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A GPS tracking study of recreationists in an Alaskan protected area

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ABSTRACT

Understanding human movement and behavior in parks and protected areas is an integral part of managing social-ecological systems. In particular, spatial travel patterns of recreationists and their impacts on ecosystems have been studied in many protected area contexts. However, there is limited knowledge of recreation behavior in areas with little to no infrastructure or without formal trail systems. Drawing from Global Positioning System (GPS) tracking data, we identified travel patterns of recreationists in a nearly trail-less backcountry setting in Alaska. Specifically, we investigated the spatial and temporal dynamics of recreation use in relation to resource conditions experienced in Denali National Park and Preserve during the high-use season of 2016. We observed that recreationists' travel routes were heavily concentrated along the Denali Park Road and exhibited different spatial patterns for day and overnight backcountry use. Also, informal campsite locations, delineated using multi-day GPS tracking data, showed uneven distributions within the park. This study provides recommendations for public land management agencies in the US and highlights the need for more systematic evaluations of concentrated use in parks and protected areas.

1. Introduction

Public land management agencies are challenged to accommodate recreational activities in parks and protected areas with increased demand for public resources and associated environmental degradation. Understanding spatial patterns of human use is particularly important for making informed decisions about how best to sustain ecosystems and human well-being across spatial scales (Eagles & McCool, 2002; Margules & Pressey, 2000). However, little is known about on-ground travel patterns across protected landscapes such as federally designated Wilderness. These locations are difficult to access and often encompass large areas far from population centers (D'Antonio et al., 2010). Further, travel patterns are difficult to record in remote areas because recreational activities often occur off trail without managed paths to guide human use. A stronger understanding of the spatial dynamics of human behavior in remote protected areas is needed to direct management attention to high priority locations (Bagstad, Reed, & Semmens, 2016; Korpilo, Virtanen, & Lehvävirta, 2017) and integrate biophysical and social science information into decision-making (van Riper, Kyle, Sherrouse, & Bagstad, 2017).

Global Positioning System (GPS) visitor tracking is a well-researched method for documenting spatial patterns of human use in parks and protected areas (Beeco & Hallo, 2014; Kidd et al., 2015; McGehee et al., 2013). Numerous researchers have lauded the advancements of GPS tracking in relation to previous methods (Bauder, 2015; Beeco & Brown, 2013; Orellana, Bregt, Ligtenberg, & Wachowicz, 2012; Shoval & Isaacson, 2009) due to this tool's ability to record temporal and spatial patterns of human movement in natural and built environments (Beeco, Hallo, & Brownlee, 2014). GPS tracking research has been applied in public land management contexts given its potential to support agency decisions related to balancing resource protection and human use across spatial scales (Beeco, Hallo, & Giumetti, 2013; D'Antonio, Monz, Newman, & Lawson, 2013; Edwards, Dickson, & Griffin, 2010; Taczanowska, González, & Garcia-Massó, 2014). Specifically, GPS tracking methods have been employed to document human impacts on the environment from activities such as hiking (Kidd et al., 2015; Wimpey & Marion, 2011) and camping (Cole, 2004; Leung & Marion, 2004).

This study incorporated GPS visitor tracking and survey methods to better understand backcountry recreation use in Denali National Park and Preserve (Denali). GPS units were used to collect precise and accurate estimates of travel patterns, avoid recall bias, and bridge the gap between reported and actual use. Diverging from most GPS tracking research focused on formal trail and road systems (Hallo et al., 2012),

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the backcountry recreationists examined in this study traversed a nearly trail-less landscape, making human use in this context less predictable and more difficult to document. Moreover, this research expanded upon existing GPS tracking literature by capturing multiple-day trips and identifying informal campsite locations in the backcountry. In identifying spatial clusters of both hiking routes and campsite locations, the present study illuminated areas that may be subject to environmental degradation and addressed management concerns about crowding and informal trail creation (Abbe & Burrows, 2014; Marion, Leung, & Nepal, 2006). Understanding the spatial and temporal patterns of day and overnight use in protected areas such as Denali is important for resource planning and management, as well as refining knowledge of how best to capture the dynamics of spatial behavior.

2. Literature review

2.1. Space-time methods

Space-time travel patterns provide valuable information for land management agencies responsible for optimizing experiences for the public while minimizing environmental degradation. Researchers and managers have developed a number of methods to assess travel patterns and understand visitor behavior in parks and protected areas (Manning, 2011). Traditional data collection has involved visitor recollection, automated trail or vehicle counters, and researcher observations. For example, previous research has relied on surveys (Anderson, 1971), paper diaries (Stewart & Cole, 2001), and other techniques by asking visitors to recall where they went and how much time they spent in different locations (Hallo, Manning, Valliere, & Budruck, 2004; Kidd et al., 2015). Automated technologies such as trail and vehicle counters have also been employed to document use patterns (D'Antonio et al., 2010). In addition, counters have generated high quantities of visitor use data and are relatively inexpensive. Advanced counter technology is available to detect the direction of travel and distinguish between use type (Greene-Roesel, Diogenes, Ragland, & Lindau, 2008).

Although a range of tracking methods have been developed, previous work has highlighted several limitations (D'Antonio et al., 2010; Kidd et al., 2015). For instance, travel recollection requires extensive time and consideration from respondents, which can be cognitively burdensome and result in low survey completion rates (Hallo et al., 2004). In addition, reported activities may yield data that are influenced by an individual's knowledge of the area (van Riper & Kyle, 2014), study design (e.g., sites highlighted on a map) (D'Antonio et al., 2013), or social judgment bias (Birnbaum & Stegner, 1979). Counter technology can relieve burden from both the researcher and respondent and be camouflaged to not disrupt the visitor experience (Cessford & Muhar, 2003; James & Ripley, 1963; Leonard, 1980). However, the spatial richness of this technique is often limited to conditions at fixed points, and researchers and managers cannot identify complex spatial distribution and density patterns. Lastly, observational studies are more reliable and less burdensome for the respondent but require a considerable investment of researchers' time and resources (Arnberger, Haider, & Brandenburg, 2005).

2.2. GPS visitor tracking

GPS technology captures on-ground travel patterns to provide insight into the densities, flows, and distributions of human movements. Studies that use GPS technology to understand use often require respondents to carry small, unobtrusive units that are returned after their visit and converted into a spatially-rich dataset (Edwards & Griffin, 2013). The spatial and temporal data received from GPS units is increasingly more accurate, detailed, and complete (Beeco & Brown, 2013; D'Antonio et al., 2010; Edwards & Griffin, 2013; Kidd et al., 2015). Further, this method requires little additional time and resources from participants and researchers (Edwards & Griffin, 2013). In a study comparing the efficacy of visitor self-reported data and GPS-derived data, results indicated that the GPS method recorded more accurate data, elicited a lower refusal rate, and was more efficient overall than the self-reporting method (Hallo et al., 2004); it was “not humanly or technologically feasible” to obtain similar results that the GPS units produced using self-reported methods (p. 172).

GPS tracking methods have been applied in an array of disciplines and geographic areas. Previous research in geography, tourism, and recreation ecology has relied on tracking to understand spatial patterns of tourists and recreationists (Bauder, 2015; Beeco & Brown, 2013; Edwards & Griffin, 2013; Edwards et al., 2010; Modsching, Kramer, Gretzel, & Hagen, 2006; Orellana et al., 2012; Shoval & Isaacson, 2009; Shoval, 2008; Wolf, Hagenloh, & Croft, 2012), with particular focus on human use patterns in parks and protected areas (Hallo & Manning, 2010; Hallo et al., 2004). Distance traveled, time spent in a particular area, destinations visited, and use concentrations contribute to a comprehensive understanding of human use across protected landscapes. Spatial data can also be linked to survey, interview, and value mapping data to understand the theoretical and practical implications of human use in natural resource management contexts (Beeco et al., 2014; Evans & Jones, 2011; Pettersson & Zillinger, 2011; Plieninger, Dijks, Oteros-Rozas, & Bieling, 2013; van Riper et al., 2017).

2.3. Ecological impacts of dispersed use

Tracking technology has been used for monitoring human impacts on natural resources such as wildlife, water, soil, and vegetation (Hammitt, Cole, & Monz, 2015; Monz, Pickering, & Hadwen, 2013). Overlaying use patterns on ecological conditions enables resource management agencies to identify the current and future impacts of recreational activities (Leung & Marion, 2000; Monz et al., 2013). Previous research indicates the distribution of recreation use tends to be uneven. High-use areas carry implications for ecological disturbance as recreationists tend to concentrate along linkages such as trails or roadways and at nodes such as facilities or campsites, which can cause environmental impacts such as soil compaction, erosion, and vegetation destruction (Hammitt et al., 2015; Manning, 1979, 2011). Though, areas of low or dispersed use also warrant particular attention. The development of the use-impact curve (Hammitt et al., 2015) and other function models that describe ecosystem responses to recreation use (Monz et al., 2013) indicate initial use results in the majority of impact on an environment, especially vegetated surfaces. Thus, concentration of dispersed use is particularly problematic because short-term impacts can have long-lasting effects. In addition, impact from recreation use is especially concerning for areas that have a sensitive resource base such as tundra or alpine vegetation with fragile species and a short growing season (Goonan, 2009; Whinam & Chilcott, 1999; van Riper, Manning & Reigner, 2010).

Areas that adopt dispersed use strategies to manage ecosystems encourage recreationists to spread out and recreate on undisturbed terrain. Dispersal strategies are only effective, however, where “use intensities are low, vegetation types are durable, and [users] practice Leave No Trace techniques” (Cole & Monz, 2004, p. 83). If these criteria are not met, negative outcomes (i.e., informal trails and campsite formation) can arise. Informal trails, also known as ‘social’ trails, are visitor-created trails that form with repeated foot traffic along the same path. Informal trails might begin as a shortcut or as a game trail eventually used by humans. When vegetation is trampled and soil is compacted, a more desirable path is created, which encourages future use of unmanaged paths (Hammitt et al., 2015). These informal trails are arguably the most widespread environmental consequence of recreation use (Monz, Cole, Leung, & Marion, 2010). They can potentially change species composition and advance soil erosion (Monz et al., 2010).

Previous GPS tracking research has focused attention on the creation of informal trails caused by activities such as hiking, backpacking,