Journal of Outdoor Recreation and Tourism 17 (2017) 44–53

Contents lists available at ScienceDirect

Journal of Outdoor Recreation and Tourism

journal homepage: www.elsevier.com/locate/jort

Coupling visitor and wildlife monitoring in protected areas using camera traps

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ARTICLE INFO

Keywords:
Monitoring
Camera trap
Protected area management
Recreation
Trail

ABSTRACT

The global rise in nature-based recreation and tourism brings an increasing need for research on visitor activity in protected areas. Understanding the nature, distribution, and intensity of visitor activity can lead to better management of protected areas, potentially improving visitor experience while reducing impacts on the environment. Although passive infrared cameras (i.e., "camera traps") are now a standard monitoring tool for wildlife researchers, they are less commonly applied by recreation social scientists for visitor monitoring in natural areas. Because study objectives differ between these two applications, protocols for camera placement also vary.

In this study we optimized camera traps to quantify human trail-based activity while meeting established wildlife-oriented protocols. The method streamlines the data collection process, thus making visitor monitoring data more accessible. We first determined the wildlife-appropriate camera position optimal for capturing human trail use through a field test, in which we varied the speed of biker movement, camera angle, and distance to the trail. The optimized camera protocol was 1–2 m from the trail edge, oriented 20° to the direction of movement, where the target is moving slower than 8 kph. We then experimentally tested this optimized camera protocol in a field setting along an unpaved, multi-use trail typical of many outdoor recreation locations. Two pairs of cameras were set following the optimized protocol while two pairs were set with a randomized protocol as the control. Compared with field observations, optimized camera traps recorded 82% of pedestrians ($p < 0.05$) and 75% of mountain bikers ($p > 0.05$). There was also a difference in performance between camera models, with the best model recording 86% and 97% of pedestrians and bikers, respectively. We conclude that camera traps can accurately quantify human trail-based activity while being set to wildlife science standards, reducing the cost of collecting visitor use data and producing high-resolution human-wildlife interaction data.

MANAGEMENT IMPLICATIONS:

Motion-triggered camera traps can be used to efficiently collect data on humans and wildlife through a single data collection process. Camera traps should be calibrated with field-based observation and positioned according to the following guidelines: located where traffic moves slower than 8 kph, oriented at a shallow angle to the direction of movement, and placed at knee-height on trees within 1-2m of the trail edge. It should be noted that camera traps might under-sample quickly moving visitors such as bicyclists. This cost-effective method can provide long-term data useful for monitoring both human trail-based activity and wildlife presence.

1. Introduction

The global rise in nature-based recreation participation (Balmford et al., 2009; Hammitt, Cole, & Monz, 2015) highlights the urgency of improving our understanding of how visitors use protected areas and its associated ecological, economic, and social effects. Although parks are managed in part for the provision of recreation opportunities, there is still a shortage of data on visitor use, with the broad spatial and temporal dispersion of visitors making their use difficult to monitor in many protected areas (Cessford & Muhar, 2003; Eagles, 2014). In parks and protected areas worldwide, trails

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http://dx.doi.org/10.1016/j.jort.2016.09.007
Received 5 May 2016; Received in revised form 11 September 2016; Accepted 11 September 2016
2213-0780/

are an important and common infrastructure which concentrates human movement while allowing people to travel through the landscape (Leung & Marion, 2000), and are thus a structure often targeted for visitor use monitoring efforts.

High-use recreational trails have been found to attract some mammalian species while being avoided by others (Erb, McShea, & Guralnick, 2012). Although human-wildlife interactions have been studied widely, generalizations from this research are difficult to make due to the diversity of recreational activities, wildlife responses, study settings, and the complexity of animal movement (Kays, Crofoot, Jetz, & Wikelski, 2015; Monz,Pickering, & Hadwen, 2013). Fine-scale long-term data collected simultaneously on humans and wildlife is crucial in exploring these interactions, and could ultimately lead to improved conservation of wildlife species in protected areas.

Wildlife researchers have developed techniques using motion-triggered cameras (henceforth referred to as "camera traps") to gather data on wildlife as they move past a given site (Kays & Slauson, 2008; Kays et al., 2011; McCallum, 2013; Meek et al., 2014; Rowcliffe et al., 2011; TEAM Network, 2011). Researchers interested in human-wildlife interactions have analyzed these data in relation to human use factors such as proximity to human development, intensity of recreational use, and hunting regulations (Erb et al., 2012). Although camera-based methods have also been used to monitor human trail activity for park management (Arnberger, Haider, & Brandenburg, 2005; Campbell, 2006; Duke & Quinn, 2008; Fairfax, Dowling, & Neldner, 2012), the method has rarely been employed to observe humans and wildlife simultaneously. Previous research using camera traps to observe visitors utilized substantially different study designs than those implemented in wildlife studies. In these studies cameras are typically set substantially higher off the ground and further from the center of activity than recommended for capturing small- to mid-sized terrestrial wildlife. Streamlining data collection on wildlife and humans through one optimized method would increase the likelihood that visitor data are collected, reduce overall monitoring costs, and provide important data related to human-wildlife interactions. In this study we set out to develop the camera trap method to allow simultaneous observation of humans and wildlife in a trail-based setting. Using two camera models commonly employed in wildlife research, we test a range of camera positions appropriate for observing wildlife to determine the optimal camera position for gathering information on trail-based human activities and visitor demographics. We then empirically test this optimized protocol in a field setting to evaluate its effectiveness.

1.1. Visitor monitoring techniques

Accurate and reliable visitor data is an essential component of science-based protected area management. Recreation social scientists have developed several methods for gathering these data including field-based and remote data collection. Popular methods for remote data collection include active infrared trail counters, which record each time an infrared beam oriented across a trail is broken, and passive infrared trail counters, which record each time a temperature differential is detected (Active Living Research, 2013; Cessford & Muhar, 2003). Although trail counters are relatively easy to use and require low maintenance, this method systematically underestimates trail use due to clusters of visitors triggering the counter once, and often results in false triggers by animals or sun-warmed leaves. Additionally, trail counters deliver only a count of total trail use and do not provide information regarding trail user activity, direction of travel, or demographics (Active Living Research, 2013). Field observation has typically been implemented to gather more detailed information on visitors, including activity, direction of travel, group size (Broom & Hall, 2010), number of people at a location (Manning & Anderson, 2012), and demographics (McKenzie, Cohen, Sehgal, Williamson, & Golinelli, 2006). These data are often used for park and visitor management purposes (see Cessford & Muhar, 2003). Combined with wildlife data, these visitor use data could be valuable in revealing fine-scale patterns in terms of human-wildlife interactions.

Since the advent of digital camera traps, several researchers have used them to collect visitor use data in protected areas. Campbell (2006) found camera traps to be a cost-effective means of gathering detailed trail use data. In that study, cameras were used to collect information on numbers of trail users, type of activity, group size, direction of travel, day vs. overnight use, and the length of time spent on the trail. The camera method was considered an improvement over trail counters, capturing activity type and minimizing the possibility of false counts triggered by animals. In another study researchers placed camera traps on human and wildlife trails to determine the intensity of human and wildlife use both spatially and temporally, finding the method to be an effective way to monitor all trail use (Duke & Quinn, 2008). However, trail counters require less time for data extraction than do camera traps, making counters a more sustainable tool for long-term monitoring of visitor use only.

The accuracy of camera traps in capturing people or wildlife moving past them depends on two technical aspects of their performance: motion sensor sensitivity and trigger delay. Most modern camera traps use passive infrared motion sensors, which trigger when they sense changes to the temperature profile, typically due to the movement of a warm-blooded animal (Kays & Slauson, 2008). Distances over which cameras trigger depend on the camera model and the size of the animal, with larger animals triggering the sensor over a larger area (Rowcliffe et al., 2011). All digital camera traps have a delay between when the sensor detects motion and when the camera captures an image, typically ranging from 0.1 to 3.0 s (Trailcampro, 2015).

Fast-moving targets traveling near the camera could trigger the camera and be out of view before an image is captured. Thus, camera traps must be set close enough to trails to reliably trigger on people or animals walking along a trail, but not too close, or at too sharp an angle, to allow moving targets to exit the picture frame before an image is captured. This limitation was seen in one study that found that only 63% of cyclists were captured on camera, while 82% of pedestrians, 90% of motor vehicles, and 100% of horses were captured (Fairfax et al., 2012). This is likely due to the speed at which users passed the cameras as well as the size of the user, with size enhanced by the use of motor vehicles and horses. Camera-based methods also yield different visitor counts from field-based observation depending on intensity of use. A study using video cameras found cameras to produce more reliable data than field observers in high use areas, while the opposite is true for low use areas (Arnberger et al., 2005). Camera-based methods have the potential to be a useful tool in visitor monitoring, but there are limitations that must be considered when designing the study.

1.2. Contrasting camera protocols

Recreation social scientists using camera- or video-based methods to collect data on visitors have come to consensus that cameras should be calibrated before the data are used, and several sources provide guidelines for positioning cameras to capture human trail users (Arnberger et al., 2005; Campbell, 2006; Duke & Quinn, 2008; Fairfax et al., 2012). However, through our literature review we did not find any sources in which these guidelines were empirically tested. Additionally, the protocols implemented by recreation social scientists often vary considerably from those used by wildlife researchers, as summarized in Table 1.

One of the major differences between studies focused on quantifying human activity compared with those focused on mammalian wildlife activity is camera height in relation to the ground. While wildlife-focused studies generally place the camera approximately knee-height from the ground to capture small- to medium-sized mammals (, Erb et al., 2012; Meek et al., 2014; TEAM Network, 2011), human-focused studies often place the camera higher (1.5–5 m)