Siegrist, D., Clivaz, C., Hunziker, M. & Iten, S. (eds.) (2006). Exploring the Nature of Management.
Proceedings of the Third International Conference on Monitoring and Management of Visitor Flows in Recreational and Protected Areas.
University of Applied Sciences Rapperswil, Switzerland, 13-17 September 2006. Rapperswil.

Developing Spatially-Balanced Sampling Protocols for Visitor Impact Monitoring in Protected Areas

David Pettebone[1], Peter Newman[1], David Theobald[1] & Yu-Fai Leung[2]

[1]Colorado State University, USA
dpettebone@peoplepc.com
pnewman@cnr.colostate.edu
davet@nrel.colostate.edu

[2]North Carolina State University, USA
leung@ncsu.edu

Keywords: GIS, spatial sampling, visitor impacts, campsites, trails, Rocky Mountain National Park.

Introduction

Protecting park resources and providing a quality visitor experience are two goals of the U.S. National Park Service mandated by the Organic Act of 1916 and the Wilderness Act of 1964. Developing programs for monitoring visitor impacts to natural resources can provide park managers with useful information that can inform resource and visitor management decisions.

Literature Review

Monitoring visitor impacts is logistically challenging in backcountry and wilderness areas due to the dispersed distribution of sites and trails over the landscape and associated field time involved. It is imperative to create a robust and efficient visitor impact monitoring program that will inform visitor capacity management frameworks and adaptive management approaches (Grumbine 1994). Recent advances in geospatial techniques have benefited campsite and trail impact monitoring, especially the use of global positioning system (GPS) technology to document location of sites and impact attributes (Leung & Marion 2000). In contrast, while geographic information systems (GIS) have been utilized to derive spatial sampling strategies in landscape ecology and conservation biology (Theobald 2005), little attention has been paid to the potential of adapting the same concept to facilitate trail impact monitoring. Recently, efforts were made to apply the concept of spatially-balanced sampling designs to trail condition monitoring in Rocky Mountain National Park. This paper presents results of these applications.

Methods

This study was conducted to develop an efficient sampling plan for measuring recreation related impacts to trails in the Bear Lake corridor in Rocky Mountain National Park, Colorado and addressed the following objectives: 1) Estimate the number of visitors along the Glacier Gorge trail; 2) Inventory trail conditions; 3) Examine the relationship between visitor use and trail conditions; 4) Compare results of different data collection methods. Visitor use was estimated using automated infrared trail counters and trail conditions were sampled using a 100 meter interval based sampling plan and a spatially balanced sampling plan

The spatially balanced sampling plan was based on visitor accessibility. Accessibility was defined as the time it would take a hiker to travel to a location within the study area along the trail based on distance from the trail head and slope. ArcGISv9.1 was utilized to create an "accessibility probability surface". Since visitor use diminishes at further distances from the trailhead it was assumed that more impacts would occur where more hikers visited. All locations within one hour of the trailhead were given a probability of 1, locations within two hours of the trailhead were given a probability of 0.9, and locations beyond two hours of the trailhead were given a probability of 0.8. All locations outside of the trail corridor were given a probability of 0. For each point, Universal Transverse Mercator (UTM) coordinates were provided that allowed navigation to the sample point. Ninety-nine prioritized points were visited.

Results

Results estimate that 474 visitors per day hiked to Alberta Falls, 157 visitors per day hiked to Mills Lake, and 46 visitors per day hiked to Black Lake. The average trail width for the entire trail was approximately 4.5 feet and the average maximum trail depth was approximately 2.75 inches. Because trail condition samples were drawn from a population using an unequal inclusion probability, we weighted the importance of each sample based on the inverse of their inclusion probability. That is, the more likely that a location was sampled (e.g. approaching 1.0), the smaller the weight – and the less likely that a location was sampled (e.g. 0.1), the larger the weight (1/0.1 = 10). The strength of using a probability-based sample is that a statistically reliable estimate of the population can be made. Furthermore, no statistically significant difference was found between the results of the spatially balanced dataset and the 100 meter interval dataset for trail width and depth. Regression analysis revealed a strong relationship between visitor use and trail width.

Conclusion

Protecting both resources and visitor experience can be very challenging for parks and related areas experienceing increasing visitation and diverse types of activities and managers often rely on management by objectives planning framworks such as Limits of Acceptable Change (LAC) and Visitor Experience Resource Protection (VERP). At the heart of management by objectives planning frameworks are setting appropriate management objectives, the development of associated indicators and standards of quality and a strong and consistent monitoring program that signals when management action should be taken. Over the last several years, there has been much discussion about the efficacy of such planning frameworks. Moreover, budget constraints have forced many parks to do more work with fewer people and often let monitoring and analysis of data fall by the wayside. For all of these reasons, researchers and managers must work together to develop creative approaches to collecting data that balances efficiency and precision and acknowledges the constraints of managers in the field. The above approaches are a step in this direction and use the latest spatial technology, knowledge from current literature, and spatial statistics to accomplish these tasks hence strengthen management by objectives planning frameworks.

References

Grumbine, E. R. (1994). What is ecosystem management? In: Conservation Biology (8), p 27-38.

Leung, Y.-F. & Marion, J. L. (2000). Recreation impacts and management in wilderness: A state-of-knowledge review. In: Cole, D.N. et al. (eds.), Proceedings: Wilderness Science in a Time of Change; Vol. 5: Wilderness ecosystems, threats, and management, May 23-27, 1999. p 23-48. Missoula.

Theobald, D.M. (2005). GIS Concepts and ArcGIS Methods. Conservation Planning Technologies. Fort Collins.