patrols are primarily conducted on foot, although vehicle patrols also occur, and all patrols generally comprise 2–10 patrol staff. RMNP is subdivided into three patrol sectors or ranges—Manas Range, Umling Range, and Gomphu Range (Figure 2). The total area of the three ranges varies from 321 to 388 km². Patrols in RMNP vary seasonally with few patrols conducted during the monsoon season. Patrols also vary in length with the park deploying short and long-range patrols depending on the current situation or strategy employed at any one time with direction to patrolling strategy relying heavily on SMART data which informs the management of the level and location of threats occurring within the protected area. In addition to understanding the spatial distribution and level of threats, the tool also provides insight as to the distribution and occurrence high value or threatened wildlife and current or previous patrol effort. All of this information then feeds back to management who are able to respond appropriately with strategic patrol deployment and other actions such as human–wildlife conflict mitigation.

In order to assess the impact of SMART on patrol results, analysis was conducted on patrol effort and frequency between 2013 and 2017. This was also used to determine the impact of patrols on the intensity of illegal activities, as well as wildlife observations. Initial querying to extract the needed data were conducted within the SMART software. Outputs were expressed as number of patrols, patrol coverage, patrol distance, total number of illegal activities (poaching, logging, land encroachment, fishing, and related human encounters) through time, controlling for patrol effort (measured as distance patrolled), termed as catch per unit effort (CPUE; Stokes, 2010). In order to determine the strength of linear association between patrol effort and wildlife observations, and patrol effort and threat observations, a Pearson product-moment correlation coefficient test was conducted using R Studio Version 1.1.456.

4 | RESULTS

Annual patrol frequency was analyzed for 5 years between 2013 and 2017. Patrol frequencies were particularly low in 2013 and 2014; this can be partly attributed to the infancy of SMART implementation as well as reflecting actual initial lower levels of patrol frequency prior to the introduction of LEM. Patrol effort throughout RMNP increased from 267 (N) patrols in 2015 to as high as 338 (N) patrols in 2017 (Table 1); however, a dip in patrol frequency was observed in 2016. This is attributed to a number of factors, including extreme weather and flooding in the region as well as managerial changes and staff transfers. Patrol coverage expanded and average distance walked (foot patrol) per month increased considerably from 69 km/month in 2013 to 712 km/month in 2017. The patrol effort in 2017 demonstrated almost 80% coverage in Umling and Manas Range and 60% coverage in Gomphu Range (Figure 3).

The SMART data showed that the overall threat occurrence in RMNP increased between 2013 and 2015 followed by a decrease in 2016 and 2017 (Figure 4). However, threat detection may not actually indicate a change in the number of threats, but the ability to detect threats may have changed due to the adaptive strategy meaning threat increases between 2013 and 2015 should be approached with caution. While illegal logging and hunting observations have decreased from 2015, the occurrence of illegal fishing was found to be intermittent with the highest number of threats recorded in 2015 and an increase in 2017 on 2016 figures (Figure 5). One might associate the downward trend in threat occurrence from 2016 to the increased patrol effort in 2015 (N = 267) to 2017 (N = 388); however, this reduction in threat occurrence is likely a result of multiple factors. The improved patrol effort and threat reduction suggests that SMART was a contributing factor likely through increasing and better allocating patrol effort and resources across critical areas of the national park based on strategic planning that enabled more effective and rapid operational responses. In order to review the correlation between improved patrolling through SMART implementation, a Pearson product–moment correlation test was used to show negative collinearity between patrol effort and threat observation (Pearson’s $r = -0.34$ and $p = 0.05$).

The illegal activities detected per unit of patrol effort or CPUE, calculated using distance patrolled, also showed a relative decline from 0.012 CPUE to 0.0041 CPUE in 2015 and 2017, respectively (Figure 6). The highest CPUE of
poaching-related threats was observed in 2014 at 0.0269 which can be associated with similar patrol effort and improved threat detection. The comparison on the level of deterrence, characterized as a reduction in the rate of illegal activity caused by an increase in patrol effort (Dobson & Lynes, 2008), is deemed credible from 2015 onward, as patrol effort through SMART implementation was functional across all the three ranges from 2015.

TABLE 1  Patrol results from 5 years of SMART data in Royal Manas National Park (2013–2017) demonstrating improved results since the introduction of SMART

| Year | Number of patrols | Patrol distance (km) | Wildlife observations | Threat observations | CPUE (threats) |
|------|-------------------|----------------------|----------------------|---------------------|----------------|
| 2013 | 15                | 628.89               | 203                  | 11                  | 0.0175         |
| 2014 | 24                | 929.24               | 386                  | 25                  | 0.0269         |
| 2015 | 267               | 4,987.44             | 1,365                | 60                  | 0.0120         |
| 2016 | 142               | 3,347.11             | 604                  | 35                  | 0.0105         |
| 2017 | 338               | 6,576.23             | 1,788                | 27                  | 0.0041         |

Abbreviations: CPUE, catch per unit effort; SMART, Spatial Monitoring and Reporting Tool.

FIGURE 3  Patrol frequency and coverage of Royal Manas National Park (RMNP) in 2013 and 2017. Patrol intensity refers to number of patrols entering each 1 km grid cell.

FIGURE 4  Total number of patrols and threats per year in Royal Manas National Park (RMNP) between 2013 and 2017.
Wildlife observations per year by patrol staff increased steadily between 2013 and 2017. A Pearson product–moment correlation test also demonstrated positive collinearity between wildlife observations and patrol effort (Pearson’s $r = .96$ and $p = .002$) demonstrating the increase in wildlife observation data occurring from increased patrolling. This does not, however, indicate that wildlife observations were more numerous due to improved law enforcement only that SMART has been able to capture increased observations of wildlife likely resulting from improved patrol effort and affinity with the SMART tool. The increase in wildlife sightings may also be due to other extraneous factors which have not been isolated in this research.

5 | DISCUSSION

Given the vital role that protected areas play in the preservation of biodiversity and the reduction of extinction risk of threatened species (Margules & Pressey, 2000; Brooks et al., 2009; Hoffmann et al., 2010; Geldmann et al., 2013; Gray et al., 2016) their effective management is of utmost importance to conservation (Brandon et al., 1998; Leverington et al., 2010). The, often intense, human pressures put upon protected areas through illegal hunting (Harrison et al., 2016; Sodhi, Koh, Brook, & Ng, 2004), logging and land encroachment (Wilcove et al., 2013) emphasizes the need to ensure these protected areas are in fact protected effectively.

Protected areas around the world rely on a varying degree of law enforcement such as ranger patrols, intelligence gathering and effective criminal justice systems (Challender & MacMillan, 2014; Tranquilli et al., 2014). The first line of defense being ranger patrols which provide the primary deterrent giving weight to higher-level legal policies (Leader-Williams & Milner-Gulland, 1993; Rowcliffe, de Merode, & Cowlishaw, 2004). The number of ranger outposts and patrols in vulnerable regions of protected areas has a significant impact on the probability of threats, such as poaching, disappearing (Moore et al., 2017); thus, LEM tools that aim to optimize these patrols are beginning to demonstrate their effectiveness in curbing these illegal activities (Duangchantrasiri et al., 2016; Critchlow et al., 2016; Hörte et al., 2016; Moore et al., 2017).
LEM in protected areas is becoming increasingly common and the presence of SMART as a tool deployed in sites around the world has grown from <100 sites in 2013 to ~800 in 2018, and uptake by new sites continues to grow (SMART, 2018). The systematic monitoring of law enforcement in protected areas has great potential for evaluating the effectiveness of protection-based conservation initiatives and protected area management (Duangchantrasiri et al., 2016; Hötte et al., 2016; Stokes, 2010) and research is beginning to demonstrate the ability of such tools to contribute to improved managed, patrol efficacy, poaching reductions and even wildlife population recovery (Duangchantrasiri et al., 2016; Critchlow et al., 2016; Hötte et al., 2016; Moore et al., 2017). The use of patrol data collected through LEM tools is also beginning to open up new possibilities, such as the development of artificial intelligence models capable of predicting threat occurrence and generating patrol route suggestions (Xu et al., 2019). While the effective deployment of such developments is still some way off, perhaps the most important factor in the deployment of LEM tools is the incorporation of data into a holistic framework through which patrol data are directly feeding back to management and allowing for informed decision making in the deployment of resources (Hötte et al., 2016; Stokes, 2010).

The Royal Government of Bhutan has been highly receptive of the use of LEM since the introduction of SMART in 2013 and is one of a number of countries that has adopted the tool at a national level (SMART, 2018) with SMART implementation directly factored into protected area management plans (RMNP, 2015; Thinley & Tharchen, 2014). This consideration into the effective use of SMART created the enabling environment that has allowed for the results to demonstrate a positive impact of SMART on patrol results in RMNP. An enabling environment for effective LEM tool use revolves around having the management structures in place, commitment and endorsement from relevant authorities, active patrolling and financial planning, all revolving around the concept of adaptive management. SMART allowed for the regular analysis of patrol information, by management, such as patrol numbers, frequency, coverage, and rate which all improved year-on-year during this study period (2013–2017) demonstrating the ability of LEM to facilitate and drive improved patrol effort. In addition, this study provides evidence for the ability of SMART, under supportive management conditions, to improve patrol efficacy in the effort to detect and reduce threats to a protected area, however, to draw a clear conclusion between the use of SMART and threat reduction will require further analysis. The perceived reduction in threat detection observed in 2016 and 2017, as per SMART observation data, when considered alongside the increased patrol effort, suggests that targeted law enforcement, enabled through the use of SMART, can be successful in deterring illegal activities and therefore protecting wildlife. It is likely the increase in threat observations in 2014 and 2015 is a result of improved patrol deployment. Despite this, it is difficult to confidently attribute the reduction in threats solely to improved patrol effort due to many extraneous variables that may have impacted these results. The records of wildlife observations by patrol staff also increased through time, this is likely a result of increased patrol effort; however, future analysis of wildlife abundance in RMNP will allow for additional validation of the impact of enhanced law enforcement on the populations of wildlife in a protected area with other studies demonstrating that these desirable impacts can occur (Duangchantrasiri et al., 2016; Hötte et al., 2016). Despite this, the progressive increase in wildlife observations by patrol staff provides useful data in and of itself and provides further evidence of the utility of LEM tools for observing wildlife and other aspects of protected areas which can be utilized in management as well as research decisions.

These results by no means suggest that simply implementing LEM tools in a site will be sufficient to improve law enforcement or management within a protected area but attest to the ability of such tools to aid management and improve law enforcement when implemented as part of a holistic adaptive management framework (Hötte et al., 2016; Stokes, 2010). Successful use of the tool itself requires significant consideration, including staffing, financing, equipment, and training at various levels of protected area management (Hötte et al., 2016; Stokes, 2010). The amount of time needed to institutionalize and standardize procedures varies between sites (Hötte et al., 2016) and the impact of the support of site management and relevant agencies at a national and local level is documented (Hötte et al., 2016; Stokes, 2010) and cannot be understated as a key enabling factor in demonstrating positive results from the implementation of LEM tools.

In addition to operating LEM under enabling management conditions, of course, it cannot be expected that law enforcement alone is capable of sustaining conservation efforts in a protected area. This study focused on the deployment of patrols and law enforcement alone but a great deal of consideration must also be given to other crucial components in the effective management of protected areas such as capacity building of park staff (Dearden, Bennett, & Johnston, 2005), community engagement (Andrade & Rhodes, 2012; Mariki, 2013), human–wildlife conflict (Dearden et al., 2005), and many others. These considerations are all undertaken to some degree in RMNP (RMNP, 2015) and without doubt...
compliment the effective deployment of law enforcement patrols.

6 CONCLUSIONS

This study, which provides a review of law enforcement results, suggests that with the enabling factors in place in RMNP it was possible to demonstrate the ability of LEM to document and contribute to improved patrol effectiveness in a protected area in Bhutan. The theory behind this, that information from LEM factored into an adaptive management approach, is broad and can be applied to protected areas across the world. The monitoring and use of data will continue to be refined and there is a need to validate these results with long-term analysis of wildlife populations to fully understand the impact of improved law enforcement and management through LEM tools on wildlife conservation in RMNP; however, the simple analysis of law enforcement results provides evidence to the efficacy of LEM for enhancing law enforcement results in protected areas.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

The work for this article was conducted by RMNP staff and written by Alexander Wyatt with support from Kuenley Tenzin and Rohit Singh and was completed following initial research and analysis from park staff Sonam Wangdi, Singye Wangmo, and Jampel Lhendup on the ground in Royal Manas National Park with the support of the Royal Government of Bhutan Department of Forest and Park Services.

DATA AVAILABILITY STATEMENT

All raw and analyzed data are available through contact with the corresponding author.

ETHICS STATEMENT

This article included no human or animal subjects in experimentation. The data obtained and analyzed on park rangers are data that are collected as part of their daily duties. The paper was produced with the permission of the authorities of Bhutan and national park staff. A significant proportion of the work was conducted by local staff in Bhutan listed here as coauthors of the paper. The results of this article are already in the possession of the relevant authorities in Bhutan in the form of reports.

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