# A REVIEW OF RECREATIONAL TRAMPLING IMPACT ON NATURE TRAIL

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## ABSTRACT

*Trampling is the most visible and systematically studied mechanism of recreational disturbance on nature trails. The impact of trampling can be classified to resource components such as soil, vegetation, wildlife and water. This paper reviews the selected literature available on recreational trampling impact in ecosystem especially trail, soil and vegetation, the survey, site comparison and experimental methods used to identify the trampling impact and finally, the research gap of trampling study was identified. The research gap found based on the review are the lack of studies related to the impact of seasonal change as most of the recreational trampling studies involves intensity of trail usage, impacts on vegetation and long-term effect of trampling. In addition, there are also reduced number of studies using the qualitative method. Based on this review, research with both field sampling and questionnaire survey including seasonal change as parameters have been proposed. This type of research can be a baseline for limiting the tourist per activity to reduce the impact to nature as well.*

*Keywords : Recreational trampling impact, Seasonal change, Vegetation, Soil.*

## 1. INTRODUCTION

Trampling is defined as the act of walking upon a natural substrate repeatedly resulting in pressure effect in Cambridge Dictionary. A recreational trampling study is the scientific study of environmental impacts resulting from trampling in protected natural areas (Liddle, 1997; Hammit et. al., 2015).

Initially, trampling was observed and identified as a problem in the early 90s. The first trampling experiment was conducted in the 1930s at the United Kingdom followed by multiple experiments in the United States for the next 20 decades (Cole, 1987; Sun and Walsh, 1998; Cambi et. al., 2015). Active research with rapidly increasing impact and usage were carried out in the period of 1960s to 1970s. As for East Asia, the first trampling experiment was conducted in 1960s (Leung, 2012). Trampling experiments were actively integrated with management framework in the year of 1980s (Sun and Walsh, 1998; Leung and Marion, 2000; Leung, 2012). Starting from the 1990s until now, the trampling studies have been undergoing method refinements as well as an exploration of the new topic from different perspectives such as monitoring protocols, resource protection, and human dimension (Leung and Marion, 2000; Leung, 2012; Pescott and Steward, 2014; Cambi et. al., 2015).

The pattern of methods and approaches to investigate the relationship between trampling intensity or the usage amount with the se-

verity of the impact toward forest ecology have been developed and modified in recreational trampling studies for the past years (Cole, 1987b; 1995; 2004; Growcock, 2005; Pescott and Steward, 2014). The impacts of recreational trampling on ecology was classified into four main elements namely soil, vegetation, wildlife and water which eventually dispersed into other elements such as trail, forest type, season, activities and intensities (Liddle, 1975; Newsome et. al., 2012; Hammit et. al., 2015).

Besides that, studies related to the evaluation of environmental characteristics with the quality of recreational impact also have increased gradually (Buckley, 2004; Pescott and Steward, 2014). According to Marion and Cole (1996), there is also an increase in adoption and implementation of the methods in recreational trampling studies according to the study scope as the time passes. Research on recreation trampling also focused on indicators selection, as well as basic principles and monitoring procedures to support the certain process of management planning (Marion and Cole, 1996; Roovers et. al., 2004; Kissling at. al., 2009).

Therefore, the main purpose of this paper is to identify the gaps in past studies on recreational trampling. Although there are many studies regarding trampling conducted nowadays, there are still some factors which are least considered to be included in trampling studies. The common methods used to evaluate the impact of trampling on the trail, soil, vegetation and season will be reviewed further based on the selected recreational trampling studies.

## 2. REVIEW OF METHODS ASSESSING RECREATIONAL TRAMPLING IMPACT

A large number of recreational trampling assessments has used a quantitative approach which consists of precise data based on sampling and experiments (Marion, 1995; Pickering et. al., 2010). On the other hand, a qualitative approach was used to evaluate the trail condition based on a questionnaire survey and descriptive survey which involves visual monitoring (Rochefort & Swinney, 2000; Marion, et. al., 2011). Therefore, this section was divided into three sub-sections to review common research methods used to evaluate the impact of trampling on the trail, soil, vegetation and season.

### 2.1 Trail impact

A segment of trail research was contributed to the environmental influences on the trail which includes trail widening, vegetation cover, soil compaction and soil erosion (Leung and Marion, 1996; Marion et. al., 2011). Trail impact assessment is qualitative surveys which have been classified into three general types namely trail attribute inventory, trail prescriptive management assessment and trail condition assessment (Marion et. al, 2006).

Firstly, a trail attribute inventory is the inventory survey of recreational trails which includes attributes such as utilization type, point features, trail grade slope ratio and tread substrate (Marion et. al., 2011). This inventory uses professional-grade global positioning system (GPS) units to map trail system characteristics which provide accurate geographic information systems (GIS) trail layers for mapping, planning, carrying capacity planning, analytical, and decision-making functions (Wimpey, 2009; Marion et. al., 2011). On the other hand, inventories of informal trail networks provide data on their spatial distribution, areal extent and aggregate linear (Marion et. al., 1993; Rochefort and Swinney, 2000; Marion and Leung, 2001; Marion et. al., 2006; Leung et. al., 2011).

Secondly, trail prescriptive management assessments evaluated and recorded maintenance needs, sustainability attributes, use-type capabilities, and relocation options (Williams and Marion, 1993; Marion et. al., 2006). Prescriptive assessment work logs documented the condition of work needed on existing trail features, or the need for new features, including gates, barriers, bridges, signs, and tread drainage features (Marion and Olive, 2006; Houston, 2012). Work log assessments must be applied by experienced trail professionals, who prescribe the specific types of trail work needed and to provide materials and estimate workforce (Leung and Marion, 1999; Marion et. al., 2011).

Lastly, trail condition assessments documented trail resource conditions to provide data on the type, severity, and, in some surveys, the location of specific types of trail impacts (Marion and Leung, 2001; Houston, 2012). This assessment is classified into three type of surveys which are point sampling survey, problem assessment survey and condition class survey (Marion et. al., 2011).

Generally, a point sampling survey method assesses trail conditions at

transects established at a fixed interval following a randomly selected first point (Marion and Olive, 2006; Marion et. al., 2011). This approach provides excellent data for characterising and monitoring continuous trail attributes or common impacts such as trail incision and soil loss (Naber, 2008; Houston, 2012; Santarem et. al., 2015). For example, a recent study in Yangmingshan National Park, Taiwan compared the effectiveness of different trail surfacing options such as stones, gravels and concrete in reducing trail widening, a common problem around high-use surfaced or paved trails (Leung, 2012).

A problem assessment survey provides census data by recording every occurrence of predefined impact problems, such as excessive trail width, soil loss, or muddiness (Leung and Marion, 1999; Nepal and Way, 2007; Verlič et. al., 2015). This method provides useful location data to direct trail maintainers for remedy impacts, and also for better indication of less common forms of trail impact such as mudholes and braided trails (Cole, 1991; Marion and Leung, 2001; Marion, 2003; Marion and Olive, 2006; Pickering et. al., 2010; Houston, 2012).

Meanwhile, condition class surveys apply impact ratings based on descriptions of levels of trail impact to characterise sections of trails with similar conditions (Marion, 1995; Wimpey and Marion, 2011; Houston, 2012). Higher ratings indicate greater trail impact. This highly efficient survey method is most commonly applied to informal trail networks to map and track by impact class (Rochefort and Swinney, 2000; Marion et. al., 2006). The majority of the trail condition assessment adopted trail assessment classification system and trail condition scale from Marion et. al., 2006 with some amendments according to the study site (Wood, 2006; Wimpey, 2009; Marion et. al., 2011; Ólafsdóttir and Runnström, 2013).

### 2.2 Vegetation and soil impact

The vegetation and soil parameters are listed as the most common ecological component tested in trampling studies (Hammit et. al., 2015). Basically, there are four type of methods commonly used to determine the vegetation and soil impact in recreational trampling studies which are, the descriptive surveys, site comparison, before-after-control-impact (BACI) and also experimental approaches (Sun and Walsh, 1998; Pescott and Steward, 2014). Most of the past studies referred to these common methods, which was originally proposed by Cole (1987) as guidelines for further and proper modifications. The study design used also depends on the parameters tested in the research.

The descriptive survey involves the estimation or the measurements of the conditions of particular parameters taken on recreational site immediately (Cole, 1987; Leung and Marion, 1999; Growcock, 2005; Verlic et. al., 2015). This method is the easiest method with minimum cost and produces quick results within short period of time (Sun and Walsh, 1998). Descriptive surveys often used together with condition class surveys (Rochefort and Swinney, 2000; Growcock, 2005; Verlic et. al., 2015). The disadvantages of the descriptive survey are the limitation in the production of reliable results as it may not produce accurate information by visual monitoring (Sun and Walsh, 1998; Rochefort and Swinney, 2000; Wimpey, 2009).

On the contrary, site comparison method compares the environmental conditions based on measurements taken on paired disturbed and undisturbed sites (Cole, 1978; 1987; Meryem at. al., 2009). The vegetation and soil impacts will be assessed by paired plotting on trail and control transect adjacent to trail plot with no evidence of trampling on it in order to compare the disturbance (Hall and Kuss, 1989; Kutiel et. al., 1999; Nepal and Way, 2007; Barros et. al., 2013).

Being similar in many ways is the before-after-control-impact (BACI) method, in where, the only difference is the disturbed and undisturbed sites will be compared before and after usage (Cole, 1987; Olive and Marion, 2009). Therefore, the measurements are taken before the site is being used and after the site is being used to determine the amount of damage with specific usage (Growcock, 2005; Holmquist and Schmid, 2008). BACI study design also involves experimental usage of the previously undisturbed area to identify the relationship of environmental damage with the amount of usage (Growcock, 2005; Kissling et. al., 2009; Hesp et. al., 2010).

Finally, the experimental approaches is a controlled experiment, in where, the measurements were taken before and after the treatment usually in the form of usage intensity and frequency applied (Cole, 1987; Cole and Bayfield, 1993). This method is commonly used to quantify vegetation response to the recreational disturbance (Sun and Walsh, 1998; Talbot et.al., 2003; Cole, 2004). The treatment plot includes a control plot with no disturbance and plots with different trampling intensities (Cole, 1995; Pescott and Steward, 2014). The

width and length of the treatment plots will be equal and decided according to the study site (Cole and Bayfield, 1993; Korkanc, 2014; Pescott and Steward, 2014). Sulaiman (1998), conducted an experiment with three trampling treatment turf grass species in few golf club in West Malaysia.

### 2.3 Seasonal change

Growcock (2005) stated that seasonal change is the effect of different season or weather condition to the trampling impact. Subsequent to the previous methods, seasonal change also used the same method but the time factor plays an important role to identify the seasonal change impact (Cole, 1987; Growcock, 2005; Meryem et. al., 2009). The effect of seasonal change on recreational trampling impact tends to be popular in four seasons' countries. Therefore, most of the research was commonly being conducted and compared during summer and winter season (Gallet and Roze, 2001; Dorwart, 2007; Kissling et. al., 2009).

The seasonal change experiments are also being classified into long term impact and short-term impact (Gallet and Roze, 2001). Most of the research conducted to examine the impact of the seasonal change was on long term period (Growcock, 2005; Kissling, 2009; Meryem et. al., 2009). The long-term impact includes the seasonal recovery as well (Cole, 1987; Gallet and Roze, 2002). Trampling studies contributing to the seasonal change in countries without four seasons were proposed to be conducted by comparing results during the dry and wet season (Cole, 1987; Kissling, 2009; Santarem et. al., 2015).

## 3. CONCLUSION

Studies on recreational trampling impact have been conducted by experimenting combination of the methods to identify the trampling impact towards forest ecology. The most commonly tested parameters are the soil and vegetation impacts. Seasonal change is the least used parameters in recreational trampling impact studies, especially in East Asia. The methods popularly used are the controlled experimental sampling with different intensities as well as the comparison of sampling in the disturbed trail and undisturbed trail which acts as a control point.

*Table 1: Summary of selected trampling research with the method, parameters experimented and analysis factor.*

| Author (year) | Method | | | | | | | Parameter/ Variable | | | | | | | Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Qualitative | | | | Quantitative | | | | | | | | | | | | | | | | | |
| | Trail attribute inventory | Trail prescriptive management | Descriptive | Trail condition assessment | Site comparison | BACI | Experimental approaches | Trail | Soil | Vegetation | Season | Forest / Area | Intensity | Activities | Descriptive | ANOVA | t-test | Regression | Chi-square | Biodiversity | Multivariate | Dissimilarity |
| Barros et.al., 2013 | | | | | ✓ | | | ✓ | ✓ | ✓ | | | | | | ✓ | ✓ | ✓ | | | | ✓ |
| Cole, 1987 | | | | | ✓ | | | | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | ✓ | | ✓ | | |
| Cole & Bayfield, 1993 | | | | | | | ✓ | | | ✓ | | | ✓ | | ✓ | | | | | ✓ | | |
| Gallet & Roze, 2001 | | | | | | | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | ✓ | | ✓ | | ✓ | | |
| Growcock, 2005 | | | ✓ | | | ✓ | | | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | |
| Hall & Kuss, 1989 | | | | | ✓ | | | | ✓ | ✓ | | ✓ | | | | | ✓ | | | ✓ | | ✓ |
| Hesp et. al., 2010 | | | | | | | ✓ | | | ✓ | | ✓ | ✓ | | ✓ | | | | | ✓ | | |
| Kissling et. al., 2009 | | | | | | ✓ | | | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | | |
| Konkanc, 2014 | | | | | | | ✓ | | ✓ | ✓ | | | ✓ | | ✓ | ✓ | | | | ✓ | | |
| Leung & Marion, 1999 | ✓ | ✓ | | | | | | ✓ | | | | ✓ | ✓ | | ✓ | ✓ | | ✓ | | | | |
| Marion & Cole, 1996 | | | | | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | ✓ | | | ✓ | | | ✓ | | ✓ |
| Marion & Olive, 2006 | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ | ✓ | | | | ✓ | ✓ | ✓ | | | | | ✓ | |
| Meryem at. al., 2009 | | | | | ✓ | | | | | ✓ | | ✓ | | | | ✓ | | | | | | |
| Nepal & Way, 2007 | | | | | ✓ | | | | | ✓ | | ✓ | | | | | ✓ | | | ✓ | | ✓ |
| Olafsdottir et. al., 2013 | ✓ | | ✓ | ✓ | | | | ✓ | ✓ | ✓ | | ✓ | | | | | | | ✓ | | | |
| Olive & Marion, 2009 | | | ✓ | ✓ | ✓ | | | | ✓ | | | | ✓ | ✓ | | ✓ | | | | | ✓ | |
| Pickering et. al., 2011 | | | | | | | ✓ | | ✓ | ✓ | | | ✓ | ✓ | | ✓ | | | | | | ✓ |
| Talbot et. al., 2003 | | | | | | | ✓ | | ✓ | ✓ | | | ✓ | | ✓ | | | | | | | |
| Verlic et. al., 2015 | | | ✓ | ✓ | | | | ✓ | | | | ✓ | | | | | | ✓ | ✓ | | | |
| Wimpey et. al., 2011 | ✓ | | ✓ | ✓ | | | | ✓ | | | | ✓ | | ✓ | ✓ | ✓ | ✓ | | | | | |
| CURRENT STUDY | | | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ | | | | ✓ | ✓ | |

Hence, the objective of this paper which is to identify the gap of recreational trampling studies has been achieved. The studies gap found is a lack in seasonal change parameter used in trampling impact studies. The summary of selected studies from the review has been tabulated in Table 1 to identify the gaps of the trampling studies clearly. Therefore, based on this literature review, the parameters as well as the research methods and analysis of my current study was determined. The research on trampling was conducted during the dry and wet season with a combination of different research methods and analysed using advanced statistics.

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