Methodological considerations for using remote cameras to monitor the ecological effects of trails users: lessons from research in Western Canada

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Abstract — The Livingstone River Area in southwestern Alberta, Canada is an ecologically significant area of public land that provides an important connection between adjacent protected areas. Most of the area is zoned for multiple use; which means the area is available for resource extraction and recreational activity. Recreational use in this area consists primarily of off-highway vehicle (OHV) use, random access camping and fly fishing. Recreational use is largely unmanaged and increasing. The proliferation of trails and campsites has become extensive in the past decade. Furthermore, much of this activity is concentrated along critical riparian movement corridors and in sensitive montane, subalpine and alpine environments. Human use and associated linear disturbance is recognized as among the most significant habitat fragmentation factor limiting sensitive wildlife (especially large carnivores) in the region. We have developed a sampling method that employs remote digital infrared cameras on known human trails and wildlife trails. The cameras have proven to be very effective for monitoring all trail use. We provide a review of our methods, report on the effectiveness of the cameras and provide some guidance on the use of cameras based on the lessons we have learned.

Index Terms — Remote cameras, access management, monitoring methods, wildlife.

1 Introduction

Monitoring the spatial and temporal patterns of human use in wildland settings is essential to developing adaptive land-use management plans. Interactions between individual recreationists and user groups as well as between people and environment are complex and multi-faceted. Researchers and managers would benefit from non-invasive methods that provide unbiased, accurate and timely data to provide quantitative information on visitor use patterns and the response of the environment. In this paper we focus on a method to monitor and explore the relationships between the flows of visitors and wildlife in a multiple use landscape using remote cameras.

Human use of linear features results in direct and indirect effects to wildlife. The nature and significance of the effects are a function of the type, timing, intensity, predictability and spatial distribution of the activities. In addition, the responses are highly variable across wildlife species and it is difficult to identify sta-

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tistically significant causal relationships due to confounding variables. Increasing human use, especially motorized off highway vehicle (OHV) use, can result in loss of habitat connectivity at local and regional scales, habitat fragmentation and habitat alienation [1], [2], [3], [4], [5], resulting in reduced population viability, increased edge effects and loss of genetic variability [1], [6], [7], [8], [9]. These factors can also result in negative effects on wildlife movement patterns and could make important habitat patches and their associated uses such as breeding, denning, feeding and rearing grounds, inaccessible [4], [5], [10], [11]. Disturbance by human use may also alter the availability of prey for the large and meso-carnivores that inhabit the region.

The Livingstone Range is located in the Crown of the Continent, an international ecosystem spanning the shared Rocky Mountain region of British Columbia, Alberta and Montana. The 1200km^2 area provides a critical linkage between the protected area complexes of Waterton-Glacier and Kananaskis-Banff. The study area encompasses four natural sub-regions defined primarily by elevation including the foothills parkland, montane, subalpine and alpine regions. The diversity of habitats results in high native biodiversity and the original floral and faunal assemblage remains largely intact.

Landscape disturbance associated with recreational and industrial trail use in the Livingstone Range is significant and continues to intensify with regional population growth. The area is entirely comprised of public land and supports a variety of industrial activities including petroleum exploration and development, forestry, and mining which have resulted in a proliferation of access roads and trails. In addition, the landscape provides a wide range of opportunities for “unmanaged” recreational activities such as OHV use, equestrian use, fishing, hunting, camping and hiking. Much of this activity is concentrated along critical riparian zones and in sensitive montane, subalpine and alpine environments. In recent years, OHV recreational use has been increasing significantly in the province of Alberta with sales of off-highway recreational vehicles increasing over 120% in the past 7 years.

2 Remote Camera Methods

The use of digital infrared cameras is becoming a common technique for examining the spatial and temporal responses of wildlife to recreational disturbances [12], [13], [14]. Remote sensing cameras provide effective, accurate, appropriate and non-biased data [14], [15], [16], [17]. In order to examine the spatial and temporal relationships between wildlife and human activity we developed a sampling method that employs remote cameras on known human trails and wildlife trails. Cameras were deployed from the middle of May to September in each of 2004, 2005, 2006 and 2007. The study area was stratified into 8 sampling units to ensure representational coverage. Within each of the 8 sampling areas, a series of random locations was generated from a spatial algorithm within a GIS. Each randomly generated sample focal area consisted of a camera on each human (OHV) trail and 2 cameras on adjacent wildlife trails. From each randomly generated point, a perpendicular line was drawn on a map to the nearest human trail. At this point a digital infrared camera was attached to a suitable tree to photograph all people and wildlife passing the point (day and night). A 500m transect perpendicular to the direction of the human trail was established from each of these camera points. Along this transect a wildlife trail was identified within 0-250m and another within 250-500m. Remote cameras were placed on each of these identified wildlife trails. Sites were sampled for 2 weeks and then the cameras were moved to a new location using the same process described above. Each of the 8 sampling areas had 2 of the 3-camera set-ups, resulting in a total of 48 cameras within an area of approximately 1000 km^2.

The technology available for remote cameras has changed dramatically over the past decade. Infrared sensors have long been used for counting human and wildlife use on trails and sometimes these were coupled with cameras. However, this technology was often cumbersome, difficult to power and unreliable. The development of more effective units was largely driven by the hunting industry and today there are dozens of commercially available remote cameras that are suitable for use in monitoring visitor flows and wildlife. We tested three types of remote sensing cameras over the four seasons of field research.

The three types included GameVue, Deercams (www.deercam.com) and Reconyx (www.reconyx.com). All three types require a combination of both movement and a change in heat for the sensor to be triggered and an image to be captured. Both the GameVue and Reconyx cameras are digital cameras with infrared flashes that allow them to capture images at night with only minor visual disturbance. The Deercam camera employs a standard 35mm 'point-and-shoot' camera attached to sensors with a conventional flash that allows for nighttime images at the expense of an obvious visual disturbance. All of the units are encased in rugged, weatherproof housings and can easily be attached to trees or posts.

The GameVue cameras had built-in digital memory with a capacity of 60 images. The Reconyx cameras use a compact flash cards and are capable of holding up to 5000 images on a 256 Mb card. The Deercam cameras run standard 400 ISO 24 or 36 exposure 35mm film.

DeerCam cameras were used on wildlife trails only and were used for 28% of the sample sites (1066 total). GameVu cameras were used on human use trails only and were used on 8% of the sample sites. Reconyx cameras were used on both human use trails and wildlife trails and were used at 64% of the sample sites.

During each two-week sampling period cameras were checked to ensure they were operating correctly. GameVue and Deercam cameras were checked every 4-5 days or two times during each two-week period. Reconyx cameras were able to run the entire 2-week period without being checked. Cameras were attached to suitable trees with a minimum 6-inch diameter (to prevent false image triggers due to wind shaking the tree). Cameras were mounted at approximately chest height and were tilted slightly down, at a 45-degree angle to the trail, to maximize the amount of time a subject could be detected. Cameras were set to take a picture every three seconds if the sensor was triggered. Date, time and temperature were recorded on each image.

3 Results

Four field seasons have resulted in 1066, 14 day sampling periods including over 424,000 hours of camera operation. Preliminary results include over 6572 unique large mammal events, including 484 large carnivore detections. Large mammals include grizzly bear, black bear, cougar, wolf, bobcat, badger, lynx, wolverine, coyote, moose, elk, mule deer, white-tailed deer and big horn sheep. Mule-deer and undetermined deer species were the most frequently detected large mammal (50.2%), followed by elk (13.3%), coyote (12.1%), moose (8.7%), and white-tailed deer (7.5%). Of the large carnivore detections, grizzly bear were most common (35.3% followed by black bear (18.6%), undetermined bear (14.0%), wolf (10.3%), lynx (9.3%), cougar (6.8%) and bobcat (5.4%).

Cameras detected 10473 human events on recreational trails with 9083 (86.7%) of these events included motorized use followed by hikers (7.3%), equestrian use (4.5%) and cyclists (1.4%). Human use on recreation trails peaked between the hours of 1100 and 1700 while large mammal activity peaked on recreation and wildlife trails between 0500 and 0900 and also between 1900 and 2300 with the least amount of activity between 1100 and 1800. Human activity was greatest on recreation trails on Saturdays and Sundays while there was no difference between the daily use of recreation and wildlife trails for large mammals.

4 Lesson Learned

The use of remote cameras for monitoring the flows of people and wildlife has proven to be very effective in our context. The camera technology has improved significantly since we initiated our research in 2004. In particular, the advancement of infrared illumination, digital image capture and memory capacity have all resulted in substantial improvement to commercially available cameras. In addition, the newer units draw a relatively small amount of power and can be operated for a month or more on a single set of batteries. The Reconyx cameras performed very well in our field conditions and we recommend their use. However, there are many suitable units now available commercially.

The selection of cameras depends on the type of data required, but some considerations for model selection include: size of infrared illuminator, field of detection, size and flexibility of digital memory, image quality/resolution, speed of camera to detect a target and acquire an image, and quality of the camera housing. The newest models now include an option for colour images during daylight and black-and-white during dark. Although we did not test any, there are now units available to capture digital video. Remote cameras have emerged as a highly effective means of non-invasive monitoring.

Although the use of cameras does not result in a significant direct disturbance to wildlife or visitors, their deployment raises ethical issues and has the potential affects the quality of visitor experience. Visitors need to be informed that their activities may be monitored by camera. In addition, the anonymity of visitors should be protected and identifiable images of users should be managed carefully. We recommend the development of strict policies for the use and storage of images that is clearly communicated to users. Cameras may capture illegal human behaviour and researchers/mangers need to make *a priori* decisions about how such data will be used. Vandalism and theft of cameras may be an issue in remote settings. Communication with visitors about how and why the cameras are being used is essential to managing loss and damage.

The use of remote cameras for monitoring has the potential to result in a huge volume of data. Depending on the levels of use and the sensitivity of the cameras (e.g., false triggers caused by vegetation movement in wind), each unit may capture thousands of images per week. The process of downloading, viewing, classifying, storing and managing images is currently tedious and labour intensive. Effective use of cameras in a monitoring program requires an adequate budget to perform these tasks and analyze the data. The potential for automated classification of images using change detection software and artificial intelligence is in its infancy, but has the potential to greatly improve the efficiency of managing camera data. The authors are currently exploring automated methods to help in the process of image classification.

The use of remote cameras requires carefully methodological consideration to the spatial and temporal distribution of sampling. Quantitative comparison of results between areas or between different time periods requires the acquisition of viable sample sizes over adequate periods of time. We recommend that researchers work closely with statisticians to ensure that the sampling design is providing the type of data that is needed.

5 Conclusion

The use of remote cameras to monitor visitors and wildlife has emerged as a highly effective approach for park and wildland researchers/managers. New technology allows for the capture of high quality images, virtually unlimited digital storage and efficient operation on battery power. The deployment of cameras requires careful consideration of ethical and sampling issues. The methods are largely non-invasive and provide a means of collecting a large amount of data on both visitors and the environment. As with all monitoring methods, a commitment to long-term and adequate sampling is required to provide managers with defensible, quantitative data for decision support.

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