Learning from patrol data to improve law enforcement in Cambodia's protected areas

A research briefing produced for, and informed by research carried out as part of the project "*Learning from observational data to improve protected area management*", funded by the UK's Natural Environment Research Council [grant NE/N001370/1]. The project was a collaboration between the University of Edinburgh, the University of Oxford, the University of York, the Wildlife Conservation Society Cambodia and the Cambodian Ministry of Environment.

Summary

- Law enforcement measures are an important tool for protecting wildlife in Cambodia's protected areas, but the design of patrol strategies should be based on robust evidence about their effectiveness

- The records of ranger patrols are widely used to monitor patrol performance, but simple maps and summaries of offences recorded in patrol data can be seriously misleading as a measure of illegal activity because of (i) variation in the type, amount and distribution of patrolling and illegal activities, (ii) the difficulties of detecting different types of illegal activity, and (iii) challenges in ensuring full and accurate reporting.

- All of these mean that places where illegal activities (e.g. snares or logged trees) are detected are not necessarily representative of places where most activities are actually carried out, and trends in the number of activities found may not represent trends in the number of activities actually done.

- Catch-per-unit-effort (CPUE) measures may provide a better reflection of the level of illegal activity under certain conditions. CPUE is calculated by dividing the number of activities found in a particular area and period of time by the effort used in searching (e.g. time spent patrolling). However, trends in CPUE over time are also prone to bias.

- Analyses which control for important sources of variation are generally superior to CPUE. SMART is developing a Spatial Analysis plugin[1]. Although not yet widely promoted, the plugin is freely available, and can be used to control for many sources of variation.

- Deterring potential offenders is an important goal of many law enforcement measures, but deterrence is hard to measure because offenders moving to another part of the reserve, or making their activities harder to detect may be confused for real deterrence. A simple and relatively robust diagnostic for deterrence compares the change in CPUE between one time period (e.g. one month) and the next, to the change in effort over the preceding period.

- Patrols are better at detecting whether offenders are being deterred if their routes are more systematic and widely distributed, if they collect additional information about sources of potential bias (e.g. changes in hunter behaviour or where patrols go), and if rangers are helped to record data more consistently. Rangers will also be better able to find and deter threats if they are better equipped, motivated and rewarded.

- Choices about how to use patrol data should be made based on the specific objectives of a law enforcement programme. Measures to improve the quality of patrol data for law enforcement monitoring may be cost-effective if they reduce the need for sophisticated bias-correction or if they ultimately improve the efficiency of law enforcement.

Background

Law enforcement is a key tool for reducing threats within protected areas from illegal activities such as snaring, illegal logging and land clearance. Ranger patrols can contribute to conservation in several ways: they can catch offenders; they can remove or disable threats such as snares; they can deter potential offenders from carrying out illegal activities in the future by creating the risk of capture and punishment; and they can also collect data that can be used to monitor trends in threats over time. However, patrols can't fulfil all of these objectives to the same level of efficiency at the same time (e.g. searching for snares may distract rangers from catching offenders). Managers therefore need to prioritise. This should be done based on robust scientific evidence about the effectiveness of different approaches.

Monitoring patrol effectiveness is challenging, so one of the most widely used sources of information is the reports of patrols themselves. Readily available software makes it easy to collect and store patrol data in a consistent, useable format. For example, SMART (Spatial Monitoring and Reporting Tool) is a widely used piece of free software that has been implemented in more than 500 conservation areas globally, including more than ten in Cambodia. The success of innovations such as SMART has meant that detailed, consistent patrol data are now widely available to managers, but these data can also be misleading and care must be taken to avoid drawing the wrong conclusions.

This briefing discusses what patrol data can be used for, how biases can arise in their interpretation, how to collect better patrol data and how to improve their analysis. It draws on the results of research carried out in 2016-2019 as part of the project "Learning from observational data to improve protected area management", which was funded by the UK Government's Natural Environment Research Council, and carried out as a collaboration between three UK universities (Edinburgh, Oxford, York), WCS-Cambodia and the Cambodian Ministry of Environment.

What can patrol data tell us?

Patrol data can be used to monitor the distribution of law enforcement effort and map patterns of illegal activity across a protected area, to understand how they change over time, and potentially to provide insight into the effectiveness of patrols in deterring rule breaking. However, the observations made by patrols are affected by various factors, including the amount of illegal activity, the type of patrol, the amount and distribution of patrol effort, and how able rangers are to detect threats (Figure 1). These factors in turn are influenced by the choice of patrol strategy, the type of threat (e.g. snares may be harder to detect than illegal logging), the terrain (e.g. threats may be harder to detect in closed forest than open terrain), and the skill, training and motivations of patrol members. Most of these factors vary from patrol to patrol and over time, meaning that naïve interpretations of simple summaries or maps plotted from raw patrol data can be misleading (Figure 1).

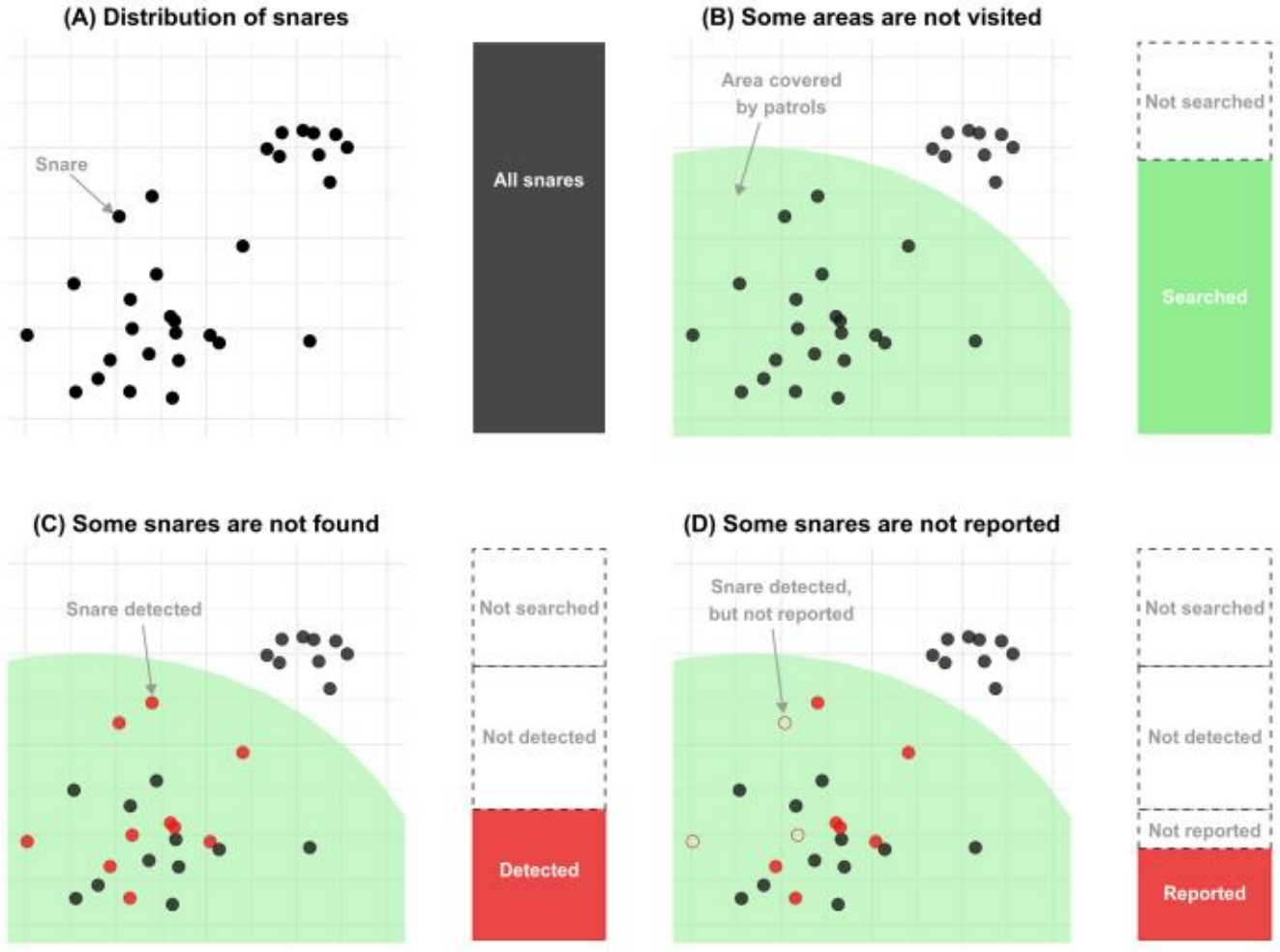

Figure 1 | Simple summaries of patrol data can be misleading because of biases caused by incomplete coverage, detection and reporting. For example, observations of snares detected by patrols typically mis-represent the true distribution of threats within a landscape (shown in A) because: patrols do not cover all of a protected area at sufficiently regular intervals (the area visited is shown in green in B); within areas visited by patrols, a significant proportion of snares typically go undetected (detected snares are shown as red circles and undetected snares are shown as black circles in C); and some snares that are detected may not be recorded, e.g. because of equipment malfunction (reported snare detections are shown as red filled circles and unreported detections are shown as red open circles in D). The bias that each of these processes can introduce into simple summaries of the count of snares recorded in patrol data is illustrated in the bars to the right of each panel, with the full height of the bar representing the total number of snares present in the area and the white sections with dashed borders indicating the variable contribution of these processes to the resulting bias.

Making better use of patrol data

Monitoring trends in illegal activities

An important improvement over the use of raw data about illegal activity (e.g. on the number of snares found in an area) is to standardise it by dividing the raw counts by the amount of effort that patrols used to find them, typically measured in terms of time spent on patrol or distance travelled (e.g. 3.5 snares per km searched). This is called a "catch per unit effort" (CPUE) metric because it was first developed in fisheries to standardise the amount of fish caught by the effort used to catch them. Simple CPUE metrics are often calculated to improve comparisons across areas or time periods with different intensities of patrolling. However, despite their apparent usefulness, trends in CPUE may still be misleading if factors other than the amount of effort vary over time or between sites. For example, if the same amount of snares are present in a forested area and an open area, but they are harder for patrols to detect in the forested area, a simple comparison of CPUE between the two sites might wrongly suggest that the threat from snaring is lower in the forested area.

More complex analyses that can account for these other sources of variation in patrol records are possible if appropriate data have been consistently collected. For example, in this case, if the vegetation type in the area being patrolled was recorded, more sophisticated statistical analyses can allow managers to test for differences in the detectability of snares in each vegetation type separately. Such analyses are generally better at reducing bias but can be technically demanding. However, they can be facilitated by software such as the SMART Spatial Analysis plugin[1] which will allow patterns of illegal activities in space and trends over time to be visualised and compared.

Detecting deterrent effects of patrolling

An important practical question for conservation managers is whether law enforcement patrols are effective in deterring potential offenders from undertaking illegal activities. Deterrence (i.e. an actual reduction in illegal activity caused by law enforcement) is particularly challenging to measure because it is hard to separate from displacement (i.e. moving hunting to different areas or times, or encouraging hunters to shift from one technique to another to avoid detection, rather than causing an overall reduction in hunting) or reductions in illegal activity that are caused by independent, non-patrol-related factors that are changing at the same time (e.g. better prices for crops so people spend more time in their fields). As a result, convincing demonstrations of a deterrent effect of patrols are rare and have required sophisticated statistical modelling.


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A new, relatively simple, metric that can be used to explore whether there is evidence for deterrence in a data set is a plot of the difference in CPUE from one time step to the next (e.g. from one month to the next) against the difference in patrol effort from one time step earlier (Figure 2)[2]. A negative slope on this plot is an indication that patrols may be producing a deterrent effect, while a slope near zero or a positive slope suggests that deterrence is weak or absent at the scale being investigated.

No specialist tools or software are required to produce these plots, but the choice of spatial and temporal resolution, the way in which patrol effort is measured and the scope of the analysis (i.e. the type of illegal activity, the area included and time period considered) are important decisions that can substantially affect the results. These decisions should be made based on an understanding of the behaviour of offenders and rangers themselves (e.g. how quickly is it reasonable to expect that knowledge of an increase in patrol intensity could be reflected in the behaviour of potential hunters). In general, we recommend that different types of illegal activity (e.g. snaring, gun hunting, illegal logging) should be analysed separately rather than aggregated together, because the ability of patrols to detect them may differ (e.g. snares may be detectable for long periods after they are first set, but gun hunting leaves fewer lasting signs) and a patrol strategy that is an effective deterrent for one form of activity may not work so well for another.

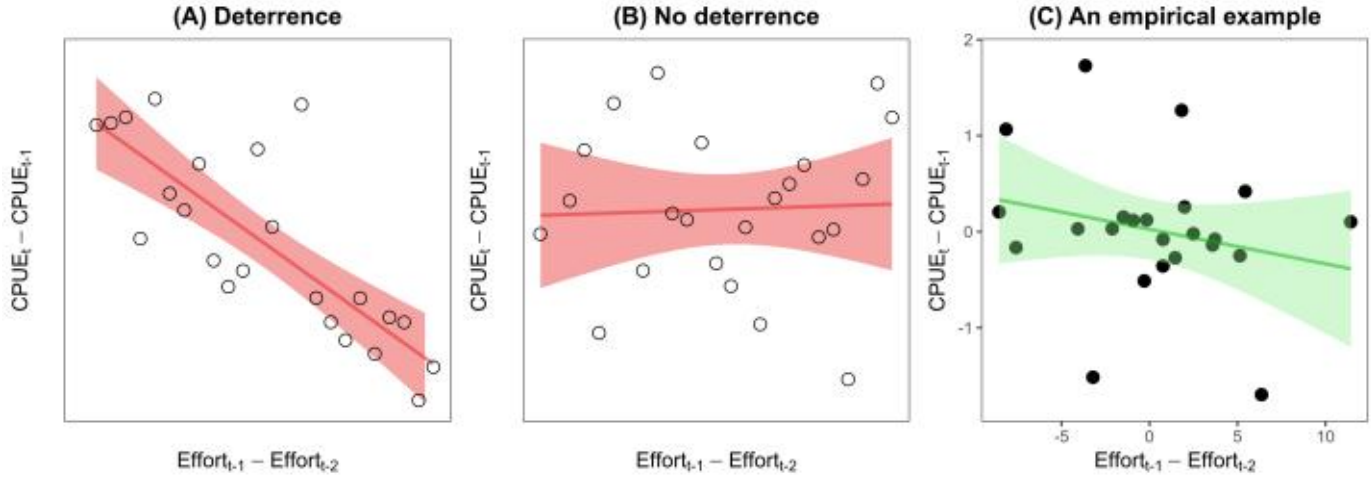

Figure 2 | Plots of difference in CPUE against difference in patrol effort can be used as a simple metric for assessing the evidence for deterrence: (A) hypothetical data showing a clear negative slope suggestive of deterrence; (B) hypothetical data showing a slope closer to zero suggests that deterrence may not be operating over the time period and at the spatial and temporal scales investigated; (C) an empirical application of the technique to records of snares collected from a real protected area using SMART, aggregated across the entire protected area into 28 day periods and measuring patrol effort as the proportion of the park visited by patrols. The slope in this plot is not clearly different from zero, suggesting that the deterrent effect of patrols on snaring was weak or absent at this scale. The example using real data is adapted from Dancer, A. (2019) On the evaluation, monitoring and management of law enforcement patrols in protected areas. PhD thesis. University College London, London, U.K.

Collecting better data from patrols

Two ways to make patrol data more useful as a source of information about illegal activity are: (i) to design patrols so that they control factors that would otherwise vary from patrol to patrol, so that the data are more comparable between sites or over time (e.g. comparing detections made by the same team searching for a similar amount of time in two areas), and/or (ii) to record additional data on important sources of variation so that they can be included in the data analysis, such as habitat type and patrol type (e.g. monitoring or intelligence-led).

Both approaches can be pursued simultaneously, but decisions about modifying patrol strategies and collecting additional data should be taken considering the costs and benefits involved, and the ultimate conservation objectives. Often there may be trade-offs involved. For example, designing patrol strategies to provide more consistent information and broader coverage (e.g. by employing the same teams in a given area, maintaining a similar amount of effort over time and distributing it evenly over a protected area rather than targeting known hotspots of illegal hunting) might be expensive, and in some circumstances might be less likely to apprehend or deter offenders. However, if choosing patrol routes that focus exclusively on hotspots generates data that are more prone to bias, they may create other costs. For example, hunters may move their activities so that they don't get caught and, if the data don't show these changes, managers may not be able to respond rapidly. It may also be harder to know if there is an emerging threat from hunting if there is less patrolling in certain areas of the reserve.

More broadly, the motivation of rangers is important for the quality of the data that they collect. Patrolling can be a physically demanding and stressful occupation that can place rangers in uncomfortable or dangerous situations. Previous research surveying rangers across Asia has highlighted the importance of factors such as the lack of alternative employment opportunities as a major reason why some people choose to become rangers. Steps to maintain or increase ranger motivation to collect these datasets, thereby improving the quality of the data they collect, include:

- Discussing with them how their data are being used, and feeding back the processed data so they can see the benefit of the datasets for themselves
- Consulting them about patrolling strategies and how to improve data collection
- Improving working conditions, job security and opportunities for promotion and advancement that reward achievement and ability,
- Ensuring that they are adequately trained, equipped and supported.

In practice, the greatest insights into law enforcement practices will often come when data collected by patrols are compared with data from independent sources, such as experiments, independent surveys designed specifically to maximise the likelihood of detecting illegal activities, and social research with local communities. The benefits of independent data are likely to be particularly great when aspects of a problem are difficult or impossible to learn directly from patrol data (e.g. the reasons why people choose to hunt illegally; the relationship between patrol effort and the proportion of threats detected; the length of time threats such as snares remain active if they go undetected). For an example of how independent data sets can complement patrol data to inform law enforcement strategies, please refer to the accompanying briefing: "*Hunting and Law Enforcement in Keo Seima Wildlife Sanctuary: Lessons for Management*".

Project updates and further information

Project website: http://bit.ly/patroldata
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References

1. SMART Spatial Analysis Installation guide: http://bit.ly/2LHUj9k; User manual: http://bit.ly/2Xyn2Vk
2. Dobson, A. D. M., Milner-Gulland, E. J., Beale, C. M., Ibbett, H., & Keane, A. (2019). Detecting deterrence from patrol data. Conservation Biology, 33(3), 665–675.