Integrating geospatial technology with behavior mapping method in monitoring visitor use in open landscapes

Yu-Fai Leung, North Carolina State University, USA, leung@ncsu.edu;
Chelsey Walden-Schreiner, North Carolina State University, USA; **Anna Miller**, North Carolina State University, USA

Introduction

Open landscapes like meadows, dunes, beaches and urban natural areas are valued resources that serve as vital plant and wildlife habitats as well as spaces for diverse visitor activities. These resources are subject to a variety of ecological pressures exacerbated by anthropogenic threats, including intense visitor use and the resulting biophysical impacts to flora and fauna. Informal trails are a common and growing impact issue in protected areas due to the unmanaged and proliferating nature of this problem. Defined as identifiable pathways outside of a protected area's formal trail system (Leung et al. 2002), managing informal trail impacts requires timely information on the character of visitor use and trail impacts. Quantitative and spatial data on the location, intensity, and nature of visitor use can alert managers to potential resource or experiential impacts and guide future management action.

Method

Multiple points of visitor access and limited or no containment infrastructure common in open landscapes present unique monitoring challenges for protected area managers seeking to obtain visitor use data. To address these concerns, we implemented a field monitoring method that integrated geospatial technology with an established observation method known as behavior mapping to characterize spatial patterns of visitor use in open landscapes. Behavior mapping entails a systematic scan to record the location of individuals and observable attribute data within identified target areas. A PC-based tablet computer running ESRI ArcPad 7 was employed to map visitor locations directly into shapefiles with pull-down menu in which pre-coded visitor attributes, including gender, age group and activity type, were recorded.

Study Location

Researchers from North Carolina State University, USA, applied the behavior mapping method to three high-use meadows in Yosemite National Park, California, USA, in the summer of 2011. Yosemite National Park, a UNESCO World Heritage site, was the third most visited national park in the United States' National Park Service (NPS) in 2011 (NPS, 2012). Meadows are an integral component to the ecosystem and visitor experience in Yosemite National Park and comprise 85 sq. km. of the park's 3,026 sq. km. The United States' National Park Service (NPS) routinely monitors several aspects of meadow health and resource condition in select meadows, including informal trail proliferation in the meadows chosen for behavior mapping.

Findings and Discussion

Accuracy and Reliability

Prior to data collection and analysis, researchers assessed accuracy and inter-observer reliability. A trained observer mapped a second researcher on the base map, while the second researcher collected GPS waypoints. A comparison of 22 matched points established an 11.32 m margin of error. A percent agreement method comparing independent collected observable attribute data for three observers examined inter-observer reliability. Percent agreements fell within acceptable ranges at 82.4% for activity category, 86.8% for age category, and 88.2% for gender.

Visitor Use

The descriptive data generated from the behavior mapping method offered a snapshot of visitor demographics and activity. A total of 108 behavior mapping scans were conducted during the summer of 2011, resulting in 1,507 visitor use points. The number of visitors recorded was roughly equal across the three meadows. Overall, a slight majority of visitors were male (53.9%), visitors were more often engaged in active activity (e.g., biking, walking, running) and visitor use was greatest between noon and 16:00.

Several spatial analysis tools available in GIS software examined the concentration of visitor use as well as the spatial association of use with respect to informal trails. Across all three meadows in this study, visitor use was highly concentrated at statically significant levels ($p = .0001$). Kernel density maps, a graphic representation of density using a kernel density equation, illustrated areas of intense visitor use. In one study meadow, El Capitan Meadow, the kernel density map indicated concentrated visitor use along the northern and eastern boundaries of the meadow, as well as moderate use of informal trails (figure 1).

Visitor Use of Informal Trails

The utility of the visitor use data also extends to other spatial data sets. When compared to informal trail data, an independent t-test found a statistically significant difference ($p = .000$) between distance visitors were observed from informal trails and activity category (i.e., stationary, active). Stationary activities, such as standing or photography, occurred further from the informal trail corridor ($M = 5.52$ m, $SD = 8.29$) than active activities ($M = 2.40$m, $SD= 2.63$ m). However, a one-way ANOVA found no statistically significant relationship between informal trail condition class (i.e., barren, some bare ground, stunted vegetation) and distance visitors were observed from trail ($F=1.145$, $p = .319$).

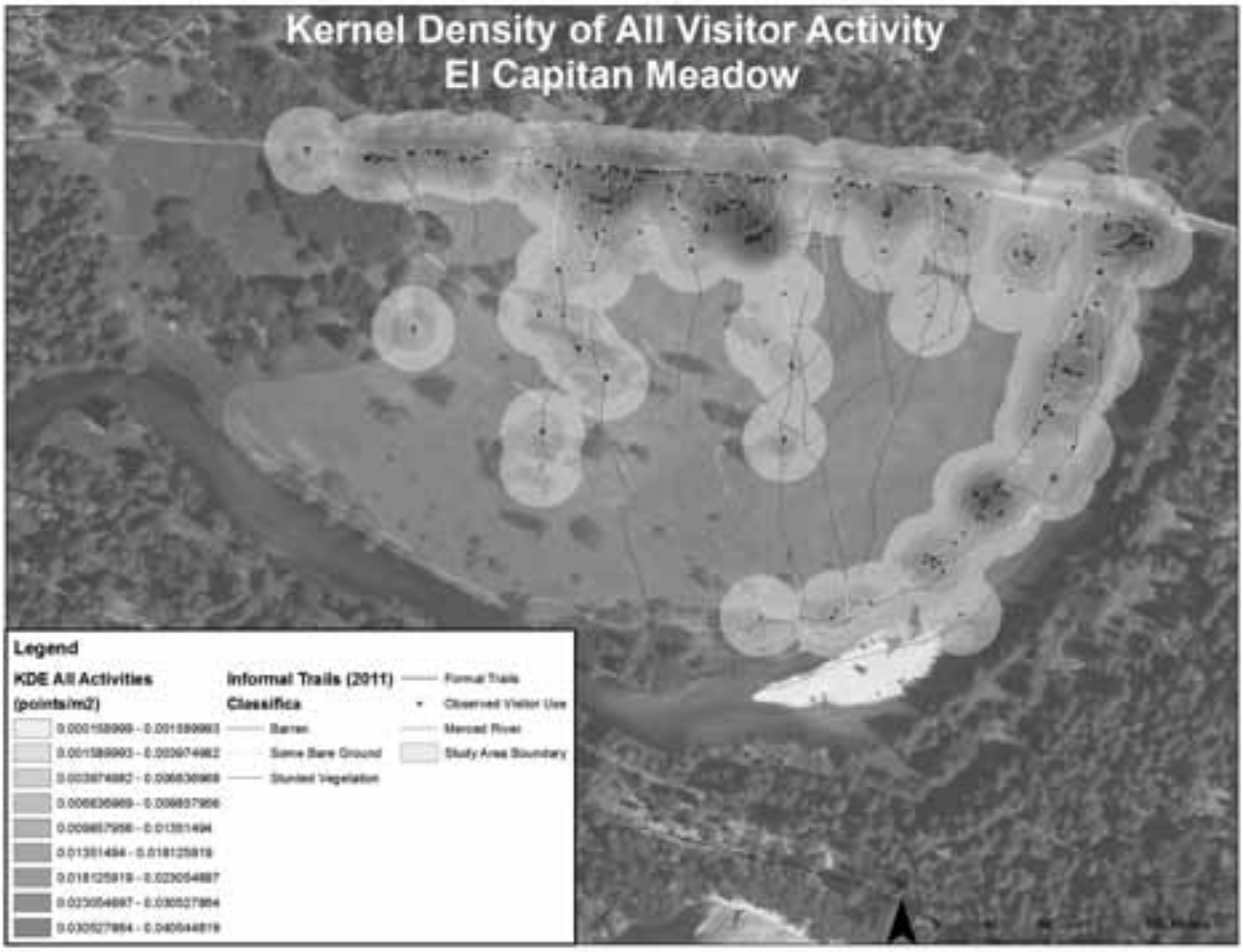

Figure 1. Kernel density map of El Capitan Meadow illustrating intense visitor use along the northern and eastern borders.

Conclusions

The behavior mapping method proved adaptable to the open landscape as well as an acceptably accurate method to monitor visitor use of open landscapes. Researchers chose observation locations that allowed for complementary views of the scanning area that also lessened the opportunity for visitor interaction. However, distance from use and vegetation height may have influenced accuracy. The accuracy level found in this study may be acceptable for visitor management purposes, however further consideration is warranted for integration with other spatial data layers. Areas with dense informal trail networks may consider subdividing the study area to increase accuracy or employing a complementary method.

A major consideration and benefit to behavior mapping is the ability to implement the method with a wide variety of individuals, including volunteers. A paper-and-pencil version of the method allowed volunteers to collect longitudinal data in two of the three study meadows for examination of seasonal variation in visitor use. Open source software and advances in mobile technologies may reduce material cost and increase the efficiency of behavior mapping with volunteers while reducing the time pressure to protected area staff and providing an opportunity for stewardship education.

Behavior mapping may also prove effective in other protected areas with open landscapes, like beaches or dunes, experiencing visitor pressures. Unlike questionnaires or visitor-carried GPS studies, behavior mapping does not require participation from the visitor and therefore may lessen the influence on behavior or impact on visitor experience. Resulting descriptive and spatial data can aid management in identifying areas of intense visitor use, help inform trail maintenance or surface hardening plans, or support restoration efforts.

Leung, Y-F., Shaw, N., Johnson, K., Duhaime, R. 2002. More than a database: integrating GIS data with the Boston Harbor Island carrying capacity study. George Wright Forum, 23, pp.36–49.

United States' National Park Service (NPS). 2012. National Park Service Public Use Statistics Office.[online] Available at: <http://www2.nature.nps.gov/stats/>. [Accessed 25 June 2012].