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Research Paper

A new framework for prioritising decisions on recreational trail management

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ABSTRACT

Many Protected Natural Areas provide benefits for both conservation and recreation. The frequent trade-offs between these activities pose challenges for management and require decisions to be made about how to prioritise and direct management actions. Here we propose a new prioritization framework that can provide National Park managers with an enhanced ability to control recreational trail conditions, improve visitor safety, and increase the efficiency of protecting the environment at the same time. Regression tree analysis of a large sample of data collected for the entire trail network in Gorce National Park, Poland revealed that type and amount of use, and type of plant communities, were the most significant factors affecting trail degradation. Based on the level of recreational impacts as well as environmental, use-related and management-related factors, we distinguished 12 types of trail degradation, which we grouped into four levels of degradation to serve as the basis for recommendations for monitoring. We proposed the following monitoring approaches: (1) for trails with an acceptable (minimal) level of degradation – a rapid inventory every 2–3 years; (2) for threatened trails – annual monitoring, preferably immediately following the main tourist season; (3) for damaged trails, which are the type of trail most at risk from further damage – twice-yearly monitoring focusing on sections of trail subjected to changes in type or level of use or subjected to extreme weather events; and (4) for heavily damaged trails – monitoring every 1–2 years, concentrated mainly on sections that may create difficult or unsafe travel conditions. We recommend a full assessment along the entire trail system every 10–15 years.

1. Introduction

Protected Natural Areas (PNAs) such as National Parks often constitute regions that are rich in bio- and geodiversity with beautiful scenery (Adamowicz, Naidoo, Nelson, Polasky, & Zhang, 2011). Currently, they are under increasing pressure to supply both conservation and recreation, which can lead to conflicts of interest (Anon, 1994; Dudley, 2008; Newsome, Moore, & Dowling, 2012). Recreation often brings important revenues for conservation as well as benefits to human health (cf. Rosenberger, Bergerson, & Kline, 2009; Sandifer, Sutton-Grier, & Ward, 2015), so the exclusion of visitors is not an appropriate management strategy. However, recreation unavoidably leads to negative impacts (cf. Cole, 2004a; Monz, Pickering, & Hadwen, 2013). Management needs to be directed towards minimising conflicts between recreation and conservation, although compromises are frequently necessary (Hawes & Dixon, 2014; Maes, Paracchini, Zulian, Dunbar, & Alkemade, 2012). Hence, Park managers must make an assessment of the maximum acceptable level of degradation of the environment and adjust their management actions in an adaptive way so as not to exceed that level.

Recreational trails provide access to tourist attractions scattered across Protected Areas and at the same time restrict visitor traffic to prepared routes. Hence, pristine areas can be protected from human use and impact (Cole, 1993). On the other hand, even low levels of visitor traffic concentrated along trails inevitably exposes them to far more deterioration through wear and tear compared with inaccessible areas (Cole, 2004a; Hammitt, Cole, & Monz, 2015; Leung & Marion, 2000). The adverse impacts of recreational trails on flora, fauna, soil and water resources have been widely reported (e.g. Coleman, 1981; Conradi, Strobl, Wurfer, & Kollmann, 2015; Dixon, Hawes, & McPherson, 2004; Monz, 2002; Ólafsdóttir & Runnström, 2013; Olive & Marion, 2009; Pickering, Rossi, & Barros, 2011; Tomczyk & Ewertowski, 2011; Wimpey & Marion, 2010; Yoda & Watanabe, 2000). Trampling leading to changes in plant community composition, trail widening, develop-

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ment of visitor-created trails, soil erosion and muddiness are problems often encountered.

An increase in trail width means that vegetation cover is reduced, resulting in greater exposure of soil. Bare soil is very prone to geomorphic processes such as surface water flow, wind activity and needle ice development (cf. Yoda & Watanabe, 2000), so as trail width increases, more soil erosion occurs. Soil loss is considered the most persistent negative trail impact as it is irreversible without expensive treatments (Cole, 1985; Dixon et al., 2004; Olive & Marion, 2009). The surface of the trail tread can lower unevenly as erosional rills and gullies develop and plant roots and rock fragments may also be exposed (Marion & Leung, 2001; Tomczyk & Ewertowski, 2013). Such uneven trail surface can degrade the quality of recreational experience and create difficult and unsafe travel conditions (Deng, Qiang, Walker, & Zhang, 2003; Marion & Leung, 2001; Moore, Leung, Matisoff, Dorwart, & Parker, 2012; Verlič, Arnberger, Japelj, Simončič, & Pirnat, 2015). Therefore, visitors can start to trample trailside vegetation, leading to additional trail deterioration such as trail tread widening and/or the development of new parallel trail treads. In consequence, a positive feedback loop is established between increasing total trail width and increasing area prone to soil erosion.

Usually, trails that are used in a sustainable way (i.e. with a type and level of usage compatible with specific environmental conditions) are characterised by a stable and relatively low level of degradation (Cole, 2004b). However, after crossing a tipping point related to the intensity or type of use, deterioration can occur much faster. Furthermore, development of newly damaged sites is more likely than a significant deterioration of previously damaged sites (Cole, 1993). According to Marion and Cole (1996), who studied the impact of developing canoe campsites along the Delaware River, the majority of detrimental impacts occurred during the first year of use. However, recovery took six years, despite this area being characterised by long growing seasons and fertile soils. In another study at Pieniny National Park (a mid-mountain region in the southern part of Poland), Guzikowa (1982) concluded that trampling could destroy grass plant communities in a couple of years. However, regeneration at this less fertile site, following exclusion of recreational use, took up to 15–20 years. In more fragile environments (e.g. in the Arctic or high mountains), damage to vegetation and soil can occur even more rapidly and recovery may take decades or even centuries (cf. Hartley, 2000; Tomczyk & Ewertowski, 2010).

The magnitude of adverse impacts on trails is influenced by factors related to recreational use (e.g. type of use, amount of use, visitor behaviour) and environmental attributes (e.g. vegetation type and density, topography, soil type, climate) (cf. Barros, Gonnet, & Pickering, 2013; Olive & Marion, 2009; Pickering, 2010; Wimpey & Marion, 2010). Management actions can modify many of these factors and consequently avoid or minimize negative trail impacts (Hammitt et al., 2015; Leung & Marion, 1996, 2000; Olive & Marion, 2009). Trail management includes practices such as trail design, construction, maintenance, repair, regulation of type and amount of use, and education of trail users.

According to Hawes & Dixon (2014), effective management of natural areas requires the prioritisation of management decisions. The setting of priorities can identify which tasks are urgently needed in order to limit or avoid the physical and irreversible deterioration of recreational trails and their immediate environs, and which tasks can be postponed without undue environmental and monetary costs. However, methodologies to inform the prioritisation of management activities have received little attention in previous studies.

This study demonstrates how field-based observational data on trail impacts can be used to assist National Park managers in prioritising management tasks. We use regression tree analysis based on data from the recreational trail system in Poland's Gorce National Park (GNP). Trail width and trail incision have been used previously as the two main indicators of trail degradation (Leung & Marion, 1996). In this study we use trail width as the main dependent variable for analysis due to the three reasons. Firstly, data on trail width was available for all sections of the trails and was always greater than zero. In contrast, trail incision can be zero for some sections. For example, in GNP, surveys of all sections of trails showed that an incision > 0.1 m occurs for only 30% of the trails' length; the remainder of the trails were characterised by very limited (less than 0.1 m) or no incision (Tomczyk & Ewertowski, 2011). Secondly, vegetation loss is the primary effect of trampling, and occurs throughout the trail width. As a result, soil is exposed, and secondary erosion processes can occur (Hammitt et al., 2015). The severity of these impacts will therefore be related to trail width. Removal of vegetation cover also has other serious consequences such as habitat fragmentation, decreases in aesthetic values, changes in plant composition and increases in water run-off (e.g. Barros, Monz, & Pickering, 2015; Hammitt et al., 2015; Kim & Shelby, 2006; Wimpey & Marion, 2010). Thirdly, trail width can be measured in a simpler and more time-efficient way than trail incision. Therefore, it is more suitable for monitoring over extensive trail networks.

We propose a new approach to underpin a prioritization framework that can be used to identify locations requiring different frequencies of trail monitoring and indicate trail sections that should be repaired. Priorities are assigned based on recreational impacts as well as environmental, use-related, and management-related factors associated with them. The objectives of the paper are:

1. To analyse types of trail degradation and their spatial distribution within GNP.
2. To investigate the most important factors affecting trail width.
3. To provide Park managers with information that enables the prioritization of trail monitoring tasks and repairs.

2. Study area

The study area for this research was GNP in Poland (Fig. 1). It comprises an area of 70.3 km^2 (Central Statistical Office, 2014) in a mountainous region called the Gorce Mountains (part of the Outer Western Carpathians). GNP is located in a temperate climatic zone, modified by its altitude above sea level. The mean annual precipitation ranges from 700 mm in the foothills to 1200 mm at the highest points (Miczyński, 2006). Forest is the main type of land cover (94%) (Ruciński & Tomasiewicz, 2006), with semi-natural meadows and pastures in the glades. The general pattern of vegetation varies with elevation.

According to the management categories of the International Union for Conservation of Nature (IUCN), GNP is classified as a category II Protected Area (Anon, 1994). GNP is managed for the sake of nature protection and recreation, but more than 50% of the Park's area is strictly conserved. The Park receives 70,000 visitors per year (Central Statistical Office, 2014), mainly hikers (> 94% of visitors) and far fewer mountain cyclists (< 6% of visitors) (Semczuk, Majewski, & Gil, 2014). Recreational trails are prepared for single- or multi-use. Some trails are also used as forestry roads for 4-wheel drive vehicles. According to the simplified theoretical model of environmental sensitivity developed by Tomczyk (2011), some parts of GNP are more prone to trail disturbance than others. Areas that are most vulnerable to recreational impact through trampling are found in the zone of hillsides, while those that are more resistant to recreational impact are found in the valley floors and upper parts of the ridges. The average environmental sensitivity in GNP is not very high; however, 36% of the length of the trails and forest roads are routed in vulnerable areas where high levels of recreational impact will occur (Tomczyk, 2011). Trail impacts are substantial. The average trail width is 2.4 m (range: 0.3 m–24.5 m), and soil loss characterised by maximum incision (i.e. distance between the ground level following trail construction and the lowest point on the trail tread) greater than 0.1 m affects 30% of the trails' length (reaching a maximum incision of 3.4 m)