OVERVIEW OF IMPROVING PATROLLING EFFORTS: A CASE STUDY OF FOREST STATION IN PU HU NATURE RESERVE, VIETNAM

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Abstract. Effective management of the special-use forests in Vietnam, e.g. nature reserves and national parks, depends on information about disturbances of illegal activities due to the effective protection as patrol ranger efforts (PREs). Patrol rangers are indispensable for protecting forest in conservation areas. Moreover, to enhance PREs efficiency is regularly to reject illegal activities and support conservation. This paper explores the quantification of PREs in terms of illegal activity encounters collected by rangers in Nam Tien Forest Station (FS). Based on a monitoring system of ranger's efforts, the study conducted surveys for monthly activity reports at the central office. The results revealed that the patrol efforts such as patrol-day and distance were inversely proportional to the number of illegal activity encounters and fluctuated in accordance with the time when they were conducted each year. This study will be useful for forest management at the local level in relation to the planning and monitoring of patrol activities. Usefully, this study's finding are critical for application to the various protected areas with respect to curbing illegal activity and enhancing forest resources-based forest management practices.
Keywords: *patrol ranger effort, patrol, conservation, illegal activity, forest*

Introduction

Globally, continued biodiversity loss is undoubted (Squires, 2014; Adhikari et al., 2017) and even forest managers of Protected Areas (PAs) have variable success in protecting the biodiversity of their areas (Bradshaw et al., 2015). In particular, tropical forest areas all over the world have been experiencing widespread and rapid deforestation and forest degradation, because of pressures of logging, fire, cultivated encroachments, and poaching in their immediate surroundings, and inadequate protection inside the reserves (Baillie et al., 2004; Koh et al., 2013; Bradshaw et al., 2015) such as biodiversity declines and this cause a massive loss of species (Brooks et al., 1997; Harrison et al., 2016). Protected areas such as nature reserves and national

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parks, which often present viable biodiversity, are extremely important in conservation (Gray and Kalpers, 2005; Kimdung et al., 2013). The striking economic growth in the regional buffer zone of PAs shows several profits, but also brings impacts to its ecosystems and biodiversity. On the other side, it has advanced conservation opportunities (Squires, 2014).

The decline in natural resources in the tropical forest requires much attention and the efforts to arrest these declines have become a part of the Ghana government policies and law enforcement efforts (Wiafe, 2016). Much of the flora and fauna of the region in Southeast Asia like Vietnam is not found elsewhere in the world (endemic) (Koh et al., 2013). It has the highest recorded relative rate of deforestation, compared to other tropical forest areas and it could lose three-quarters of its original forests and up to 42% of its biodiversity by 2100 (Sodhi et al., 2004; Miettinen et al., 2011). The impact of human activities on natural resources might have a cascading effect on the whole biodiversity (Wright, 2003). The exploitation of any species of fauna and flora is commonly prohibited and controlled in PAs (Mubalama, 2010). Yet knowledge of protection effort is often limited because the true extent of natural resource exploitation is hard to recognize, especially if it is illegal (Nuno et al., 2013).

As a result of conservation targets, a number of the PAs have been established over the world over the last few decades. It aims is to reduce the first humanity's pressures on the natural environment (Steffen et al., 2015; Venter et al., 2016) and secondly, the source of the primary threats to a country's natural resources and its long-term persistence regarding its biological diversity (Lan et al., 2002). The arious activities are essential for human subsistence but lead to biodiversity loss, and this trend is likely to continue in the future (Baillie et al., 2004). Recent policy commitments aim to reduce biodiversity loss (Dulvy et al., 2006) because a consequence of illegal activities is their increasingly serious effect on natural resources (Gray and Kalpers, 2005) which cause biodiversity loss (Critchlow et al., 2015). Previous researchers have noted that illegal activities seem to vary in accordance with law enforcement efforts (Gandiwa et al., 2013). For example, poor law enforcement performances have been significantly linked to decreases in conservation as a result of increase illegal activities (Bassett, 2005; Ogutu et al., 2011). Additionally, effective law enforcement mechanisms are only weakly implemented by voluntary compliance in the PAs (Rowcliffe et al., 2004). Enhancing law enforcement performance like PEFs, by contrast, has been linked to declines in illegal activities such as poaching (Jachmann, 2008a, b; Martin, 2010; Wiafe, 2016).

The uninterrupted struggle between law enforcement practice and illegal activities suggests some difficulties in enforcing conservation (Lamarque et al., 2009; Wiafe, 2016). Key to biodiversity conservation and the target of forest management is to retain the representative biodiversity of all ecological regions and to conserve the integrity of ecosystems along with their biodiversity from illegal activities (Wiafe, 2016). The stakeholders as rangers in forest stations respond to the threats to conservation in several ways (Albers and Grinspoon, 1997). Previous studies have provided proof which suggests that illegal activities such as illegal logging and agricultural expansion (Khoi and Murayama, 2010) and poaching (Mubalama, 2010) have emerged as serious threats to conservation.

In Vietnam, PEFs in PAs have been applied as conservation tools of forest management. There is little doubt that planning, monitoring, and evaluation by patrol ranger efforts (PREs) are essential tools for enhancing law enforcement practices and

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compliance in such areas (Monteiro et al., 2010). Furthermore, there is proof that that investment in conservation law enforcement is effective (St. John et al., 2014). For example, anti-poaching patrols increased the effectiveness of patrol efforts to deter hunting (Jachmann, 2008a). However, there is a gap in the research considering the occurrence of illegal activity and law enforcement efforts in PAs. In Vietnam, all illegal activities have been politically observed and controlled by forest officers and a management board (Vietnam Government, 2010). Additionally, law enforcement efforts have continually been identified as one of the most important factors in making parks work (Mubalama, 2010). This research focused on contributing to the understanding of patrol efforts and illegal activity in natural resources management, specifically Nam Tien FS in Pu Hu Nature Reserve (NR). Understanding the patterns and extent of illegal activities is vital for effective patrol efforts, which constitute essential elements of illegal activities reduction (Critchlow et al., 2016) and of biodiversity loss prevention (Critchlow et al., 2015).

The aim of this study was to focus on patrol ranger efforts (PREs) carried out at the largest forest station in Pu Hu NR, namely the Nam Tien Forest Station (FS) when the short-term law enforcement dataset was available. Therefore, from January to December 2017, the objectives of this study were to: (i) evaluate the quantified patrol ranger efforts against illegal activities; (ii) find out the relationship among relevant factors that might influence patrol effort and illegal activity encounters; and, (iii) recognize fluctuations in the illegal activities encountered during the study months. This exploratory research provided insight into patrol performance related to law enforcement ranger's efforts in patrol planning, which could resulting in PAs in Vietnam and a simple analysis of them that could be applied in enforcement patrolling, which could result in illegal activities reduction aimed at halting decreases in species of conservation concern (Plumptre et al., 2014).

Material and methods

Location and general description

Pu Hu NR lies in two districts (including Quan Hoa and Muong Lat) in Thanh Hoa province. The area covers over 28.000 ha, is rugged and is located at latitude 20°30' to 20°40'N and longitude 104°40' to 105°05'E in northeast Vietnam. Amongst the six forest stations and one sub-forest station in Pu Hu, Nam Tien FS is one of the extreme pressure from illegal activities occurrence because of its dense population and the people's demands, compared to other forest stations. As explained above, this research focuses on Nam Tien FS, which is supposed to control an area of around 5,700 ha divided into nine forest sub-area plots of the Pu Hu NR. The three permanent forest officers are responsible for protecting the forest, and there are 423 households and 1,512 inhabitants in 12 villages of 2 communities in the buffer zone, namely the settlements Nam Tien and Thien Phu communities. These are the villages with the highest population density and they have the most crowded immediate inhabitants in the buffer zone areas under Nam Tien FS, compared to other buffer zones in Pu Hu. The protection efforts needed to meet conservation objectives are often different from the requirements of the fringe residents (Ormsby and Kaplin, 2005). As in the NR areas, there have been hunting, logging, cutting, and grazing illegal activity encounters. Once a nature reserve area has been established, all extraction of activities by the immediate population area is illegal (Dong et al., 2017). Rangers in Nam Tien FS have protected

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inside the NR through the forbidding of logging, poaching, and grazing by the local population, and other confrontations with forest-edge communities (Plumptre et al., 2014; Risdianto et al., 2016).

Data collection

The data on illegal activities during patrols were collected from January to December 2017. Feasible patrols recorded any observations indicating non-permitted activities by humans or livestock. Basically, rangers had been properly trained in how to record GPS-tracks through an area that had illegal activities or drastic negative effects on biodiversity conservation.

In Nam Tien FS and other stations in Pu Hu, administrative management still use conventional law enforcement in the form of foot patrols that frequently start from each of the sub-stations or from the central stations (Albers and Grinspoon, 1997; Jachmann, 1998, 2008a, b; Burton, 2010; Gandiwa et al., 2014; Wiafe, 2016). Simple patrol forms were applied for record: the numbers of rangers on patrol, and the types, quantities, and places of illegal activity encountered. They presented the exact duration of using the Global Positioning System (GPS) (Mubalama, 2010). After each patrol, field data were collected on data sheets or in patrol staff logbooks (Burton, 2010; Gandiwa et al., 2014), which were summarily tabulated in Excel sheets, then submitted to the head office at the end of each month.

For each sighting, GPS waypoints and tracks, types of human signs were legally identified and the management area where the species or signs had been detected was noted accordingly (Mubalama and Mushenzi, 2004). The typical patrol was conducted by one or two rangers patrolling and recording the patrol route, using a GPS unit in liaison with a topographic map of the particular area (Burton, 2010; Gandiwa et al., 2014). Any apparent changes or unusual situations along the patrol track were recorded (Burton, 2010). After recording for different points, it was properly compared with information from the ranger's patrolling, and added into map software for accounting the new appearances of illegal activity found (Gandiwa et al., 2014). Regularly, rangers were conducted at the Nam Tien FS, although sometimes mobile teams from central office were also deployed and re-evaluated the previous information about the site. Location points (waypoints) of illegal activities were recorded and written down, including the current name and number of officers on patrol, duration of patrol, name of the forest sub-area plot, and numbers as well as longitude and latitude of the illegal activities discovered (Jachmann, 1998, 2008a, b; Burton, 2010; Gandiwa et al., 2014; Wiafe, 2016).

Informal patrol efforts planning

Officially, regular monthly meetings and discussions were held at the Pu Hu office by The Management Board to analyse each station's patrol efforts. Due to the number of patrol tracks and the collected information from each patrol track, a short patrol report was presented in detail about the sub-area forest plot. According to the current information and planning from the monthly meeting, Nam Tien FS prepared its own plans for patrolling during the following month (Gandiwa et al., 2014; Wiafe, 2016). Additionally, patrol movements and starting times from the forest station had to be unpredictable (Jachmann, 2008b). However, the patrol teams could not always follow the given patrol plan, often made a change of strategy necessary.

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Plans for patrol routes were produced by the head of the forest station and patrollers assembled the team for each patrol of the sub-area forest (Jachmann, 1998, 2008a, b; Gandiwa et al., 2014; Wiafe, 2016). During the patrolling, the leader of a team had a decision to make about whether to use an 'arrow head' or a 'single file' formation for his officers, depending on previous information obtained from the earlier patrols (Wiafe, 2016). Based on specific planning, each ranger had to patrol at least five-time patrols per month in their protected areas.

Data analysis

The Finding per Effort index (F/E) was applied which gives an overview of indicators of illegal activities per unit (Jachmann, 1998b; Wiafe, 2016). Monthly, finding is the total number of illegal activity encounters, and effort refers to the total number of effective patrol-days (patrol-time) (Jachmann, 2008b, c). Kilometric Index of Abundance (KIA) is the proportion of illegitimate activities that were encountered to distance per kilometers (km) walked per month (Groupe, 1991). Kilometers (km) per Effort index (P/E) is the rate of the distance in kilometer (km) walked on the effective patrol-day or patrol-time per unit. Data were analyzed using Microsoft Excel software for descriptive statistics using the Statistical Package Social Sciences (SPSS) version 20.0 to determine any significant difference among various variables by testing function ($p = 0.05$); and mean values were presented as mean ± SD (standard deviation). In particular, descriptive statistics were used to summarize the illegal activity found in the data set. Data on illegal activity by different tracks were grouped together and totals, averages and percentages for patrolling routes were calculated. Burton (2010) showed that given trait data were not the normal distribution, therefore, non-parametric statistics were used to analyze correlation and compare means (Spearman rank correlation and Kruskal-Wallis test if more than two events and Man-Whitney test with two variables). So, data were analyzed by using both tests in SPSS to determine if there is any significant ($a = 0.05$) in the variables of two, or more than two events.

Results and discussion

The brief description of possible patrol routes through each sub-area forest plot presented (*Table 1*; *Fig. 1*). Establishment of all patrol routes covered sensitive biodiversity loss and illegal activity occurrence. Rangers (FS) reached to the sub-area forests from Nam Tien forest station by motorbike.

Patrol ranger efforts

The average patrol-days (patrol-hours) in the period of the first quarter to the fourth quarter in 2017 were as follows: 0.82 (SD = 0.49), 0.68 (SD = 0.51), 0.57 (SD = 0.43), and 0.69 (SD = 0.56) respectively. The average quarterly patrol-days of patrol effort fluctuated from the first quarter to the fourth quarter in 2017, i.e., from 0.82 (SD = 0.49) to 0.69 (SD = 0.56) respectively. In particular, the mean for the monthly patrol-days was not significantly different among these months ($H = 18.14$, $p > 0.05$; *Fig. 2*). Despite potentially large punishment costs (Jachmann, 2008b, c), the enforcement efforts might be sufficient, possibly due to fitting staff to salary, to create a low expected cost of the punishment relative to the gains from illegal activities (Albers and Grinspoon, 1997; Wiafe, 2016).

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Table 1. *Summary of technical tracks on the protected area*

Name of sub-areas	Name of communities	Size of sub-areas (ha)	Patrol distance (km)	Absolute height (m)
102	Nam Tien	1240.21	9 - 10	1,200 - 1,320
120	Nam Tien	1081.03	7 - 9	926 - 1,025
121	Nam Tien	754.46	7 - 8	650 - 730
124	Nam Tien	574.09	5 - 6	541 - 635
132	Nam Tien	658.82	4 - 5	230 - 335
142	Nam Tien	100.35	2 - 4	353 - 430
146	Nam Tien	678.08	1 - 3	454 - 540
147B	Nam Tien	36.06	5 - 6	600 - 752
142	Thien Phu	545.2	7 - 8	720 - 820

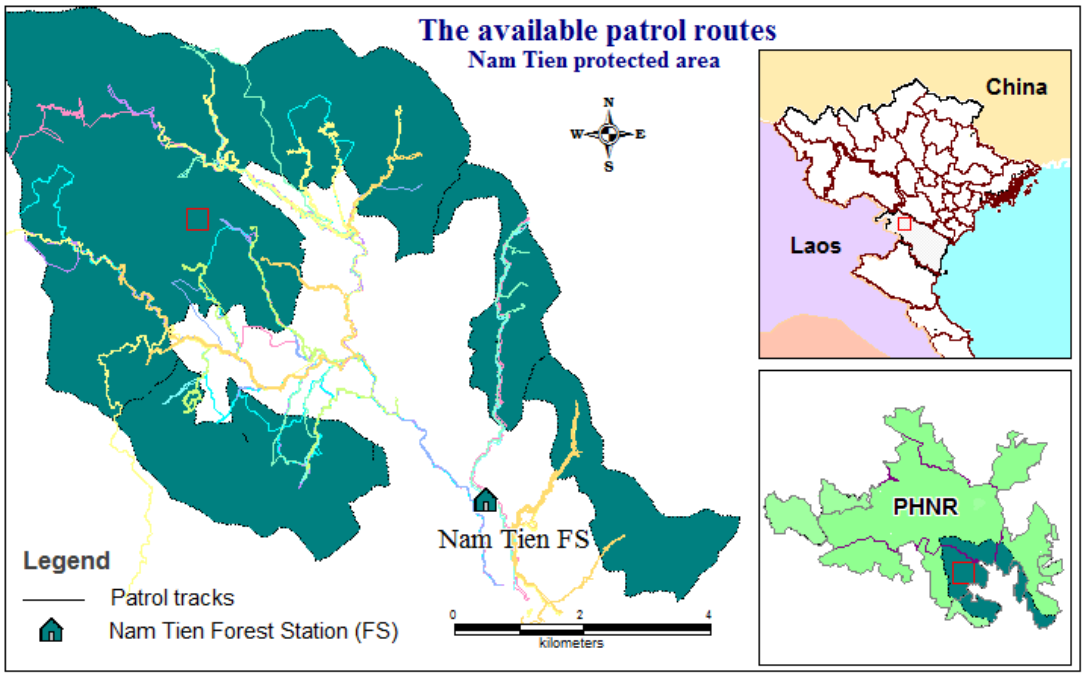

Figure 1. *The location of study area*

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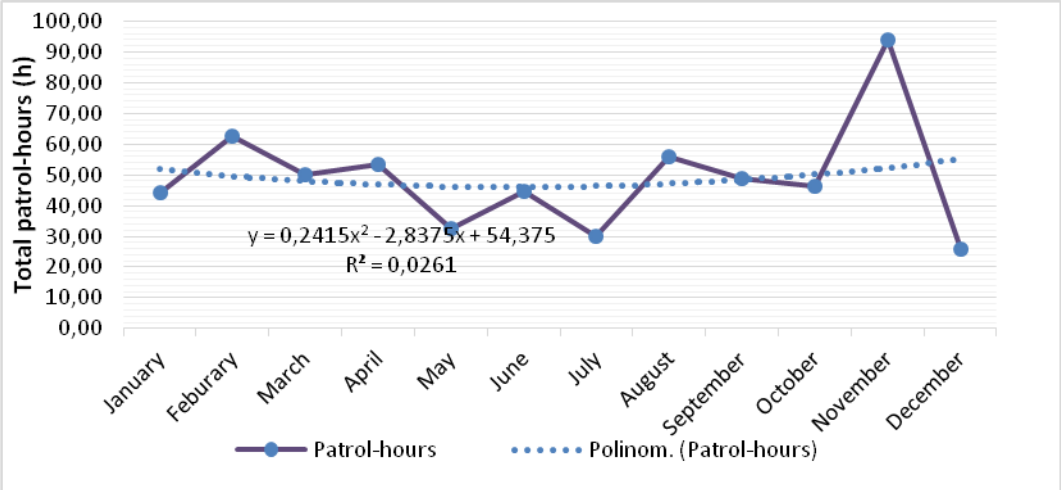

***Figure 2**. The total of average patrol-day*

Nonetheless, the distance of patrol rangers differently walked was a quarterly average of 9.25 (SD = 6.18) km in the first quarter; 8.98 (SD = 6.19) in the second one; 8.10 (SD = 6.40) and 8.61 (SD = 5.93) in the last two quarters of 2017 respectively. However, quarterly distances walked during this year did not differ among months ($H = 1.81$, $p > 0.05$). Monthly distances covered that significantly varied months ($H = 20.39$, $p < 0.05$) and the trend of the distance merely increased, after being constant in August (*Fig. 3*).

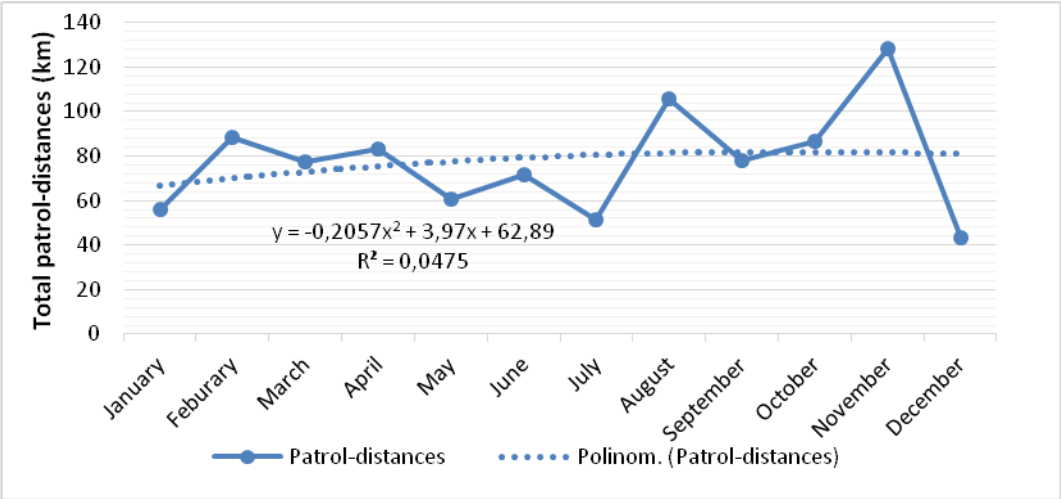

***Figure 3**. The total of average patrol distances walked out by rangers*

Generally, during 1-year of patrolling, the number of patrol-days per month was positively correlated with the number of kilometers walked in those months ($rs = 0.88$, $p < 0.01$) similar to Wiafe's (2016) findings in the research on Ghana. The greater number of staff on patrol the larger the area covered and the longer the distance because of increasing patrol-days and so patrol distances ($rs = 0.61$, $p < 0.01$; $rs = 0.65$, $p < 0.01$ respectively) (Jachmann, 1998, 2008a, b; Gandiwa et al., 2014; Risdianto et al., 2016; Wiafe, 2016). The influence of patrol-day on the distance covered could be accounted

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for with the increase in the number of staff patrolling in the field, who were able to patrol for a long period and covered longer distances (Jachmann, 2008a, b; Dhanjal-Adams et al., 2016; Wiafe, 2016).

Crucially, the factors of elevation area, and dissatisfied rangers, correlated with patrol-day and walked distance ($rs = 0.47$, $p < 0.01$; $rs = 0.38$, $p < 0.01$ respectively). Nonetheless, the trend of average elevation area was significantly stable within 12 months (*Fig. 4*). Actually, the patrol routes, based on previous small paths, were identical and rangers did not attempt to open new routes since they had used the same way of coming to NRs. Similarly, the speed of patrolling was negatively correlated with the patrol-day and patrol-elevation ($rs = -0.36$, $p < 0.05$; $rs = -0.25$, $p < 0.01$ respectively). By contrast, it was not correlated with distance ($rs = 0.72$, $p > 0.05$). The monthly speed of patrolling during this year did not vary significantly ($H = 23.62$, $p > 0.05$), even when the trend of patrol-speed was marginally increased (*Fig. 5*).

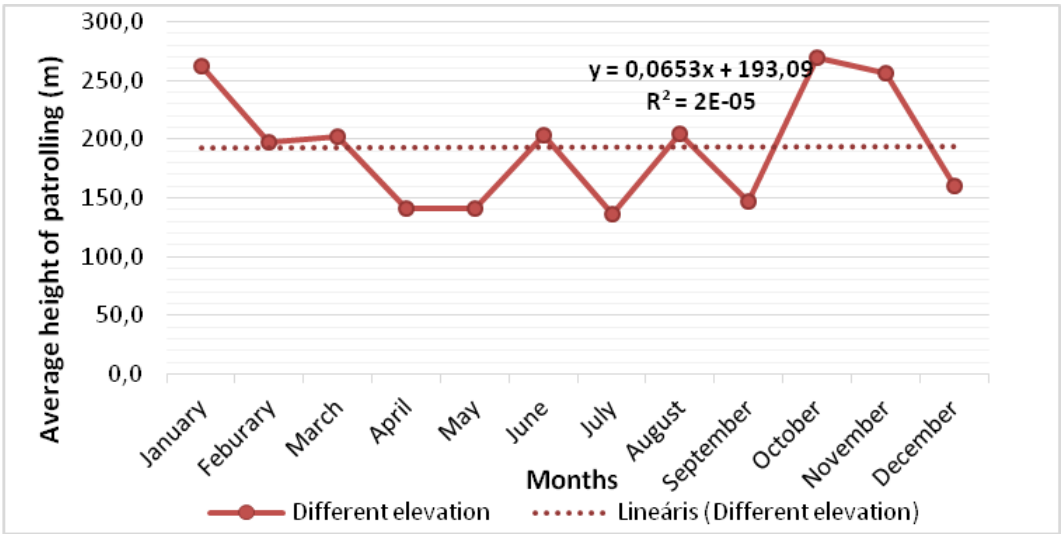

Figure 4. *The average patrol-elevation by ranger's performance*

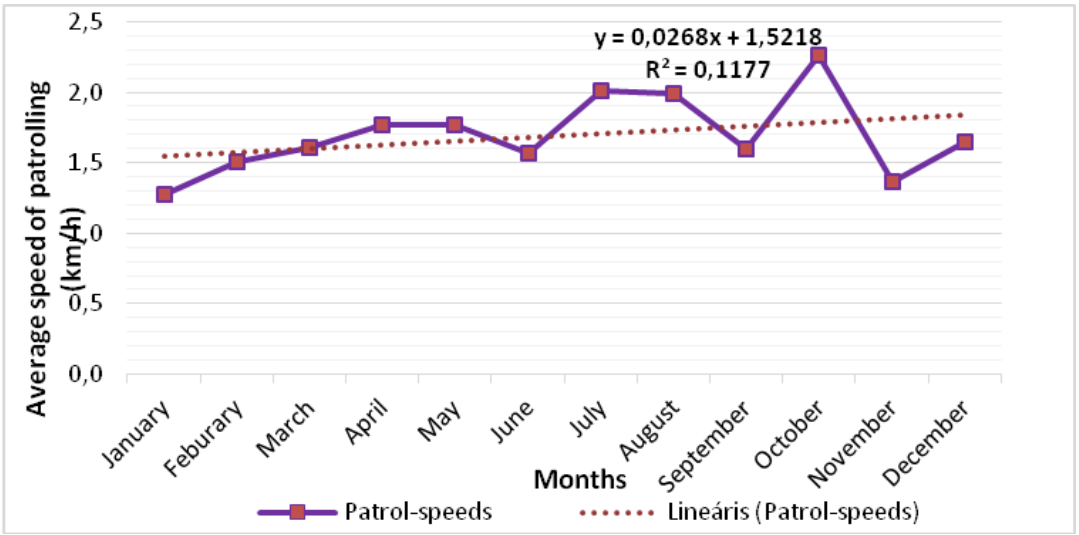

Figure 5. *The average patrol-speeds by ranger's performance*

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Illegal activities encountered from patrol efforts

Considering on the number of illegal activities found was fluctuated during the period of time (the specific quarters), the average number of illegal activities was recorded for the four quarters in 2017 as follows: 6.83 (SD = 3.69), 3.00 (SD = 1.29), 2.41 (SD = 1.45), and 4.3 (SD = 1.58) respectively. The average quarterly number of illegal activity encounters from patrol efforts declined from the first quarter to the fourth quarter in 2017, from 6.83 (SD = 3.69) to 4.3 (SD = 1.58) respectively. When rangers pushed their efforts at patrolling on the field related to the increasing hour-patrol and distance (*Figs. 2* and *3*), the illegal activity seemed to reduce. Further, there were significant differences in illegal activities found during the months ($H = 57.27$, $p < 0.001$). The increasing number of illegal activity encounters in terms of patrol-days and distance significantly increased after sharply declining in August (*Figs. 6* and *7*).

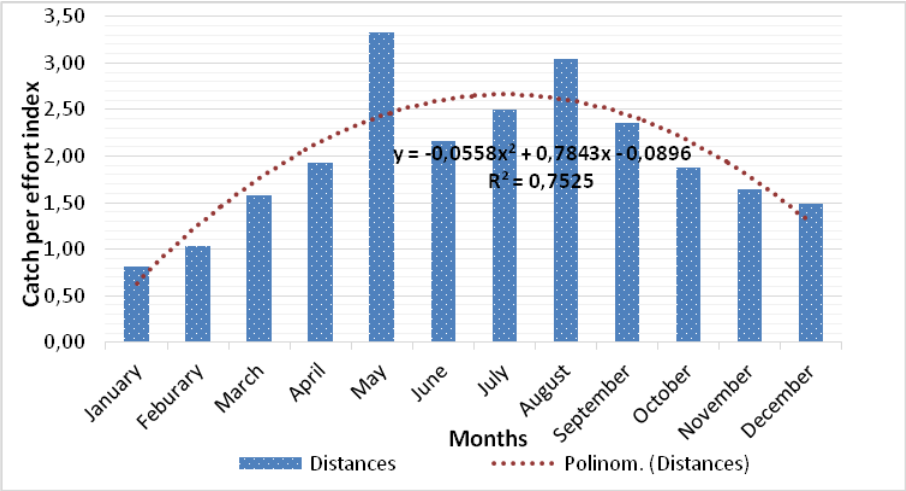

Figure 6. *The distance of indicators of illegal activities found*

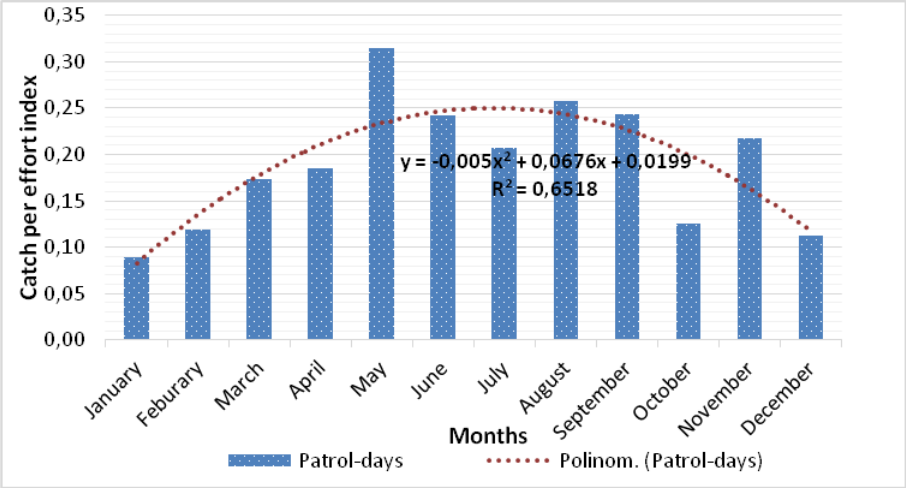

Figure 7. *The patrol-days (hours) for indicators of illegal activities found*

However, the number of illegal activities encountered was significantly correlated with patrol-day and walked distance ($rs = 0.55$, $p < 0.01$ and $rs = 0.46$, $p < 0.01$

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respectively) similar to the finding by Gandiwa et al. (2013) and Wiafe (2016). In contrast to Jachmann (2008), Risdianto et al. (2016), and Wiafe (2016), this study found that there was not a significant relationship between illegal activities found and the number of patrol rangers ($rs = 0.14$, $p > 0.05$). When illegal activity significantly declined at the current place, increasing the number of patrol staff was not a great conservation choice.

Patrol rangers in each sub-forest area plot were at liberty to alter their patrol planning and style, depending on whether or not they had attained the information on patrolling practises and in doing so they also relied on the experience (Wiafe, 2016), education and motivation of rangers (Jachmann, 2008a, b). In addition to this, patrol efforts in Nam Tien FS were also strengthened by the involvement of the Pu Hu NR which had more resources available for law enforcement practices (Gandiwa et al., 2013). Interestingly, the fluctuation of encounter rates in terms of patrol-days and distance was merely different during months (*Fig. 8*). Thus, there was no doubt that Pu Hu managers could consider pushing their staff to prevent illegal activity efficiently with their indicators of patrol-day or distance in the field.

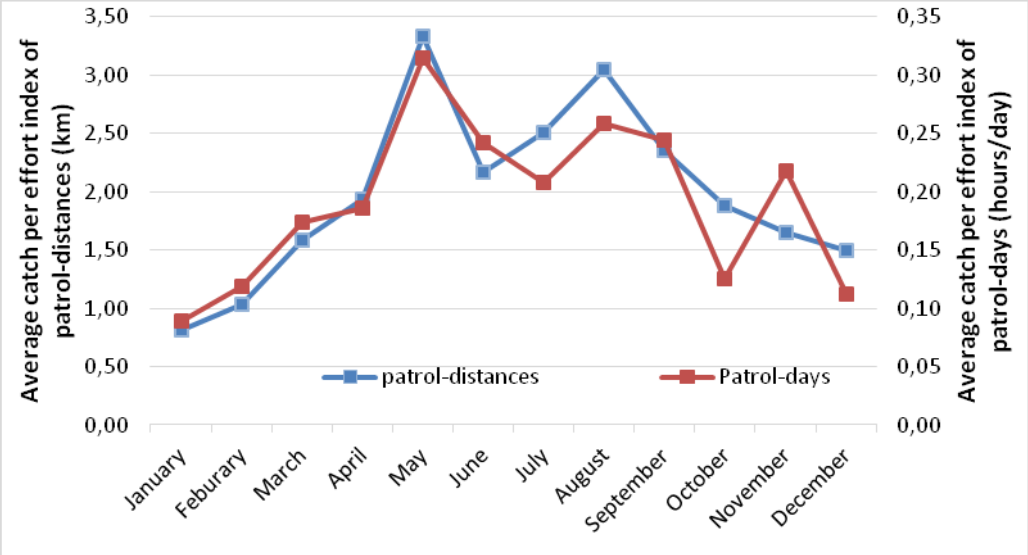

Figure 8. *Trend of illegal activities encounters in terms of patrol-day and distance*

Fluctuation in patrol ranger efforts

Almost all rangers in forest stations have regularly declined to patrol during the Lunar New Year (holiday) and rainy season (limited patrol efforts) because of difficult situation on the fields. It has therefore been speculated that these periods of time disrupt patrol efforts indicators such as days, rangers, distance, and time (Wiafe, 2016). Lunar New Year is in February-March, it confronted with inadequate staff (Moreto, 2016), because a half of staff in Nam Tien FS haves vocation with several days off. Local people attempted to enjoy the NRs by buying something for welcoming the New Year. Interestingly, the number of patrollers still correlated with patrol-distance in 2016 ($rs = 0.62$, $p < 0.05$). The monthly average number of patrol-days and illegal activity encounters were significantly different between the period of February-March and other months ($U = 411$; $p < 0.05$) and ($U = 95$; $p < 0.001$), and opposite to total of patrol-

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distances, there was no difference in two period of time ($U = 537$; $p > 0.05$). Rangers strived for covering forest areas in terms of distances; however, the insufficient number of rangers affected the number of patrol-days. Especially, rangers had issues living at forest station locations, as they were homesick because a few rangers lived in such areas (Moreto, 2016). There was no doubt that shifting patrollers might be necessary for patrolling during these months. Furthermore, as mentioned above, the potential for illegal activity significantly increased because of greater demand from society. The mean number of patrol-days and patrol-distance was higher for the day-off months 0.89 (SD = 0.43) and 9.63 (SD = 5.61) compared to other periods: 0.65 (SD = 0.51), and 8.55 (SD = 6.19) respectively.

Commonly, there are two months August and September in each year, when the number of illegal activities was significant between the precipitation season and other seasons ($U = 450$; $P < 0.05$). Locally, influences on illegal activity occurrence could be considered in terms of different seasons. By contrast, the number of patrol-days and distances in the rainy season was not different in other seasons ($U = 868$; $P > 0.05$) and ($U = 862.05$; $P > 0.05$) respectively. Interestingly, the number of illegal activities in the rainy season was also found to be significant when correlated with number of patrol-days ($rs = 0.70$, $p < 0.01$) and distance ($rs = 0.53$, $p < 0.05$), but it was not correlated with staff number ($rs = 0.22$, $p > 0.05$). This is different from Wiafe (2016), who reported that precipitation disturbed patrol efforts when the number of patrol staff was significantly correlated with patrol-days ($rs = 0.65$, $p > 0.01$) and distances ($rs = 0.69$, $p < 0.01$) that was also found to be not significantly correlated with illegal activity encounters. Almost all patrollers as rangers still prevented to the illegal hunting activities even under uncomfortable weather conditions when the criminals might have taken the opportunity to carry out their activities (Wiafe, 2016).

Conclusion

This study may be applied for evaluation of the protection efforts made by management in PAs. Locally, the leader of each forest station should pay attention to whether or not each ranger could carry out the job of protecting its natural resources effectively. From the results, it could be seen that there was a trend of illegal activity encounters that proportionately fluctuated with patrol-distances and patrol-days or patrol-times. There is an urgent need for management boards of nature reserves to increase law enforcement, based on the recording of information (Damnyag et al., 2013) and on current staff levels. In addition to this, this study focused on all the illegal activities that could similarly impacted conservation aspects. There is a need for a specific research on different activities. Moreover, the PEFs were analyzed only in a short-term period of patrolling - around one year - and extension needs to be considered in the future.

The advantage of this paper was that it presented a strategy for activity that provides planning that can be enhanced for sustainable forest protection at the local level. Improvement of law enforcement performance by inspection activity is extremely important for increasing biodiversity conservation. In some areas, the main driver of the chronic factors is the large in-migration of people to the local communities, particularly into the short and medium paths of the conservation protection areas. The energetic patrolling efforts also plays a warning role and helps prevent illicit activity in several situations in the forestry fields.

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As Wiafe (2016) reported there were various external factors (such as local policy, illegal activity occurrence, number of rangers, and financial support) that needed the increasing contribution of illegal activity and effort to bring it down. Additionally, factors like work experience, leadership style, qualification, and logistics provided could influence the walking field. However, this research did not consider it. Further research should explore the essential relationship between ranger's social aspects and patrol efforts. A step change involving increased funding support and education is urgently needed for fulfilling the improvement of motivated rangers (Watson et al., 2014). Overall, this study highlights the fact that management boards should evaluate locations of forest stations based on the final results of threat reduction and management effort (Gong et al., 2017).

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