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# Reviewing Studies on Recreational Trails: A Theoretical Basis for China's Relevant Research

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## Abstract

Many recreational activities related to trails, e.g., running or jogging, biking, hiking, have experienced a dramatic increase. Among all recreational activities, hiking is believed to be the most common one, which produces significant impacts on the ecological system. With the rapid development of China's protected areas (PAs), recreational trails also face many problems. This study reviews the existing research (125 papers) on recreational trails and their impacts in order to provide a theoretical support and referential basis for relevant future research in China's PAs such as national parks and national forest parks. Knowledge, methodologies, data sets on the trail degradation, trail resource impacts, and solutions have been accumulated in the world, and these should be a good base to future studies in Chinese PAs. Although hardened or cement-paved trails have some positive effects, those in most PAs in China should be limited as unpaved trails in other parts of the world.

Key words: China, protected areas (PAs), recreational trails, trails erosion, trails impact

## I. Introduction

A national social survey indicated that the most popular outdoor recreational activity in the USA was walking; 134 million (67 percent) of American people of sixteen years old or over participated into it (Marion and Leung, 2001). Walking happens on neighborhood streets as an everyday activity; however, more commonly on urban, suburban, rural or wildland recreational trails (Cordelll, 1999). Many recreational activities related to trails, e.g., running or jogging, biking, hiking, have experienced a dramatic increase in terms of the participation rate (Cordelll, 1999).

Among all recreational activities, hiking is believed to be the most common one, which produces significant impacts on the ecological system (Cole, 2004). As one of the most common and important infrastructure components, trails are constructed and managed to provide not only an access to destinations in remote protected natural and non-roaded areas (Marion and Wimpey, 2017) but also safe and high quality recreational experiences (Marion and Leung, 2004), nature-based activities such as mountain biking and hiking (Ballantyne and Pickering, 2015a) as well as wildlife observation (Marion and Leung, 2001; Santarém et al., 2015). Hundreds of thousands of kilometres of rails for recreation are found in natural areas with a high value of conservation. In those areas, recreational trails also function as a protection of nature and natural resources from concentrating users' activities and their impacts on narrow and resistant trail surface (Marion and Leung, 2001; Marion and Wimpey, 2007). Therefore, recreational trails are of great importance socially and environmentally.

Research have been done into various types of trails such as formal, informal, bare earth, non-specified, tarmac, paved, sand, gravel, grass and raised metal walkway (Ballantyne and Pickering, 2015b). However, no matter how many categories into which trails are classified, they do exert certain impacts on the environment. Those impacts can be different depending on their design, construction, location, maintenance and use (Ballantyne and Pickering, 2015a).

China is now experiencing a rapid increase in demand for recreational activities in natural environment (Zhou et al., 2013). In order to meet this national need, China has set up many protected areas (PAs) such as national forest parks and national parks, increasing from 600 in 1990 to 2,750 by 2016 (Ministry of Environmental Protection, 2016). This poses great challenges to China because those PAs must be under proper management and face problems such as commercial interests and local human activities (Zhou et al., 2013). Many national parks in China have focused on social and economic benefits (Wang et al., 2012). Many problems have emerged in PAs, e.g., visitor crowding and larger construction or

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Fig. 1. Examples of man-made constructions in China's National Parks (Photos: Liang Chang, 5th June 2017)

artificial architectures (Fig. 1). However, studies from outside of China are not used so far; therefore, reviewing the international studies will provide good reference for future research to cope with such challenges in China.

This paper reviews the existing research on recreational trails and their impacts in order to provide a theoretical support and referential basis for relevant future research in China's PAs such as national parks and national forest parks.

## II. Methodology

Papers collected in this study are all from peer-reviewed journals. This study collected all papers via Google Scholar. Key words such as recreational trails, trail management, and China's national parks are used to ensure that the papers collected are highly relevant.

Most papers were from journals published within the last two decades (Number of papers of China: 15; out of China: 110) as shown in Fig. 2. Then, all papers were classified into 11 different categories, which were further reorganized into 3 major topics. In this study, trail impacts are reviewed not taking trail types into consideration.

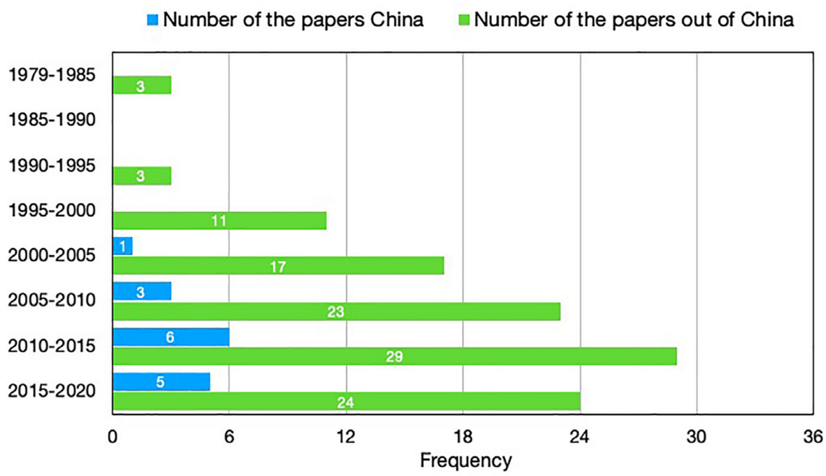


Fig. 2. The number of papers reviewed in this study

## III. Results and Discussion

### 1. Trail Degradation

The problems of recreational trail degradation (in the form of soil erosion) have been recognized worldwide (Mende and Newsome, 2006). One of the problems in many PAs is a management challenge being reported increasingly in various locations, and became common concerns for managers (Jewell and Hammitt, 2000; Ng et al., 2018). Many researchers have paid their attentions to this problem and have conducted quite a number of profound studies (e.g., Randall and Newsome, 2008; Olive and Marion, 2009; Ólafsdóttir and Runnström, 2013; Bodoque et al., 2017; Ng et al., 2018).

Trail degradation can take different forms. For example, Tomczyk et al. (2017) have categorized trail degradation into as many as 12 types of 4 levels (trails with an acceptable level of degradation; threatened tails; damaged trails; and heavily damaged trails) (Fig. 3). Furthermore, they proposed a monitoring method accordingly, which suggests different time intervals from immediate monitoring after the peak season to 2-3 years. However, this classification method is not necessarily universally applicable due to geological

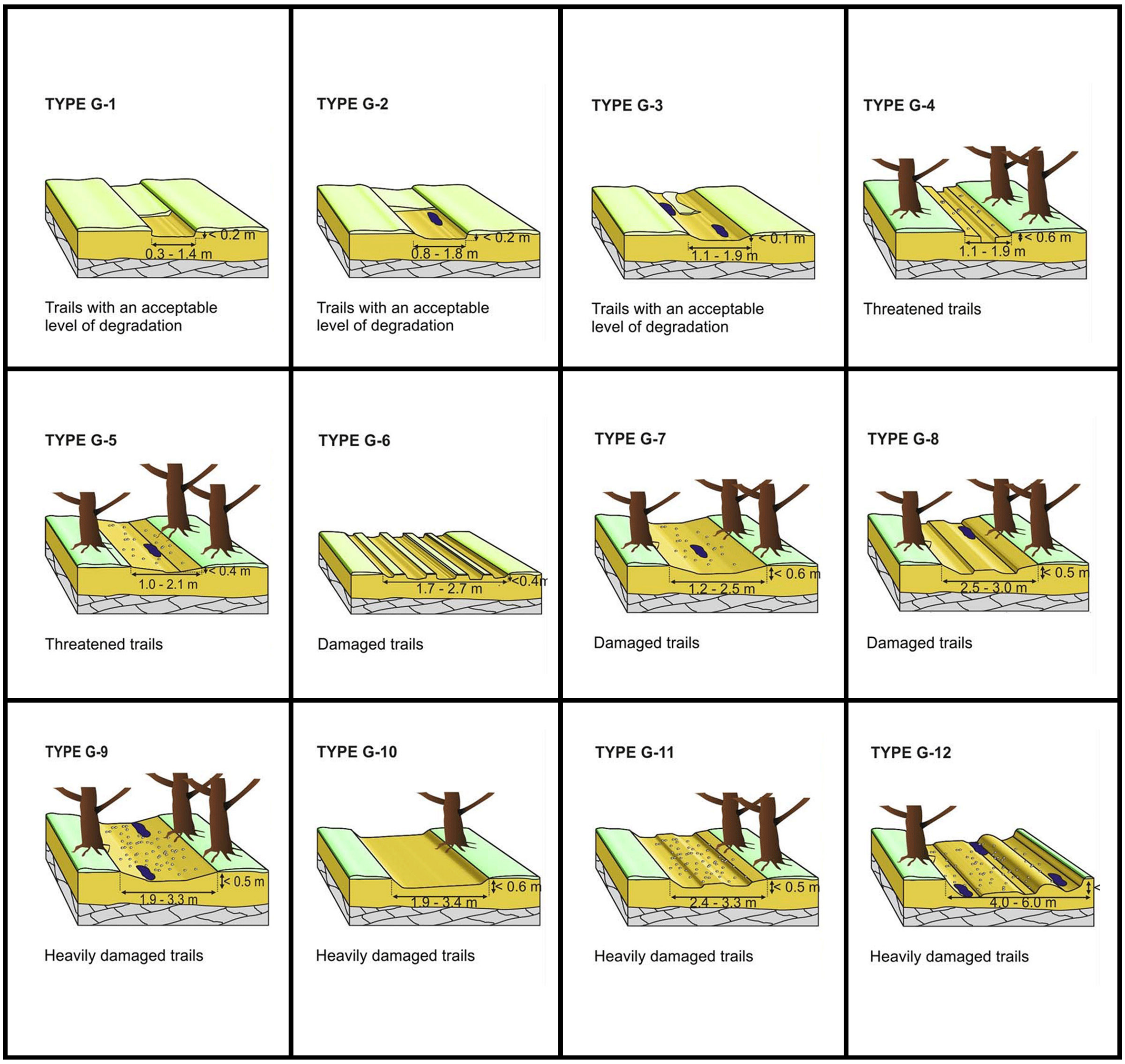


Fig. 3. Types of trail surface degradation identified during field surveys at Gorce National Park (Prepared based on the figure of Tomczyk et al., 2017)

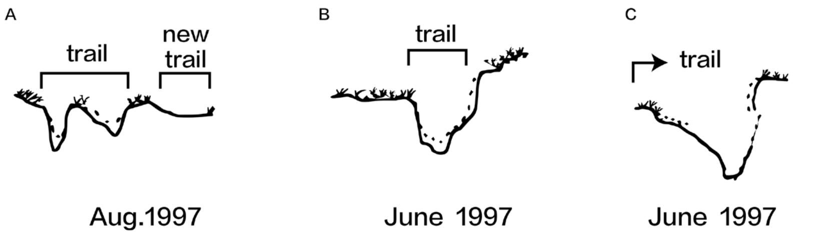


Fig. 4. Three main types of trail degradation in Daisetsuzan National Park (modified fromYoda and Watanabe, 2000)
A: gully type; B: valley-shape type; C: side-wall collapse type).

Table 1. Trail condition classes (CC) (modified from Marion and Reid, 2009).

| CC | Definition |
|---|---|
| 1 | Trail distinguishable; slight loss of vegetation cover and/or minimal disturbance of organic litter |
| 2 | Trail obvious; vegetation cover lost and/or organic litter pulverized in primary use areas |
| 3 | Vegetation cover lost and/or organic litter pulverized within the center of the tread, some bare soil exposed |
| 4 | Nearly complete or total loss of vegetation cover and organic litter within the tread, bare soil widespread |
| 5 | Soil erosion obvious, as indicated by exposed roots and rocks and/or gullying |

diversity. Research previously done in the snowy vegetated area in Daisetsuzan National park, northern Japan by Yoda and Watanabe (2000) found out that gully, valley-shape and side-wall collapse were dominant types (Fig. 4). Degradation levels (severity/condition) also can be different. Olive and Marion (2009) rates trail conditions on a scale of 1–5 (Table 1). This rating system has provided an assessment reference for the research on trail conditions. For example, it was used for the assessment of informal trail conditions by Marion and Reid (2009).

Environmental factors such as vegetation and soil type can certainly contribute to trail degradation: for example, trail widening can be minimized by some plant species in dry grassland (Farrell and Marion, 2001). Snowmelt and wind erosion also cause trail degradation (Yoda and Watanabe, 2000a). Anthropogenic factors such as the type of use (e.g., horse, all-terrain vehicle, and biking), level of use, amount of use are proved to be affecting the trail degradation (Farrell and Marion, 2001). Trail width affecting trail degradation was revealed to be influenced most significantly by type of use (Dixon et al., 2004; Tomczyk et al., 2017). Also, management could produce impacts on trails. Managers can control some influencing factors by direct or indirect manipulation to achieve the goal of avoiding or minimizing impacts caused by recreational activities (Cole, 2004).

Trail slope, substrate and drainage are also important influencing factors, which have attracted many researchers' interests (Rochefort and Swinney, 2000; Marion and Leung, 2001; Marion and Wimpey, 2007; Beeco et al., 2014; Tomczyk et al., 2017).

Trail degradation has its ecological significance because trail degradation will not recover naturally in many cases. Socially speaking, badly eroded and muddy trials may only result in unpleasant recreational experience further leading to many social issues (Jewell and Hammitt, 2000). Thus, many researchers have proposed their methods to mitigate trail degradation from monitoring, assessment, planning to the installation of physical objects, for example, fence. Through monitoring and assessment, crucial information can be obtained to evaluate the current situation needed by management or repairing (e.g., Hugo, 1999; Ólafsdóttir and Runnström, 2013; Yang et al., 2014). Grab and Kalibbala (2008) indicated that properly positioned anti-erosion logs effectively function in sediment re-position, whereas Yoda and Watanabe (2000) demonstrated that the installation of trailside ropes help mitigate degradation and is useful for vegetation recovery. Because users, of course, intend to choose the sides next to the eroded trails to walk on, which can cause a great trampling effect. Ropes can limit their activities within the designated area.

## 2. Trail resource impacts

Common trail impacts such as loss and compositional changes of vegetation, erosion and compaction of soil have received great attentions. Those impacts can be exerted on ecological system (Table 2), which can also make problems to travel difficulty, degraded aesthetics and safety (Marion and Leung, 2001).

Soil compaction, muddiness, erosion and/or trail widening may be triggered by long-term uses of recreational activities (Chatterjea, 2007). Recreational activity caused disturbance such as soil compaction can further lead to overland flow erosion (Törn et al., 2009). Lately, there has been an increase of awareness of the negative impacts produced by soil erosion (Bodoque et al., 2017) and recognition of the importance of this geomorphic process being a crucial factor in the degradation happening in natural protected areas (Wolf et al., 2009). Hence, many researchers have conducted their quantitative assessments on soil erosion rates using various methods. For example, Yoda and Watanabe (2000) adopted a method of installing rigid bars in order to obtain data on the changes in cross-sections of the trail surface. However, in some mountainous areas, due to the harsh environment

Table 2. Common trail resource impacts (Modified from Marion and Leung, 2001)

| Impacts | |
|---|---|
| Form of impacts | Ecological impacts |
| Soil erosion | Soil and nutrient loss, water turbidity/ sedimentation, alteration of water runoff, most permanent impact |
| Exposed roots | Root damage, reduced tree health, intolerance to drought |
| Secondary treads | Vegetation loss, exposed soil |
| Wet soil | Prone to soil puddling, increased water runoff |
| Running water | Accelerated erosion rates |
| Widening | Vegetation loss, soil exposure |
| Visitor-created/ informal trails | Vegetation loss, wildlife habitat fragmentation |

and unfavorable access conditions, it can be very difficult to carry needed equipment to the study area. Therefore, many alternatives emerged. Dendrogeomorphology is one of them. Roots are often found on slopes; thus, using dendrogeomorphology to determine erosion rates over larger surfaces and longer time-span is realistic with annual precision and reasonable spatial resolution (Stoffel et al., 2013).

Wildlife and vegetation can also be significantly impacted by recreational trails. For example, fragmentation of wildlife habitat (Marion and Leung, 2001) and decrease of vegetation cover (Kim and Daigle, 2012) are very common. Miller et al. (2007) conducted research on the influence of recreational trails on breeding birds. They selected two ecosystems: forest and mixed-grass prairie. They found out that bird composition adjacent to trails was altered in both research sites. Moreover, the ground-nesting bird species response most to the recreational trails (Thompson, 2015), which means recreational activities exert great pressure on those species. Mammals are also impacted by recreational trails. For example, Zhou et al. (2013) pointed out smaller mammals (less than 15 kg in weight) are more easily to bear the impacts in human-modified forest types.

Hiking trails can reduce the density and abundance of an important keystone species and alter the composition of vegetation communities, which indicates not only individual vegetation species react to the disturbance. To enhance survival possibility, one keystone species can modify the biotic and abiotic conditions to nurse another, which actually alters the ecological process (Ballantyne and Pickering, 2015a). For those sensitive species with trampling, they can be reduced in size and cover, and even moderate trampling can completely clear them out (Marion et al., 2016). Human's removal or damage to leaves can lead to a worse and degraded health condition due to the fact they are less able to produce enough sugar, which can result in the slow growth of vegetation in several years (Marion et al., 2016).

### 3. Solutions

Many researchers have proposed methods to solve or mitigate the problems related to trails, among which assessment and monitoring have been documented most (e.g., Cole, 1983; Dixon et al., 2004; Randall and Newsome 2008; Monz et al., 2010). White et al. (2006) do not think of trails as merely physical links between different locations but as a part of the whole ecosystem. Therefore, trails should be planned in an ecologically sustainable way. They proposed a complete planning procedure (Fig. 5).

Meanwhile, some researchers have shown their interests in user education (e.g., Marion and Reid, 2009; Farsani et al., 2014; Kidd et al., 2015; Guo et al. 2017; Hockett et al., 2017). Guo et al. (2017) used video and short summary statement to deliver low-impact educational information. Their results suggest that before their activities start, recreationists' behavior can be influenced by those educational messages. Many other relevant research have been well reviewed by Hockett et al. (2017). They have drawn a conclusion that most educational efforts did effectively change visitors' knowledge and behavior.

## IV. Discussion: Application to Chinese PAs

Out of China, we have seen much research done with new insights into recreational trails and relevant issues. Multiple methods have been adopted (Cole, 2004). Not much research directly related to recreational trails in China was seen. Zhou et al. (2013) carried out their study on the trail impacts on mammals and Li et al. (2005) came to a conclusion that vegetation root exposure can be effectively prohibited by applying wooden and flagstone trails. However, there are much research in which trail impacts are parts of them (e.g., Qiang et al., 2002; Xu and Wall, 2007; Zhou et al., 2011; Xu et al., 2013; Liu et al., 2016; Chen et al., 2018). This obviously calls for more research on this topic.

In eight different scenic spots of Qinling Zhongnanshan UNESCO Global Geopark in China, large percentage of recreational trails are hardened (Fig. 6). Hardened trails are good for avoiding the soil compaction; however, Pickering and Norman (2017) indicated that damage to vegetation during construction is severe and that it may not always be proper to harden the trails. In fact, most recreational trails worldwide except China, which are examined in the reviewed papers, indicate that recreational trails in PAs worldwide are not hardened or cement-paved.

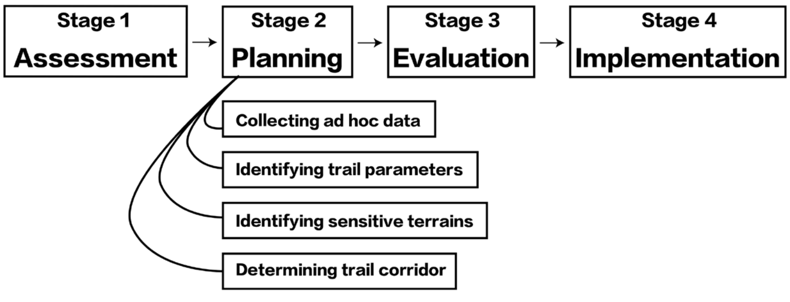

Fig. 5. A planning procedure of eco-trail (prepared based on the descriptions of White et al., 2006)

Fig. 6. Cement-paved hiking trails in Qinling Zhongnanshan UNESCO Global Geopark, China (Photos: Liang Chang, 5th June 2017)

Despite the fact that hardened or cement-paved trails have their positive effects, their percentage in Chinese PAs still should be limited. Hereby, I propose that a buffer zone concept is taken into consideration when planning the PAs in China. In core zones, the length of unnatural trails should be limited.

## V. Conclusions

This study reviewed the existing research (125 papers) on recreational trails and their impacts in order to provide a theoretical support and referential basis for relevant future research in China's protected areas (PAs) such as national parks and national forest parks. Knowledge, methodologies, data sets on the trail degradation, trail resource impacts, and solutions have been accumulated in the world, and these should be a good base to future studies in Chinese PAs. Hardened or cement-paved trails have some positive effects; however, those may not meet an international standard. Such hardened or cement-paved trails observed in most PAs in China should be limited and should be replaced to unpaved trails seen in other parts of the world.

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