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INTERDISCIPLINARY PERSPECTIVES

Camera trap theft and vandalism: occurrence, cost, prevention and implications for wildlife research and management

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Abstract

Camera traps are increasingly used to monitor wildlife populations and management activities. Failing to detect target occurrence and/or behaviour inhibits the robustness of wildlife surveys. Based on user-testing, it is reasonable to expect some equipment to malfunction but other sources of failure, such as those caused by theft and vandalism, are largely unquantified. Between May 2016 and October 2017, we undertook an international survey of professional practitioners who use camera traps for wildlife research and management projects to quantify theft and vandalism, and to document the subsequent effects on project outcomes. We also sought to record the methods used by practitioners to avoid theft and vandalism and whether or not practitioners believed those actions were effective. Most (59%) of the 407 respondents were wildlife researchers and university academics. The survey results revealed that camera trap theft and vandalism is a global issue that not only adds to costs via equipment loss (approx. USD $1.48 million from n = 309 respondents between 2010 and 2015) and theft prevention (*c.* USD $800 000 spent by respondents between 2010 and 2015) but also influences survey design. Vandalism and theft are clearly a global problem, with responses suggesting that they occur across a diverse array of geographic locations, at varying proximity to human settlements, in multiple habitat types and across device placements. Methods to deter human interference included using camouflaging (73%), security devices such as chains (63%) and boxes (43%), use of decoy camera traps, shortening deployment periods, setting the camera relatively high or low to the ground, or moving away from human traffic. Despite this, the responses suggest that attempts to mitigate losses are often not effective. In review of our findings, we make recommendations for the future of camera trapping that requires implementation and testing.

Introduction

Theft and vandalism of field-based equipment is a major limiting factor in wildlife research and management globally, with many practitioners having to develop novel methods to minimize impacts on their equipment (Kelly and Holub 2008; Gil-Sánchez et al. 2011; Guarda et al. 2016; Sparkes et al. 2016). Camera traps are now a major tool used to monitor wildlife populations and management activities throughout the world (Rovero et al. 2013;

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Meek et al. 2015; Rovero and Zimmermann 2016). As with equipment failure, theft and vandalism of camera traps has the potential to inhibit robust wildlife surveys, but the extent to which this occurs is currently unquantified.

Theft and/or damage of camera traps can have multiple negative impacts. First among these is the loss of data which may be irreplaceable. This is particularly detrimental if the lost data are time sensitive, as one example, pre-manipulation data from a *Before–After* study design or treatment specific, similarly nil-treatment data from a treatment versus nil-treatment study design. Next, although replaceable, the cost of the hardware itself, along with storage media and batteries can be expensive, as can the labour/effort required to source new equipment and replicate the interrupted monitoring programme. There are also psychological and experimental effects: survey design may need to be modified to avoid the risk of theft

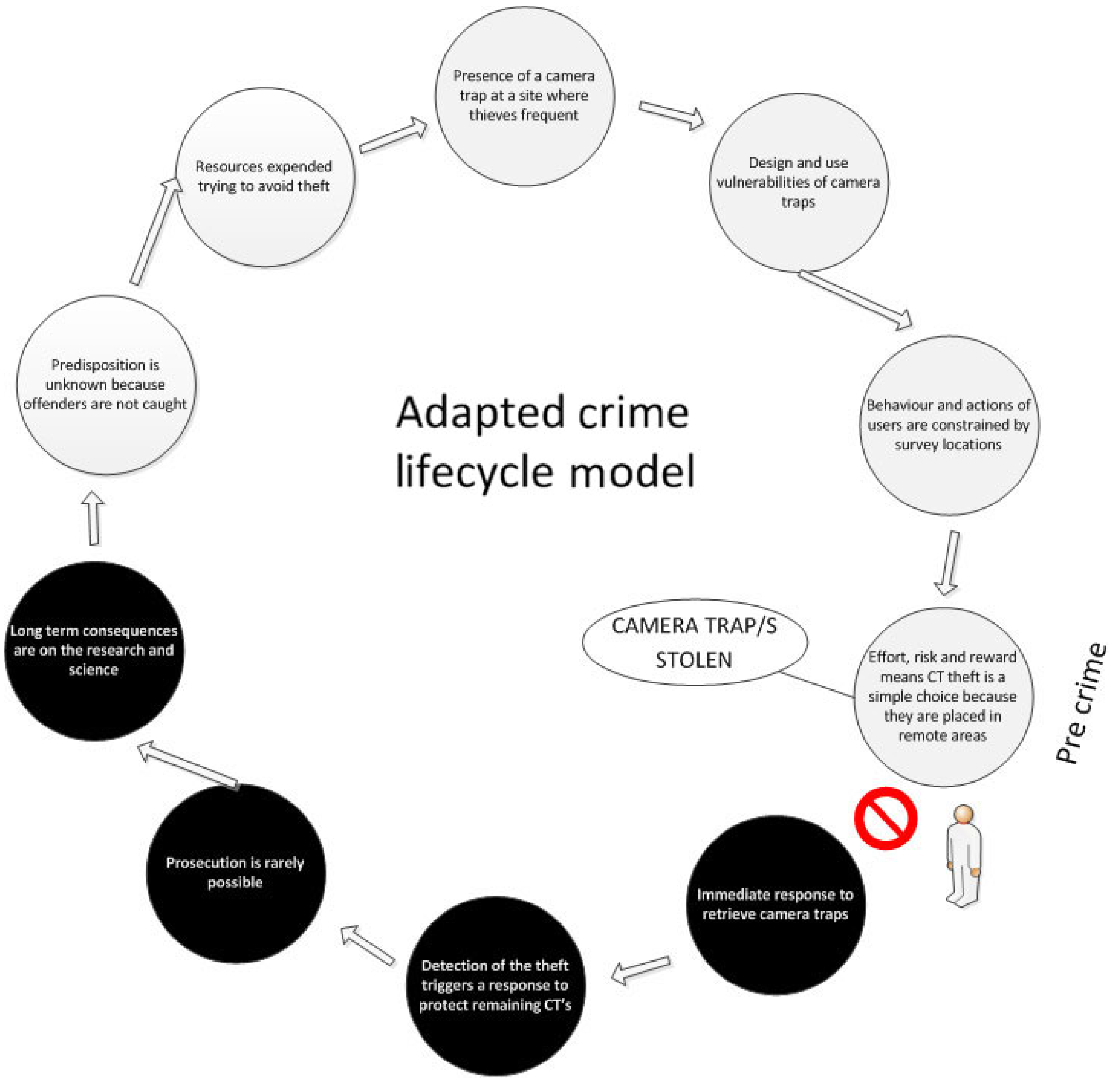

Figure 1. An adapted Crime Lifecycle Model based on the DesignCouncil (2011). The cycle describes what happens before a theft (depicted by light colored boxes) and immediately after (depicted by dark colored boxes). This model helps to contextualise how design-led crime prevention methods need to evaluate both mitigation of theft (i.e. by using a sign) and post theft responses (i.e. by using a location finder system to recover the device).

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and vandalism, or worse, projects discontinued due to risks that may have flow-on effects on project partner relationships and the community.

As wildlife researchers and/or managers, the authors are all too familiar with the impacts of camera trap loss to vandalism and theft. During our exploration of how to mitigate these impacts, we encountered the *Crime Lifecycle Model* (DesignCouncil 2011) (Fig. 1), a useful tool for contextualizing and hopefully helping to prevent impacts on camera trapping programmes. Many camera trapping practitioners currently engage in activities consistent with the model logic in their attempts to dissuade thieves and vandals from sabotaging monitoring efforts.

For example, although signs are commonly used to protect the privacy of the public (Butler and Meek 2013), they are also used to deter interference with equipment. Such messages to would be thieves or vandals range from polite to threatening although Clarin et al. (2014) found that being overtly polite wording seemed to reduce negative behaviours.

Rather than relying purely on signage, many camera trap users employ the principles of *deflecting offenders, removing targets* and *concealing targets* (DesignCouncil 2011). Camera traps are sometimes deliberately placed away from human activity (e.g. Rovero and Marshall 2009; Gil-Sánchez et al. 2011) or camouflaged, either with commercial products or with elements from the local environment such as bark and leaves.

For example, following a spate of camera trap thefts during a predator experiment in New South Wales, Australia, we tested whether placing camera traps higher in trees (3 m) would reduce theft because the camera traps were above the vision of people (Meek et al. 2016). Although we found that people did not detect or remove the higher-placed camera traps, detection rates of the target mammal species suffered, making this solution unviable.

When *deflecting offenders*, *removing targets* and *concealing targets* fail, practitioners may be left with attempts to secure their equipment via *target-hardening* (DesignCouncil 2011). Several manufacturers offer so-called 'security housings' for their camera traps and we utilized these to develop a security post (Meek et al. 2013) that we hoped would deter potential thieves. Similar approaches have been used in wildlife underpass studies (Fiehler et al. 2007). However, despite many months of trying to deter thieves with signage and outsmart them via iterative improvements to our security posts, camera traps and post structures continued to be stolen or destroyed by thieves utilizing portable angle-grinders, pneumatic jacks and even vehicle-mounted hydraulic cranes (Meek 2017) (Fig. 2).

Discussion with colleagues, from Australia and overseas, made it clear that we were not alone in our frustration or losses. Indeed, the need to minimize theft and vandalism is often discussed in camera trap papers (Karanth and Nichols 2002; Ng et al. 2004; Meek and Pittet 2012; Meek et al. 2013, 2016; Meek and Butler 2014) but rarely quantified or adequately recognised by camera trap manufacturers as important. Consequently, we aimed to survey practitioners from across the world regarding their experiences with camera trap theft and vandalism. We aimed to broadly document the impact these actions have on research and monitoring activities and to explore the range of practices used to mitigate them. The questionnaire was designed to collect broad-spectrum data that could be used to contextualise the threats posed by theft and vandalism in camera trapping studies. This study should be used to spring-board new strategies to help mitigate risks, and serves as a good foundation for a more detailed investigation to quantify project-based losses and cost-benefit analysis of mitigation methods.

Materials and Methods

Between May 2016 and October 2017, we conducted a survey of wildlife practitioners who use camera traps to

Figure 2. Security posts showing the modes of entry used by thieves to steal camera traps.

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study wildlife. The survey instrument comprised 24 questions (Appendix S1) of which 22 were multiple-choice questions and two required numerical responses (i.e. the numbers of camera traps stolen and/or vandalised and an estimate of financial loss. Social-media posts (especially Facebook and Twitter), emails to professional wildlife societies, the Yahoo Group Camera Trapping Information Exchange and direct requests to organizations known to utilise camera traps for wildlife monitoring were all used to recruit participants. SurveyMonkey® (San Mateo, CA, USA) was used to administer the self-response survey. Responses to the questionnaire were collated and manipulated using Microsoft Excel.

Results

Descriptive statistics are presented for responses to each survey question. Since every respondent did not answer every question, *n* is used to denote the total number of responses per question.

There were two spikes in participation related to the first distribution of the survey between June and September 2016 and following an E-newspaper article reminder in March 2017 (Meek 2017) (Fig. 3).

Researcher/Academics (59%) were the largest group of the 407 respondents, followed by public land managers (23%). Ecological consultants (9%) were the third largest group and a relatively small number of law enforcement officers, private land managers and hunters also participated. Most respondents were from Oceania (50%) followed by Europe (15%) and North America (14%), with the remainder from South America, Central America and Africa.

Respondents tended to mostly use camera traps for wildlife monitoring and management activities, although a smaller number used them for informal surveys, people monitoring and compliance (Fig. 4). The main categories of fauna surveyed respondents (n = 401) were nocturnal mammals (83%) and diurnal mammals (68%). Among those respondents who selected ‘Other’, 12% of respondents monitored both diurnal and nocturnal mammals. Birds (14%) and herpetofauna (7%) were targeted by some camera trap practitioners.

Most of 404 respondents placed camera traps off-trails or along animal trails (63%) with only 18% primarily using road and vehicle tracks (Fig. 5). The numbers of cameras deployed at any point in time was highly variable with practitioners placing 1–5 (28%), up to 25 (24%) and up to 50 (21%) camera traps per survey, although 13% set more than 50 per survey (Fig. 6). Almost a quarter of respondents had camera traps set continuously (24%) with 22% deploying them from a month, and slightly fewer deploying them for up to three months (19%).

Among 398 respondents, 74% had personally experienced camera trap theft but just 42% reported experiencing camera trap vandalism. Most thefts were in the 1–10 unit range but several respondents reported theft of between 30 and 50 units (Fig. 7). The highest numbers of camera traps stolen from the 12 habitat categories presented in the questionnaire (see Appendix S2) were from temperate and tropical forests. Most thefts occurred

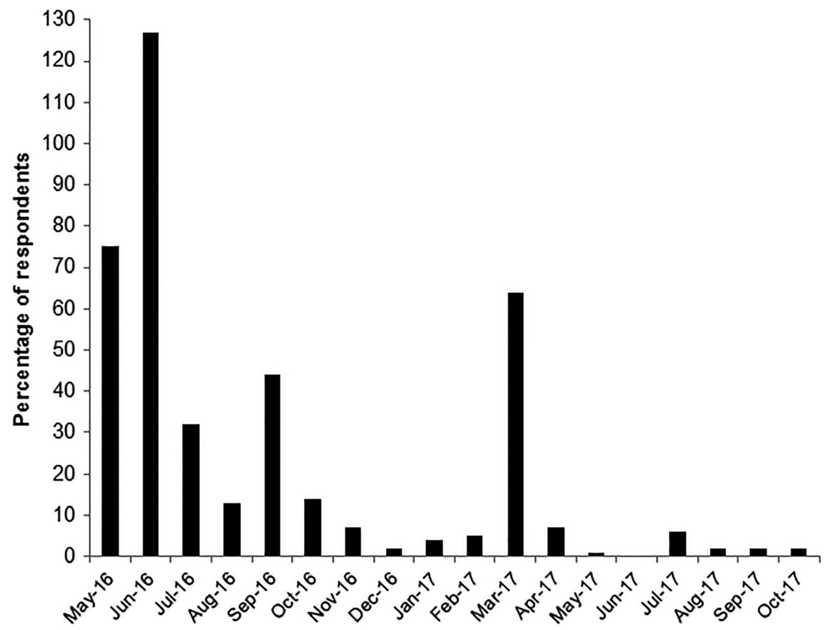

Figure 3. Questionnaire response rate between May 2016 and October 2017.

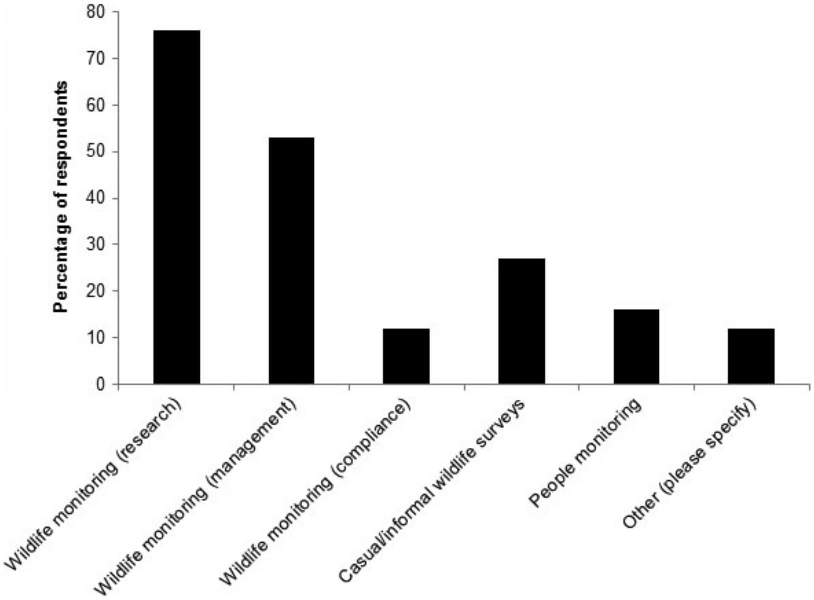

Figure 4. Reasons for camera trap use by survey practitioners.

within 50 km of human settlement (96%) but nearly 20% of thefts happened more than 100 km away from a town. One respondent had cameras stolen more than 1000 km from a populated area.

The respondents varied considerably in their perception of how the threat of theft affected their deployment behaviour: 41% of 405 people indicated that they were reluctant to set cameras because they were worried about theft and in a subsequent question 90% of 406 respondents reported there were places they would not set cameras due to theft risk. However 38% of respondents indicated that they did not consider the risk of theft was an issue for them and felt they were unaffected and 20% of people were not sure if it affected their deployment, or not.

Respondents were less concerned about vandalism than theft, with 48% of people indicating it was not an important concern affecting where they placed cameras. Indeed, only 27% of respondents indicating they were concerned with vandalism.

Information from 404 people suggested that 81% of practitioners were considering the risk of theft when placing individual camera traps. Whilst 69% of people said that they had changed how they deployed camera traps in surveys to avoid theft, only 16% had not changed their design and 15% were undecided. Almost half of respondents (43%) were concerned that changing placement to avoid theft had an impact on their monitoring effectiveness; around a quarter (24%) said, it did not have an

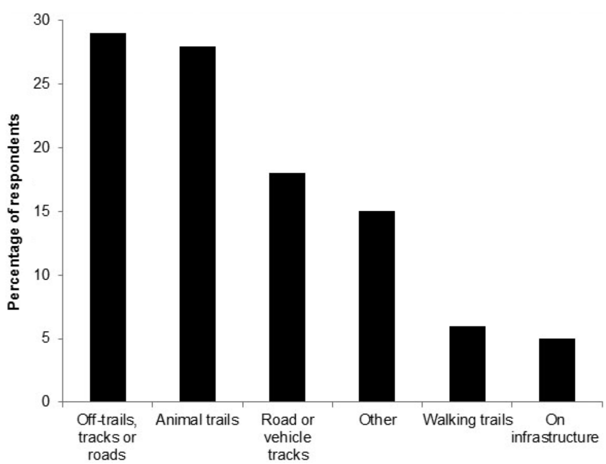

Figure 5. Location of camera trap placement by respondents.

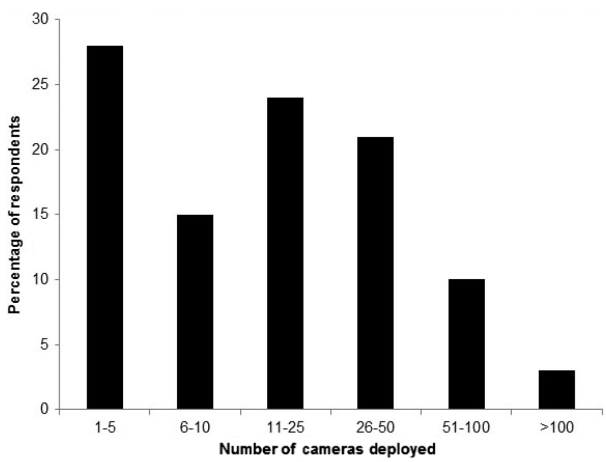

Figure 6. Numbers of camera traps deployed per survey period.

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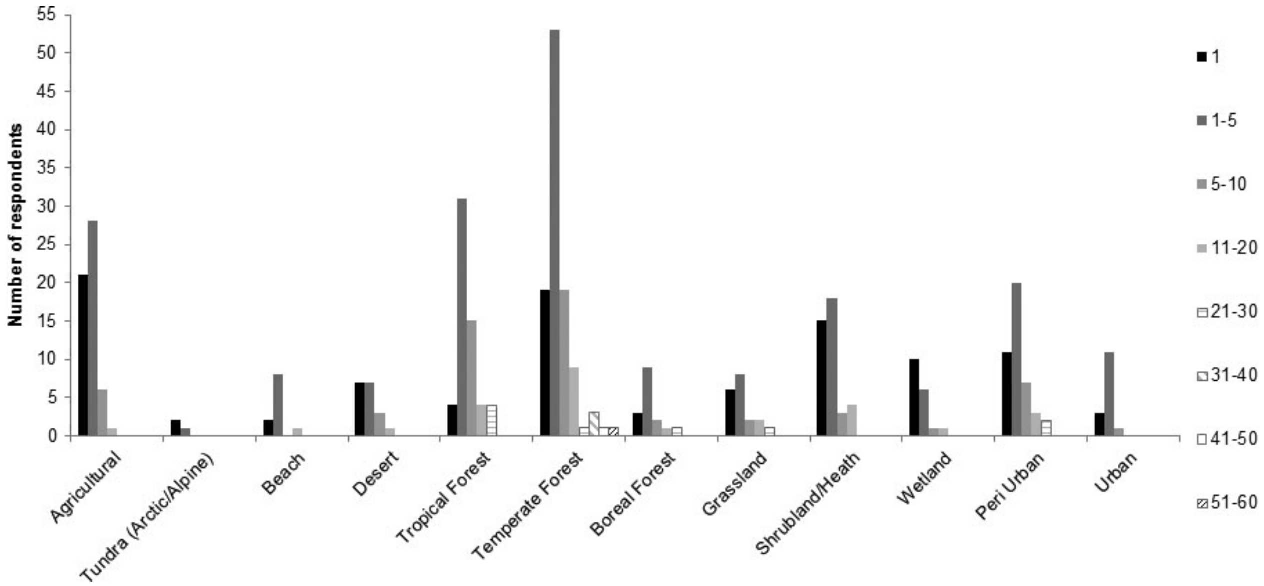

Figure 7. Numbers of camera traps stolen from 12 broad habitat types around the world.

impact and another 22% were unsure what the effects might be for their projects.

In response to our attempt to quantify the cost of theft and vandalism, 309 respondents suggested their recent total loss was between \$846 500 and \$1 475 500 USD (Table 1). For context, the majority of practitioners (94%) in this survey reported they started trapping between 2010 and 2015. In addition, 325 respondents reported the costs (excluding camera traps) they had incurred in trying to avoid camera trap theft since 2000 (Table 1). Costs expended showed a major increase between 2000 and 2015 following the global trend in camera trap use (Rovero et al. 2013; Meek et al. 2015). Between 2010 and 2015, practitioners declared their costs associated just with avoiding theft amounted to between \$416 900 and 796 500 USD (Table 2). Between 2000 and 2005 one project invested over \$50 000 USD just trying to avoid theft of camera trap equipment.

The types of anti-theft methods used were diverse with many practitioners using multiple techniques in attempts to reduce their risks (Fig. 8). Camouflage (73%), chains and cables (63%) and security boxes (43%) were most commonly employed by respondents. Only 14% used a single method, with three (25%), two (21%) and four (19%) methods used by respondents most commonly. One person reported that they used all 10 methods listed but it was not possible to know which methods or combinations of methods were used in specific surveys by respondents. Less common methods included the use of decoy camera traps, short deployment periods and setting their cameras low to the ground.

When asked if they felt their efforts to minimize theft (n = 401) and vandalism (n = 368) had been effective, only 45% of practitioners felt their efforts helped to reduce vandalism, 47% were unsure and 8% believed it did not help. More respondents (57%) believed their efforts did reduce theft, although 30% were unsure and 13% felt it had no effect on whether their camera traps were stolen.

Table 1. Estimated financial losses due to camera trap theft between 2000 and 2015 in wildlife monitoring projects (n = 309).

Equipment	Min Cost, \$USD	Max Cost, \$USD
Camera traps	625 400	1 079 500
Batteries	85 600	152 500
SD cards	70 500	123 500
Security devices	65 000	120 000
Sub-total	846 500	1 475 500

The costs provide a lower and upper range in USD consistent with the range values listed in the questionnaire (see Appendix S2).

Table 2. Estimated financial losses from efforts to prevent camera trap theft over a 15 year period (n = 325).

Year	Min Cost, \$USD	Max Cost, \$USD
2000–2005[1]	74 100	98 500
2005–2010	62 500	122 000
2010–2015	280 300	576 000
Sub-total	416 900	796 500

[1]Costs in 2000–2005 are skewed by one project that expended \$50 000 USD.

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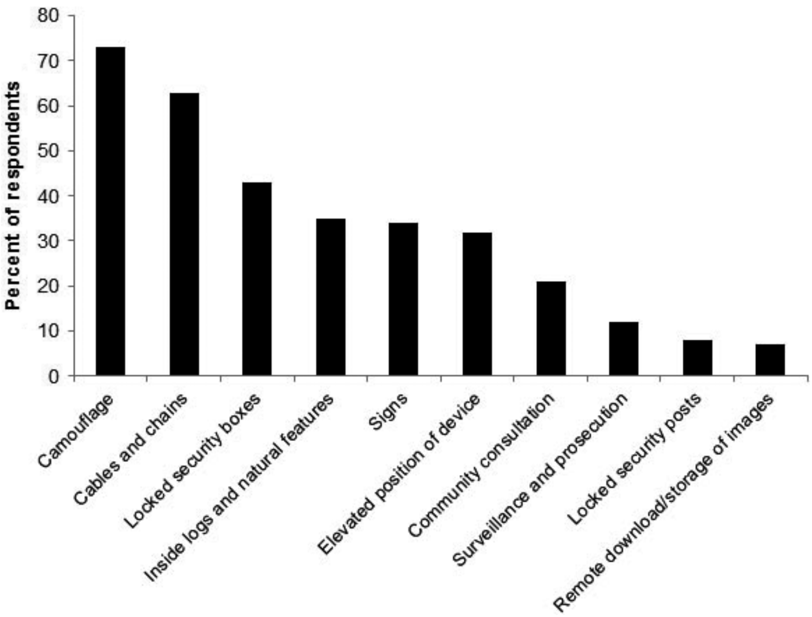

Figure 8. Percentage of respondents using particular anti-theft measures to deter theft and vandalism of camera traps.

Discussion

The loss of camera traps has serious implications for ecological research and monitoring projects. Survey data collected during this study confirm that camera trap vandalism and theft are increasing as camera traps are more widely adopted by practitioners. The costs of trying to protect equipment and the financial losses associated with theft and vandalism are imposing unnecessary resource burdens on practitioners (see Karanth and Nichols 2002). Across just a few hundred participants, from around the world, over a million USD dollars in camera trap equipment were reported lost to thieves. A serious under-estimate of the real costs across all camera trap users globally. Project teams neither continue to replace stolen equipment nor chase costly methods of reducing their risk of damage or loss. Levels of loss such as this seem unsustainable at a time when research and conservation funding is difficult to secure.

Although important, there were two consequences of theft that we were unable to quantify; firstly the resource cost (e.g. labour, vehicle expenses) wasted during camera trapping projects that is lost when camera traps are stolen. Secondly and more importantly are the real and immeasurable costs associated with stolen data. These data are irreplaceable and often unrepeatable. The costs of these data can never be adequately quantified and can lead to failed studies or projects, or at least, creates a gap in a temporal and/or spatial data set.

There is a broadly held view amongst practitioners that camera trap theft is positively correlated with the proximity of the study area to areas of human habitation. This assumption is reasonable but the data (and our personal experiences) suggest that theft occurs equally in sites whether they are 1 km or 50 km away from human settlement. In this study, some respondents recorded theft of camera traps more than 100 km from settlements, with one desert project experiencing theft over 1000 km away. These data are evidence that camera trap theft is not just a result of placing devices too close to settlements where people are likely to encounter devices regularly.

While most people would assume that camera traps set on trails are less likely to be encountered and, as such, stolen, our data suggest that theft is not correlated with camera placement (i.e. on or off-trails). It is more likely that theft is correlated with human activities. For example in Cambodia, our research team and another (B. Chan, pers. comm. 2018) have had many (>50) camera traps stolen from remote habitats used by villagers for illegal logging and hunting in the last 2 years. However, quantifying the effects of camera placement with regard to tracks, human activity centres and other relevant factors would require additional study via a further survey or well-designed experiment.

There were a common set of methods used by practitioners to reduce the risks of vandalism and theft comprising signage, camouflage (including using logs and natural features) and security systems. Placing camera traps high in trees was used by 125 practitioners, despite recent research having shown this can reduce the detection probability for target species (Meek et al. 2016). Clearly, other options need to be found.

Signage, mostly aimed at discouraging criminal activity, was commonly used and often included words that

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highlighted dangers to the would-be thief or vandal. To that end, many respondents admitted to trying to bluff people by using 'danger' symbols, or by threatening contamination or infection from handling equipment. Warning messages indicating that devices could be tracked using GPS-technology were also reported. Others declared that the devices were code-locked thus rendering stolen cameras useless. Apart from these, some respondents tried to appeal to the good nature of would-be-thieves by advising that they were only interested in animal images and that human images would be deleted.

A plethora of ideas to prevent theft were provided by practitioners including placing camera traps around beehives as a deterrent, setting camera traps on camera traps to detect thieves, putting false antennae on cameras with a warning sign saying they can be tracked, using visual distractions and using automatic anti-thief dye mechanisms. All of these methods focussed on a fear factor, aimed at making people question the risk before they attempted to steal devices, most of which relied on bluff.

People working in remote areas stated that engagement and consultation was effective where risks of theft were posed by indigenous peoples. Communicating via cultural protocols and describing what these devices were being used for, thus creating ownership with local residents/communities was believed to be effective. This approach was taken by Thomas (2014) with villagers in Papua New Guinea and was credited as being a valuable engagement process.

Signage and engagement are clearly effective in some situations. Unfortunately when dealing with growers of illegal drugs, people illegally dumping rubbish and/or poaching, engagement is far more difficult. Therefore, a range of different measures need to be adopted and explored including the integration of technology.

Bancroft (2010) proposed the incorporation of location technology (GPS) into camera traps. Until recently, the size of these devices has precluded pursuing this option. Our research team has assessed tracking options using location systems like TrackR (www.thetrackr.com) or Bluetooth tracking technology (www.thetileapp.com), but these systems have key limitations, including limited use in less populated areas where telecommunication is poor or non-existent. In the case of TrackR technology, efficacy is dependent on human participation so outside of urban area like cities they have limited value. Furthermore, these tracking systems rely on thieves taking stolen equipment into populated areas, so recovery is constrained by thief behaviour and their place of abode.

When respondents were asked whether the threats to camera traps had caused them to modify their survey effort and methods, they were more concerned about theft than vandalism. Many people (42%) considered theft an important consideration and 69% said they had changed their study designs to cater for the risks of theft. Further, 43% of participants felt they had jeopardized their projects by placing cameras in ways that reduced the risk of theft. Most people (90%) stated that they deliberately avoided some places because they were concerned about theft. The overwhelming message from this group of practitioners is that theft is a high priority issue for them in their projects and that consequently, practitioners are selecting sites not to optimize the scientific rigour but to prevent lost data and equipment. The question is; to what extent are we compromising scientific rigour to avoid theft and damage?

Based on our personal exposure to this problem and the information collated during this survey, we assert that the issue of camera trap theft is an example of market failure. Demand to resolve this problem is high, but solutions are few. In the light of this, we believe it is time to look towards smart technology to help overcome this problem. In the parlance of the Crime Lifecycle Model (DesignCouncil 2011), we are overdue to move into the *post-crime phase* by developing technology that transfers all data to the researcher, or another safe place, in real-time (improved data security), enables real-time alerts of interference or theft (communication with the practitioner) and facilitates detection and recovery opportunities for stolen equipment (on-board tracking and signalling). Obviously, any endeavour to recover stolen equipment and data must be in collaboration with local law enforcement agencies and consistent with legislature to ensure due process is followed.

If manufacturers are able to build new technologies into camera traps to protect data or reduce theft and vandalism risk, it will come at a cost. This means practitioners will have to trade-off the higher cost of a device for greater data and device security, or whether they buy cheap models and risk the loss of data and device. There is no simple solution or available option to date.

The purpose of this study was by design aimed to collect general data and information on theft and vandalism to provide insight and a mechanism to pave a way towards solving a global problem. Many specific questions remain unanswered. There is scope for a subsequent survey to collect more detailed data on project budgets in relation to camera trap theft and mitigation activities. To also collect specific data on anti-theft methods used, their costs, success and failures of methods used. However, our hope is that current manufacturers and innovative entrepreneurs will utilise our information to stimulate ideas and formulate solutions to address current gaps in the global camera trapping market. We hasten to add that the target group is a small subset of the entire camera trapping market with many recreational hunters and agricultural producers also utilizing camera traps for recreation and work purposes. Any improvement to the security of devices for our community of practice will also aid other users.

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Conflict of Interest

The authors have no conflicts of interest associated with the submission of this manuscript.

Data Accessibility

Data collected and analysed in this paper will be lodged with the University of New England Library, Armidale Australia.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1. Twenty four questions were asked of camera trap practitioners to quantify the consequences of theft and vandalism.

Appendix S2. Theft and vandalism of camera traps in wildlife surveys.

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