Monitoring Trail Use with Digital Still Cameras: Strengths, Limitations and Proposed Resolutions

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Introduction

The monitoring of public use of natural areas has received increasing interest over the past 2 decades as managers of protected areas become concerned about visitor use types, levels, and intensity along with the accuracy and validity of their visitor use information. It has been suggested that this information is inadequate and often based upon the estimates or best guesses of area managers and park wardens. In order to deal with this lack of visitor use information a number of researchers have begun to examine and assess a variety of means of collecting visitor use data. Watson et al (2000) describe a range of approaches that have been employed to understand visitor use characteristics including estimation, visitor observation, registration, permits, surveys, mechanical counters, 35 mm camera triggered at intervals or by activity, and more recently video monitoring (Arnberger et al. 2003, 2005). Digital photography is another recent development that has seen little application in visitor monitoring but may hold promise to further the science of visitor monitoring in natural areas. Understanding the limits and benefits of the various methods is essential for informed management.

The changing structure of Canadian society and its influence on the use, appreciation and understanding of Canada's natural heritage presents a significant challenge to Parks Canada (Parks Canada 2005). In addition, there is little empirical data detailing the impacts these changes are having on the use of natural areas. Parks Canada has recognized these issues and is concerned that the changing cultural make-up of Canada coupled with a decrease in visitation will result in reduced support for parks and protected areas (Parks Canada 2005). Given its mandate and the desire to facilitate visitor experience such that Canadians appreciate their natural heritage and develop a culture of conservation (Parks Canada 2005) it is imperative that Parks Canada understand the patterns of use in its various parks. Informal and anecdotal observations by researchers and managers suggest that day use of backcountry trails and facilities is increasing and may be placing unknown stress on park resources. Monitoring of visitor use of natural areas is essential for effective management of parks and natural areas and in many cases managers rely on best guesses to estimate use (Watson et al. 2000).

This project evolved from an impact monitoring study developed in response to concerns that increasing use of the backcountry trails and campsites in Riding Mountain National Park might be negatively affecting the parks ecological integrity. Working in consultation with the park, researchers at the University of Manitoba developed and implemented a backcountry impact-monitoring program during the summer of 2001 (Campbell & MacKay 2004, MacKay & Campbell 2004). In excess of 50% of all backcountry respondents to the monitoring survey were day users, despite the fact that overnight users were strategically sampled through the use of the backcountry reservation system (Campbell et al. 2001). This mirrored results from other Canadian National Parks that suggested overnight use of the backcountry had peaked in 1979 (the year the median baby boom was aged 21) and had declined slightly since (Page et al. 1996). Clearly problems for managers of Canadian National Parks were different than those of their American counterparts where crowding and overuse are often significant issues[1].

Methods

Information regarding day use of backcountry trails can be difficult to capture as registration is not typically mandatory, voluntary registration boxes have unknown reliability, and intercept surveys are labour intensive and costly. Increasingly technology has been employed in an attempt to clarify use patterns in parks and natural areas. Infrared (IR) trail counters have had limited success as they do not differentiate between humans and wildlife, thus recording false readings. 35 mm cameras linked to IR sensors allow researchers to distinguish between wildlife and humans but film-based systems are limited to 36 exposures and therefore require significant maintenance. In addition, film based systems can incur significant costs for film and development. Digital cameras used in conjunction with IR sensors may be able to overcome some of these concerns but still remain a relatively untested technology in the field.

Over the course of the summer seasons in 2004 and 2005 several digital camera/passive infrared (IR) sensor units were installed along backcountry trails in Riding Mountain National Park in Canada. Each unit was self contained and enclosed in a waterproof housing. IR sensors were calibrated over the course of 48 hours by observers and set to low sensitivity to reduce the likelihood of being triggered by birds and small mammals. Digital cameras were set in standby mode to reduce battery drain and calendars and clocks set to the appropriate time. The cameras were also set to the lowest resolution possible to: 1) maximize the number of events that could be recorded; 2) speed the refresh rate of the camera and; 3) reduce the likelihood that individuals could be recognized in the resulting images. In addition, lenses were blurred to further reduce the likelihood of identification of individuals. Each digital camera contained a 512 MB or 1 GB memory card capable of storing 3346 or 6690 images respectively.

In the first year of the study cameras were placed on 3 backcountry trails. In the second year of the study cameras were place on 4 backcountry trails and 2 interpretive trails (at the request of the park). Placement of the cameras was critical to their accuracy and effectiveness and represented the most challenging and time consuming component of unit setup.

Results

A summary of the results of the monitoring program is presented in table 1 and is intended to be illustrative of the type of information that can be gleaned from the system employed here. As such, the significance of the results to park managers is not the focus of this discussion. The use of digital still cameras linked to passive infrared sensors can provide managers of parks and natural areas with a cost effective and accurate means of evaluating the spatial, temporal and activity type of use occurring on park trails.

The digital camera sensor units employed in the Riding Mountain Study allowed researchers to identify numbers of visitors, group size, direction of travel, the type of activity engaged in, day use vs. overnight use (evidence of backpacks) and in some cases the amount of time people spent on the trail. When compared to simple mechanical counters, combining the digital camera with the counter not only provides greater information and detail but also can be used to assess the accuracy of the counters. That is the image captured will indicate the size of the party or if there was indeed an event. When compared with counters or sensors linked to 35 mm camera advantages include ease of data management, lower maintenance costs in both time and money, and detailed information about trail use.

A primary benefit of digital cameras linked to passive infrared sensors lies in the attribute file associated with each digital still image. Using DOS, a directory file of the attributes is created and saved as an RTF file. The resulting RTF file is then imported into Excel where temporal data can be ma-

1 Cole (1997) suggests that less attention be paid to already crowded sites and more attention should be focused upon lees popular areas.

Table 1: Trail use counts, party size, type and timing based upon digital camera sensors.

Trail	Number of events*	Number of individuals	Average Party size	User type	Peak activity	% Day use
North Escarp-Ment[1]	242	88	2.1	Hike 95% Bike 5%	60% 10:00 – 14:00	92
Moon Lake[2]	88	49	2.5	Hike 90% Bike 10%	58% 10:00 – 14:00	100
Brule	542	266	2.0	Hike 92% Bike 8%	51% 10:00 – 14:00	100
Grey owl	117	19	1.9	Hike 70% Bike 30 %	55% 10:00 – 14:00	100
Central[2]	1127	234	2.5	Hike 56% Bike 36% Horse 8%	60% 10:00 – 14:00	97
Ominik[2, 3]	622	888	2.3	Hike 99% Bike 1 %	52% 10:00 – 14:00	100%

[1] Monitor placed orthogonal to trail assumed many cyclists missed
[2] Monitor placement ideal and calibration suggests `98% accuracy
[3] Interpretive trail near townsite
*Events refer to total number of times the camera was triggered, irrespective of whether there was activity captured or not. Note that in some situations (e.g. Central trail) individuals lingered in front of the camera for some time resulting in multiple counts. However the images allowed this to be easily rectified.

nipulated and analyzed. This tab-delimited file can then be exported to SPSS or other similar programs for further analysis. While 35 mm print film can also record time and date of events the data must be manually entered resulting in increased costs and time. Similarly, 35 mm cameras linked to trail counters do not provide a single merged file. In the case of digital images blank images can be eliminated from the database (stored for later review) and the data files remain associated with each image, greatly reducing the drudgery that is often associated with monitoring work (Gardner and Campbell 2002).

In addition to providing ease of manipulating time and date data, the addition of a digital camera to a passive sensor provides more information about the nature of trail activities. In the Riding Mountain study researchers were able to determine the ratio of, and type of activity (hike, bike, horse), the peak times of these activities and in some cases the length of time people spent on the trail. Some authors have suggested that Passive IR sensors can be triggered by non-human events such as snow, cloud cover etc resulting in lower accuracy than for active IR or Radio frequencies (Swedish Environmental Protection Agency 2000). By adjusting the sensitivity of passive IR sensors and combining them with digital photos these limitations can be minimized. When positioned correctly, the resultant image provides evidence of whether the sensor was triggered by a trail event or other factors. Generally, however the effect of environmental triggers is evident in the images as fog, cloud etc and data sets are easily cleaned. In addition, this overcomes the most significant limitation of Radio and active IR Beams, that of hikers traveling side-by-side and resulting in only a single count.

Arnberger (2005) noted that at low use levels, counting (by researchers) was more accurate than video observation data. However, in very large low use areas with many entry and exit points such as Riding Mountain National Park (and many other Canadian National Parks) the use of personnel to perform counts is, except in rare cases, prohibitively expensive. As noted previously counters alone (whether, Passive IR, Active IR, radio beam, pneumatic or other) require delicate calibration to differentiate between user types (eg. horse, bike) and in many cases differentiation is impossible. Furthermore, in low use areas wildlife may be a significant portion of trail activity. Film based cameras linked to active IR sensors have been employed and shown to be very effective and highly accurate. However, the costs associated with purchasing and developing film can be significant and when coupled with the limited storage capacity and additional data management costs, make film based systems a poorer choice.

All trail monitors require some degree of maintenance. Maintenance includes ensuring the units are functioning properly, monitoring data capacity and ensuring adequate power (battery life). Containing the sensor and the camera in one sealed unit thus protecting the sensitive electronics from the elements minimized maintenance of the units employed in this study. In addition the single sealed unit ensured that there was no need to connect sensors to cameras with external cables[2]. Given the advances in digital storage media (512 MB up to 3000 images, 1 GB, up to 6000 images), the fact that images were collected at the lowest possible resolution, and the relatively low levels of use in RMNP, data capacity was not an issue. The number of events and to some degree ambient air temperature impacted battery life. However, even in the most extreme of cases (high use and low temperatures – a rare condition in RMNP) battery life averaged 5-6 weeks. As a result, when batteries were replaced every 3-4 weeks no data was lost. Finally, maintenance involved checking to ensure that vandals and or wildlife did not damage the units. Despite the fact that most of the units were in plain view, none were stolen, though some were moved and this resulted in lost data. In addition, several units were damaged by wildlife, and one irreparably so. This is discussed further in limitations below.

Limitations

Despite the numerous advantages of using digital cameras linked to passive infrared sensors the system is not without its limitations. The most significant challenge in employing the current generation of digital cameras and IR sensors is the time lag between the camera emerging from standby and the taking of the picture. The units employed in this study experience a nominal delay of between .8 and 1.5 seconds between the sensing of an event and the capture of an image. In a number of cases this meant that the camera was triggered but no image was captured thus resulting in decreased accuracy. In general, this type of underreporting was noted when cyclists moving at speed passed the camera before an image could be captured.

The simplest way of resolving this issue is to ensure that the camera unit is optimally placed. This involves ensuring the unit is placed at a bend in the trail on level ground and that the trail user is moving away from or towards the unit rather than orthogonal to it. This placement has the added advantage of being able to capture large groups strung out along the trail thus providing more accurate counts. The negative consequence of this solution is that it leaves the unit much more exposed and visible and therefore increases the potential for vandalism and theft. Given that the units were secured to trees with straps rather than some form of locking mechanism, this is a significant concern.

A second approach applied in 2004 is to separate the sensors from the camera unit so that the delay from sensor trigger to image capture can be accommodated for. This setup allows somewhat more flexibility and facilitates the concealment of the camera, however it also requires external wiring to connect the sensor to the camera and more time to setup and calibrate. Given there are now three pieces of equipment, it can be more difficult to conceal and maintain. External wiring should be avoided if at all possible as wildlife has a tendency to chew through the cables. Finally advances in digital photography may provide a solution. Digital SLR cameras are currently on the market featuring startup to image capture lags (from power off to shot) of less than .2 seconds and lower lags from standby. Unfortunately, at present these units are also quite expensive and require expensive proprietary batteries. In addition, the best cameras for these purposes tend to be simple with relatively few functions and the trend has been towards more complicated instruments.

2 In comparative studies undertaken in 2004, active infrared sensors linked to 35mm cameras were frequently damaged by wildlife when connecting cables were chewed through. Cables were replaced 5 times over the course of 8 weeks and as a result very little data was collected.

While for the most part the units required maintenance checks every three weeks, on a few occasions the units were damaged or moved by wildlife and rendered ineffective for periods of time. Bears in particular were attracted to the units when new and would rub against them and occasionally chew on the housing. While only one unit was significantly damaged, the units were moved from their optimal position and as such failed to register trail events. It is worth noting that in the second year of the study the only units affected by wildlife were the new units indicating that, perhaps, there is some scent associated with the cases or electronics that is attractive to wildlife.

Conclusion

Digital cameras linked to passive infrared sensors have the potential to provide managers of parks and natural areas with valuable and detailed information regarding visitor use of the areas in a manner that is both cost effective and facilitates ease of data management. In order to capitalize upon the potential benefits of this new technology it is imperative that the units be properly calibrated and more importantly properly positioned. Based upon two years of study in Riding Mountain National Park in Manitoba, Canada the most effective configuration is one that places the camera in an exposed location oriented parallel to visitor movements and as such it must be placed in secure housings and locked to posts or poles. The first iteration of this design is currently being employed in Riding Mountain National Park and to date has been effective in dealing with the limitations identified above. Less intrusive and more visually appealing installations are being designed for use in 2007, as is the possibility that linking digital cameras with radio beam may allow for a more concealed camera placement. Finally digital SLR cameras are being investigated as possible solutions to the issues of time lags between the sensing of an event and camera firing.

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