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Measuring Effectiveness of SMART Patrol in Biodiversity Protection of Rimbang Baling and Bukit Betabuh, Sumatra

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Abstract

The main authorities and practitioners face crucial challenges in safeguarding wildlife and conservation areas due to massive direct anthropogenic disturbances, such as illegal logging, habitat conversion into human development areas, and wildlife poaching. Therefore, measuring the effectiveness of wildlife and habitat protection is essential for wider conservation intervention. This study aimed to examine patrol effectiveness using measurable effort and parameters of SMART-based data collection in Rimbang Baling and Bukit Betabuh, Sumatra. We conducted a series of planned SMART-based data collections in designated patrol blocks of Rimbang Baling from 2014 to 2018. We implemented catch per unit effort (*CPUE*) *measurement by the number of detected illegal activities and then a generalized linear model* (*GLM*) *to assess the relationship between patrol efforts and threat numbers. This study covered 209 patrols within 2,129 patrol days, 13,153.05 patrol hours, and 14,864 km. The CPUE value decreased from 0.381 to 0.191. Our GLM showed that patrol efforts significantly reduced threat numbers. This study provides new knowledge regarding SMART-based data collection and its ability to increase the effectiveness of patrols in promoting better protection and threat reduction in conservation areas in Indonesia.*

Keywords: *adaptive management, illegal activities, monitoring tools, patrol effort, population recovery*

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Introduction

Indonesia is home to rich biodiversity, yet is under pressure, implying the urgency of robust protection through establishing and managing conservation areas. Furthermore, these conservation areas have significant value as primary and important biodiversity habitats. However, they are vulnerable to direct threats to humans, such as illegal wildlife poaching, illegal logging, and habitat conversion into human development areas, agricultural plantations, and settlements (Shah & Baylis, 2015).

Indonesia has experienced the largest increase in forest loss compared to other countries such as Paraguay, the United States, Russia, and Brazil. The extent of forest loss in Indonesia has been staggered, with an annual loss of 1,021 km^2. The lowest value recorded was 10,000 km^2 year^{-1} from 2000 to 2003, whereas the highest was more than 20,000 km^2 year^{-1} from 2011 to 2012 (Hansen et al., 2013). Hence, the effective management of conservation areas has become a key element in protecting biodiversity and preventing extinction (Geldmann et al., 2013; Gray et al., 2016). This includes monitoring, managing, and maintaining conservation areas in Indonesia, which remains a crucial challenge, especially in dealing with the involvement and participation of various stakeholders (Linkie et al., 2015).

According to the Ministry of Environment and Forestry/KLHK (2016), Indonesia's national effectiveness in conservation areas was only 49.20%. These data were based on assessments of 283 areas, covering only 51% of the country's total number of conservation areas. Leverington et al. (2010) examined the effectiveness of conservation area management globally as part of a larger study. They found that 42% of protected areas had flaws or were less than 50% of their optimum value. Furthermore, 13% of management does not meet the minimal requirements for efficient operation, placing it in the insufficient group for most management effectiveness indicators. According to a study conducted by Leverington et al. (2010), this low management level is linked to insufficient funding, weak communication and public relations, and poor resource management, including specific resource management operations, law enforcement, and oversight.

This underscores the importance of studying the effectiveness of protected areas (PAs) in preventing the loss of forests and biodiversity. Effective management of conservation areas is crucial to reduce threats to animal habitats and enhance global biodiversity conservation efforts (Brandon et al., 1998; Dudley & Stolton, 2008; Moore et al., 2017). Given that conservation areas in the tropics are ecologically and biologically vulnerable and are linked to their surrounding habitats, extensive habitat degradation or disturbance can lead to a severe decline in biodiversity (Laurance et al., 2012). Therefore, such reliable tools are needed to support the effectiveness of conservation area management.

The Indonesian government has made several efforts to increase the management of protected areas. The government conducted assessments of the effectiveness of conservation area management in Indonesia in 2015 and 2016. A Management Effectiveness Tracking Tool (METT) was used for the assessment. This tool is used for self-assessment by each PA manager in the form of a questionnaire that allows multiple interpretations of the assessment points. It is likely that the results of this assessment are biased and subjective (KLHK, 2016).

One of the government's previous initiatives to decrease the likelihood of forestry crimes or forest degradation was the implementation of spatial data-based forest security patrol activities (Suprayitno & Hasiholan, 2017). Intense patrol procedures (albeit mostly conventional) were used to perform this operation. These patrols gather information from the field and act upon their discovery. Manual data collection and recording are used, and the management's interpretation of the results guides the data analysis.

A partnership between the Zoological Society of London, North Carolina Zoo, Frankfurt Zoological Society, World Wildlife Fund, and CITES-MIKE was established in 2011 to create Spatial Monitoring and Reporting Tools/SMART (SMART, 2021). SMART is a system designed and developed to assist in the management of conservation areas by facilitating the planning, implementation, and evaluation of conservation interventions in the field (SMART, 2021). SMART also assists management in allocating resources and strategically deploying field patrol teams (SMART, 2020). Conservation organizations worldwide have made efforts to protect conservation areas through monitoring conducted by trained patrol teams. These teams conduct patrols for a specified period to prevent illegal activities, particularly hunting, by deterring poachers or removing traps set by hunters (Nguyen et al., 2016).

The Indonesian government implemented SMART in 2013. The earliest conservation areas that implemented SMART were Gunung Leuser Bukit Barisan Selatan, Ulu Masen, Kerinci Seblat, and Berbak Sembilang National Park (Kholis et al., 2016). Currently, 35 conservation areas are implementing SMART (SMART, 2021). Several reports on SMART implementation have been published, such as in Resort Way Nipah Bukit Barisan Selatan National Park (Efendi et al., 2019), Rawa Singkil Wildlife Reserve (Sofyan et al., 2020), and Batutegi Tanggamus-protected forest (Subagio et al., 2020). However, the effectiveness of SMART in biodiversity protection has not yet been evaluated. In other countries, such as Royal Manas National Park, Bhutan, Wangmo et al. (2021) examined the efficacy of patrol operations against threats through CPUE values. The patrol system showed a relative decline in the threats from 2015 (0.0120) to 2017 (0.0041). According to another study, SMART can improve patrol efforts in protected regions (Hötte et al., 2016) and hence reduce the risk of poaching (Duangchantrasiri et al., 2016).

In this study, we used the Rimbang Baling ecosystem as a case study to evaluate the effectiveness of SMART patrol. This study can be used as an important reference for other PAs to evaluate the effectiveness of management and protection.

Methods

Study area This study focused on the implementation of SMART patrols as a tool to support the protection of protected areas in two important protected areas: the Bukit Rimbang Bukit Baling Wildlife Reserve (*Suaka Margasatwa Bukit Rimbang Bukit Baling*/SMBRBB) and the Bukit Betabuh Protected Forest (*Hutan Lindung Bukit Betabuh*/HLBB) which serve as two major protected areas in southern Riau Province, central Sumatra (Widodo et al., 2020). SMBRBB has been designated as a wildlife reserve based on the decision of the Minister of Forestry, Number SK. 3977/Menhut-VIII/KUH/2014, dated May 23, 2014, with a total which established the SMBRBB forest area of 141,226.25 ha administratively located in Kampar and Kuantan Singingi Regencies, Riau Province (Rahman & Veriasa, 2017). SMBRBB boasts high biodiversity and serves as a crucial conservation area for the critically endangered Sumatran tigers (*Panthera tigris sumatrae*) (Widodo et al., 2017). Additionally, the government agency for nature resource conservation (BBKSDA), as the management authority of SMBRBB in Riau, has recorded approximately 28 species of flora and 32 species of fauna in the area. However, human activity is significantly high in the region, which is directly adjacent to forestry concessions, such as pulp and paper concessions (acacia and eucalyptus plantations), agricultural concessions primarily planted with oil palm plantations and rubber, coal mining, as well as community lands (Widodo et al., 2017; Widodo et al., 2020).

The HLBB area is an ecological corridor that is expected to functionally connect the Bukit Tigapuluh National Park (TNBT) and SMBRBB. It is one of the Indonesian national strategic areas (*kawasan strategis nasional*/KSN), as established by Presidential Regulation Number 13 in 2012, which designated Bukit Betabuh Protected Forest as a KSN in the Sumatra Island Spatial Plan (Iswahyudi, 2017). The area is located in Kuantan Singingi Regency, which borders Riau-West Sumatra and Riau-Jambi Provinces. Of the total area of 43,541 ha, 15,902 ha still have secondary forest stands remaining (UPT KPHL Kuantan Singingi Selatan, 2016).

Similar to the SMBRBB, the HLBB area also faces various non-forestry activities that can threaten animal habitats, such as the presence of sub-district and village governments, settlements, and community infrastructure facilities, as well as mining and plantation activities (Ambarasti, 2016). Although SMART-based patrols have been conducted in these two areas, the effectiveness of this method has never been evaluated. Therefore, it is necessary to analyze the results of the SMART patrols carried out in the SMBRBB and HLBB areas based on the patrol efforts made. SMART was also used to analyze the relationship between patrol efforts and the number of threats found to measure the effectiveness of wildlife and habitat protection.

Data collection The designated field patrol team collects threats and other related data based on management-determined patrol plans. SMART systems utilize software that includes database storage and analysis tools, which are able to generate real-time and comprehensive survey reports. These reports allow safeguard teams to effectively advocate important information, including threats and other crucial data, to decision-makers (SMART, 2021). Collected data is essential for evaluating and enhancing monitoring efficiency while also analyzing the effectiveness of patrols (Keane et al., 2011; Critchlow et al., 2016; Moore et al., 2017; Wilfred et al., 2019).

Data collection took place over a five-year patrol period, from 2014 to 2018, in the SMBRBB and HLBB, as well as surrounding areas (Figure 1). To record information, the patrol team employed various survey tools, such as the global positioning system (GPS) to track patrol routes and positions, tally sheets to record all incidents and information encountered, and cameras to capture images of identified findings (Sadikin et al., 2016). Data collection primarily focused on illegal activities that pose threats to wildlife and their habitats, such as illegal logging, land clearing, and hunting of wildlife. Before being entered into the SMART systems, collected data undergoes several processes. This includes downloading data from the GPS devices, transferring it to a pre-configured standardized spreadsheet, and converting the data format to CSV, which needs to be accepted by the SMART platform. The SMART Patrol database or data entry officer receives and inputs this data (Kholis et al., 2016). We used the SMART 5.03 system, which enabled us to utilize the data entry process in the Patrol column in the SMART system. The system records patrol duration, including patrol number, day and night patrol, hours, patrol distance in kilometers, mode of transport, and other relevant details. Furthermore, SMART can facilitate spatial data analysis (Wangmo et al., 2021).

Data analysis *Analysis of SMART implementation results* We applied SMART to record, collect, and store databases on threats and other records. The results obtained from implementing SMART were analyzed using the query feature that allows the filtering of recorded data, which functions for data mining and analysis. The required data was obtained by applying available filters (Sadikin et al., 2020). In this study, two types of queries were utilized. The first query used was the "Patrol Summary Query" analysis to obtain results of patrol efforts conducted over a period of 5 years. The categories analyzed include the number of patrols, number of days, number of nights, number of hours, and total distance covered (km). The second query used was the "Observation Query" analysis, which incorporated a threat filter to obtain threat data. The threat data obtained included direct threats such as poaching and subsistence hunting, as well as information on the perpetrators and traps (snares, slings, nylon, poison, etc.). Indirect threats such as illegal logging and land-use change (cultivation and plantation) were also analyzed.

Analysis of the relationship between patrol efforts and the number of threats Patrol efforts tend to have either a positive or negative relationship to patrol results, especially in detecting threats or the intensity of illegal activities (Critchlow et al., 2016; Wangmo et al., 2021). In this study, we included patrol data from 2014 to 2018. The study focused on patrol frequency and its effect on patrol results, including the number of patrols, patrol distance (in kilometers), and the total number of illegal activities such as hunting, logging, cultivation, and plantation. We generated the catch of threats per unit of effort (CPUE) and control of patrol effort per year to measure the detection rates of those illegal activities. The calculations for patrol effort control were based on patrol distance, as per the methodology of Stokes (2010) and the aforementioned studies (Critchlow et al., 2016; Wangmo et al., 2021). The patrol efforts were measured by the number of patrols, the number of days, the number of hours, and the distance of the patrol in kilometers. The analysis has been conducted on a per-patrol effort basis to identify which patrol efforts are correlated with the threats observed. A statistical modeling technique called the generalized linear model (GLM) was employed. Specifically, a n-way ANOVA model will be used to analyze the data, with the number of threats as the dependent variable and the various patrol efforts as independent variables.

Results and Discussion

SMART implementation: Patrol effort During 5 years (2014–2018) of SMART Implementation in SMBRBB and HLBB, a total of 209 patrols were conducted, resulting in an average frequency of 41.80 patrols per year, or approximately 3.48 patrols per month for a 5-year patrol implementation from 2014 to 2018 in SMBRBB and HLBB (Table 1). We documented that the minimum and maximum number of patrols per month were 1 and 12, respectively (Table 2). The data reveals that the total number of patrol days was 2.129, with an average annual frequency of 425.80 patrol days per year, or 35.48 patrol days per month. The most frequent patrol duration was 12 days (38 patrols or 18.18% of 209).

The minimum and maximum number of patrol days per month was not significantly different over the 5-year period, with a minimum of 3 to 8 days, a maximum of 11 to 13 days, and an average of 10 days per patrol (Table 2). There were instances where patrols were conducted for only three days (3 patrols or 1.44% of 209) due to various field obstacles such as team injuries, inadequate road access, and management policies. Conversely, some patrols lasted for up to 18 days (2 patrols, 0.96%) due to factors such as direct involvement in resolving conflicts between animals and local communities or bad weather that caused delays.

The total number of patrol hours during the 5-year period is 13,153.05 hours, averaging 2,630.61 patrol hours year^{-1} or 219.21 patrol hours month^{-1}. The average number of patrol hours per day is 6 hours year^{-1}, with a minimum and maximum value ranging from 4 to 10 hours day^{-1}. The total number of patrol distances during this period is 14,864 km, averaging 2,972.80 km patrol distances year^{-1} or 247.73 km patrol distances month^{-1}. The average patrol distance per day is 7 km day^{-1}. This patrol range includes both walking and motorbike patrols. Motorbike patrols cover a greater distance (8,562 km over 97 patrols) than walking patrols (6,302 km over 112 patrols) because they can access areas that are farther away and are usually located on the edge of the patrolled area. The minimum and maximum values for patrol distance range from 25 to 181 km patrol^{-1}, and the

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Table 1 Patrol results from 5 years of SMART data in the Rimbang Baling ecosystem (2014–2018)

Year	Number of patrols	Number of days	Number of patrol hours	Distance (km)
2014	47	444	2,708.2	3,472
2015	37	338	1,916.5	1,778
2016	44	490	3,175.41	3,164
2017	44	474	3,047.39	2,908
2018	37	383	2,305.55	3,542
Total	209	2,129	13,153.05	14,864
Average/Year	41.80	425.80	2,630.61	2,972.80
Average/Month	3.48	35.48	219.21	247.73

Table 2 Patrol effort based on descriptive statistics

Patrol effort	Year	Minimum–Maximum	Mean ± Std. deviation
Month/Patrol	2014	1–12	4.3 ± 3.2
	2015	2–5	3.4 ± 0.9
	2016	3–4	3.7 ± 0.5
	2017	3–4	3.7 ± 0.5
	2018	2–4	3.1 ± 0.5
Total		1–12	3.5 ± 1.6
Days/Patrol	2014	5.5–12.5	9.6 ± 2.1
	2015	4.3–11.0	8.9 ± 2.1
	2016	8.3–13.3	11.1 ± 1.7
	2017	8.0–12.0	10.7 ± 1.4
	2018	3.0–13.0	10.1 ± 2.5
Total		3.0–13.3	10.1 ± 2.1
Hours/Days	2014	4.3–10.3	6.5 ± 1.7
	2015	4.1–7.2	5.7 ± 1.1
	2016	5.6–7.2	6.5 ± 0.5
	2017	5.4–7.2	6.4 ± 0.6
	2018	5.0–9.7	6.3 ± 1.2
Total		4.1–10.3	6.3 ± 1.1
Km/Patrol	2014	40.5–174.7	90.7 ± 50.3
	2015	32.0–77.7	48.8 ± 14.5
	2016	30.3–122.3	71.9 ± 33.4
	2017	25.3–130.3	64.8 ± 28.7
	2018	36.5–181.3	96.6 ± 45.7
Total		25.3–181.3	74.7 ± 39.5
Km/Days	2014	3.7–19.1	9.6 ± 5.2
	2015	3.0–17.9	6.2 ± 4.1
	2016	2.5–12.3	6.6 ± 3.2
	2017	2.3–11.1	6.0 ± 2.5
	2018	4.6–15.3	9.7 ± 3.8
Total		2.3–19.1	7.6 ± 4.1

minimum and maximum distances per day range from 2 to 19 km day^{-1}.

The average number of patrols conducted in this study is relatively small compared to the study by Wangmo et al. (2021), which had an average of 13.1 patrols during the same period. This difference is due to Wangmo et al. (2021) having a greater number of patrols with wider area coverage. The study demonstrates the efficiency and effectiveness of patrol activities based on the area coverage at the research location. The number of patrol days carried out in this study was

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supported by the patrol team's submission of funding to management, totaling 15 days of activities: one day of preparation, two days of travel (departure and return), and 12 days in the work area. The analysis of the average number of patrol hours–6 hours day^{-1} with a distance of 7 km day^{-1}–indicates a fairly effective effort by the patrol team. Nahonyo (2005) states that effective patrols last a full day, which is about 8 hours of patrol time for both walking and motorbike patrols. Travel time to the patrol area is not counted as effective patrol time or days in the SMART tool.

The patrol business also includes the task of "covering an area," which involves surveying the area that has been covered by the patrol team during their activities. Almost all research locations are covered by patrols, with the SMBRBB area being patrolled relatively more frequently (149 patrols, 10,396 km) than the HLBB (60 patrols, 4,468 km). However, there are still some locations that have not been patrolled. This is due to several factors, including poor visibility, type of vegetation, terrain, access roads, and security issues. Areas with difficult terrain, such as rocky hills or cliff edges, are challenging for the patrol team to access due to dense vegetation and limited visibility. According to Nahonyo (2005), patrolling forest areas has varying visibility, ranging from only 2 m in areas with dense vegetation to 50–100 m in areas with sparse vegetation. The map displaying the research locations that have been covered can be found in Figure 2.

Threat observation The results of this study reveal that the main categories or types of threats to conservation areas are caused by human activities that disturb the ecosystem. These threats include land clearance for cultivation and plantations, logging of forest timber, both legal and illegal, as well as hunting and exploitation of animals. The study found a total of 3,668 incidents of human activity posing threats to the Rimbang Baling ecosystem, with 2,422 incidents recorded in the SMBRBB research location and 1,246 in the HLBB location. A breakdown of the number of threats in each category is shown in Figure 3. The most significant threat was found to be land clearance, with 1,785 instances recorded. Interestingly, this threat decreased from 898 findings in 2014 to 76 in 2017 but increased again at the end of the observation period in 2018, with 334 findings.

Here are various indicators of land clearing threats, including burn marks, uprooted forests for cultivation and plantations, and land used for growing crops like oil palm, rubber, and vegetables. The total area of converted land is approximately 20,406 ha. The second most common threat is illegal logging activity, with 1,185 findings, which encompass logs, wood chips, boards, stumps, sawmills, camps, and other related items. The value of forest wood lost, such as logs, wood chips, and boards, is determined by the number of cubic meters (m^3), and the findings revealed that 1,893 m^3 of wood have been taken. For poaching, patrols found 698 findings of traps, including nylon snares, slings, cages, foot traps, snare holes, poisons, hunter camps, and more.

Snares are simple and effective tools for hunters (Hurt & Ravn, 2000; Jachmann, 2008a; Fa & Brown, 2009; Gandiwa et al., 2013), and increased patrol efforts enable hunters to

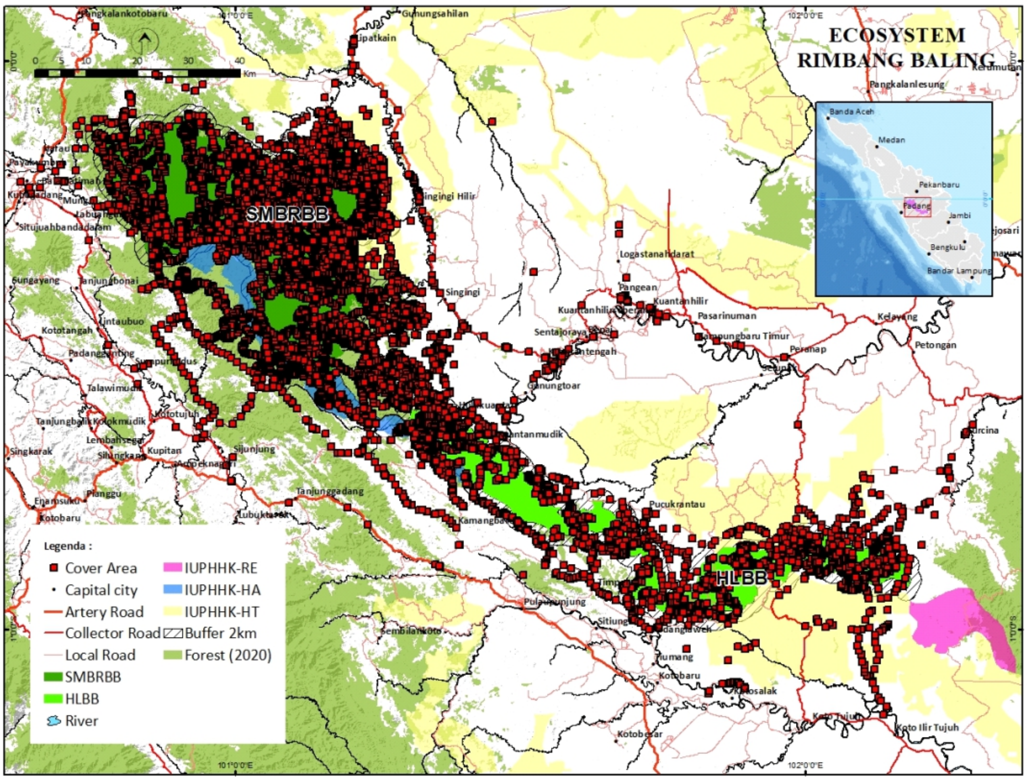

Figure 2 Map of patrol frequency and coverage in Bukit Rimbang Bukit Baling Wildlife Reserve and Bukit Betabuh Protected Forest in Rimbang Baling ecosystem 2014–2018.

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use less detectable methods, including the use of snares (Gibson & Marks,1995; Gandiwa et al., 2013). In the Serengeti National Park, Tanzania, illegal hunters were reported to use various hunting techniques, with snaring being the most common (Hurt & Ravn, 2000; Nyahongo et al., 2005; Holmern et al., 2007; Gandiwa et al., 2013). Beside of hunting for death animal, currently pet hunting is increasing due to online pet trading (Aadrean, 2013).

Conservation areas must be adequately protected given the intense pressure of human activities, including illegal hunting (Sodhi et al., 2004; Harrison et al., 2016; Wangmo et al., 2021), illegal logging, and land encroachment (Wilcove et al., 2013, Wangmo et al., 2021). Detection of the presence or absence of illegal actors is considered more effective in preventing illegal activities, such as poaching, compared to punishing perpetrators who have been caught (Dobson & Lynes, 2008).

Relationship between field patrol efforts and the number of threats This study calculated the catch per unit effort (CPUE) by dividing the number of illegal activities detected per kilometer walked. The CPUE value in this study decreased from 0.381 in 2014 to 0.119 in 2017. However, it slightly increased again in 2018 to 0.191, but not significantly (Table 3). Patrol teams are increasingly using data collection

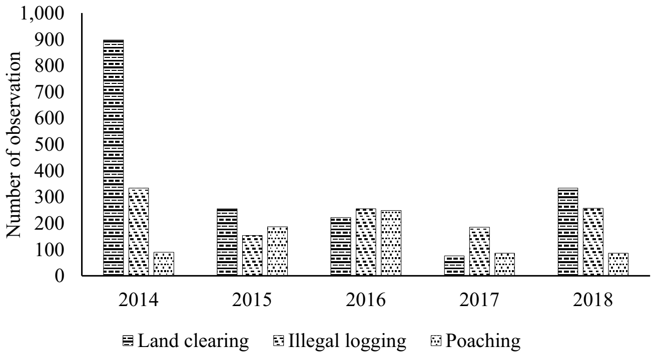

Figure 3 Observation of three different primary threats, including land clearing, logging, and poaching in Bukit Rimbang Bukit Baling Wildlife Reserve and Bukit Betabuh Protected Forest in Rimbang Baling Ecosystem 2014–2018.

to measure, evaluate, and analyze the effectiveness and efficiency of their patrols. This is being done to enhance conservation area management, including law enforcement (Keane et al., 2011; Critchlow et al., 2016; Moore et al., 2017; Wilfred et al., 2019). The relationship between patrol efforts and the number of threats or illegal activities means that patrol reports are a reliable source of information regarding all patrol activities, both in terms of technical accuracy and reporting actual incidents (Jachmann, 2008b; Gandiwa et al., 2013).

The patrol efforts have had a significant impact on reducing the number of threats. In a study conducted by Wangmo et al. (2021) in Royal Manas National Park, Bhutan, using CPUE values to assess the effectiveness of patrol efforts against threats, a relative decrease was observed from 2015 (0.0120) to 2017 (0.0041). Both studies on Rimbang Baling and Royal Manas Bhutan provide evidence of SMART's ability to improve patrol effectiveness in detecting and reducing threats within conservation areas (Table 2). However, the patrol efforts in Rimbang Baling, based on CPUE values, showed a more consistent decline almost every year. Although the reduction in threats could be affected by a variety of factors, the use of field patrol efforts was found to be more effective. Therefore, the reduction in threats suggests that SMART is one of the key factors that improve patrol efforts and resources across the entire coverage area (Wangmo et al., 2021). The prevention efforts carried out by the patrol team have a significant effect on the level of illegal activity. Research conducted by Linkie et al. (2015) shows that the deterrent effect results in lower tiger poaching rates. Even Sweden conducts intensive monitoring of animals, especially large carnivores, to reduce the economic impact and ensure the preservation of these animals (Persson et al., 2015; Rauset et al., 2015).

Furthermore, the use of SMART in several conservation areas is also considered effective in reducing illegal activities, such as in Russia (Hötte et al., 2016), throughout Uganda's protected areas (Critchlow et al., 2016), and other African protected areas, such as Gonarezhou National Park in Zimbabwe and the North Luangwa ecosystem in Zambia (Henson et al., 2016). However, Nahyono (2005) states that there are three possible patrol business relationships and a number of potential threats. Firstly, increasing effective patrol efforts will reduce the number of threats. The number of discoveries may decrease if illegal actors are intimidated

Table 3 Comparison of CPUE results at two research locations to measure the impact of patrols on threat intensity

Research site							
TN. Royal Manas Bhutan (Wangmo et al., 2021)				Rimbang Baling ecosystem (This research)			
Year	Patrol distance (km)	Threat obser-vation	CPUE	Year	Patrol distance (km)	Threat obser-vation	CPU
2013	628	11	0.0175	2014	3,472	1,322	0.38
2014	929	25	0.0269	2015	1,778	596	0.33
2015	4,987	60	0.0120	2016	3,164	726	0.22
2016	3,347	35	0.0105	2017	2,908	347	0.11
2017	6,576	27	0.0041	2018	3,542	677	0.19

Note: CPUE = catch per unit effort (measured as distance patrolled)

Table 4 General linear model statistical analysis: Illegal threats and patrol efforts

Model covariate	Estimate	SE	*Z*-value	*p*-value	AIC
Threats~Number of patrols	0.184136	0.006519	28.25	<0.001***	2,000.3
Threats~Number of days	0.0263585	0.0009408	28.02	<0.001***	1,875.1
Threats~Number of hours	0.003638	0.000159	22.87	<0.001***	2,096.2
Threats~Distance (km)	0.0031961	0.0001006	31.77	<0.001***	**1,663.8**

Note: Bold writing indicates the best model, namely the lowest value in the AIC method (Akaike's Information Criterion); *** = this sign indicates the relationship is very "high" and is less than the level of significance ($\alpha = 0.05$).

from carrying out activities in conservation areas. Secondly, increased effective patrol efforts are likely to increase threats. The more optimal the patrol effort is, the higher the number of threats that are found. A third possibility is that catches will increase linearly and then experience an instantaneous spike depending on factors such as the season or patrol effort applied.

The statistical analysis was conducted using the GLM, with the number of threats as the dependent variable and various patrol efforts as independent variables. These patrol efforts included the number of patrols, the number of days, the number of hours, and the total distance covered in kilometers. Table 4 presents the results of the analysis, which indicate that all the patrol efforts have a significant effect on the likelihood of encountering threats. This is supported by the probability value (0.00), which is lower than the significance level (α = 0.05), providing strong evidence to support the findings. In summary, the study shows that the probability of encountering threats varies based on the patrol efforts carried out, including the number of patrols, the number of days, the number of hours, and the total distance covered in kilometers.

The best regression model was selected using the Akaike's information criterion (AIC) method, and the results indicate that the total distance (km) to the threat encounter is the most influential factor, with a lower probability value and AIC value (p-value < 0.005, AIC = 1663.8, GLM) compared to the number of patrols, the number of days, and the number of hours. This finding is consistent with Hötte et al. (2016), who also used the total distance (km) as an indicator of the success of patrols, alongside the number of hours. However, unlike animal detection and patrol efforts, the total distance (km) is easier to measure and more closely related to the likelihood of encountering threats, whether patrolling on foot or by motorcycle. Additionally, Nahonyo's research (2005) also supports the importance of patrol efforts in detecting illegal activities, such as poaching. The findings suggest that longer patrol distances may be more effective than daily patrols for ensuring continuous vigilance in most areas. Therefore, reducing the proportion of daily patrols and increasing longer trips could improve the quality and effectiveness of patrol activities.

Conclusion

Field patrol efforts were carried out from January 2014 to December 2018, totaling 209 patrols with an average monthly frequency of 3.48 times. The patrols covered 2,129 days, with the most frequent patrols lasting 12 days (38 patrols, 18.18%). In total, the patrols covered a distance of 14,864 km and lasted for 13,153.05 hours. Threats were found in two research locations: SMBRBB (2422 findings) and HLBB (1246 findings). Threats include land clearing, illegal logging, and poaching. The effectiveness of patrol efforts against threats, as measured by the CPUE value, showed a decrease from 2014 (0.381) to 2018 (0.191). These results demonstrate SMART's ability to increase patrol effectiveness in detecting and reducing threats within conservation areas. The analysis suggests that the number of kilometers covered per day is the most effective patrol effort variable for mitigating threats.

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