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# Light Intensity and Soil Compaction as Influenced by Ecotourism Activities in Pahang National Park, Malaysia

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Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/intechopen.74204>

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## Abstract

Pahang National Park provides a diversity of flora and fauna, which is popular for ecotourism activities within Malaysia. The ecotourism activities such as trekking and camping may result in some degree of changes to the forest condition in the protected areas. Therefore, a study was conducted to investigate the influences of ecotourism activities on the light intensity and soil compaction in Pahang National Park. A total of 40 plots measuring at 20 × 25 m were established in camping area, trekking trail and natural area of the park. The light intensity and soil compaction were measured using hemispherical photography at nine points and a hand penetrometer at five points, respectively, randomly selected in each plot. The Analysis of Variance shows there was a significant difference in the means of light intensity and soil compaction in three study sites ( $p < 0.05$ ). The light intensity in the trekking trail is significantly greater than in natural area (18.87% vs. 13.13%). The soil compaction in the trekking trail is significantly greater than in natural area and camping area ( $p < 0.05$ ). This may suggest that ecotourism activities especially trekking activity has significantly influenced the trend of forest light intensity and soil compaction in Pahang National Park.

**Keywords:** ecotourism, forest environment, light intensity, soil compaction, Pahang National Park

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## 1. Introduction

In recent years, national parks and protected areas across the globe have become increasingly popular for recreation and ecotourism. National parks and protected areas are rich with

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natural resources and contain geomorphological structure, climate and rich biological diversity, and these areas have an important place in the continuance of the ecological cycle. These attractions may encourage tourist all over places to come and enjoy the nature. According to Lowman [1], ecotourism could be defined as nature-based tourist experiences where visitors travel regions for the sole purpose of appreciating natural beauty. Pahang National Park provides a diversity of flora and fauna and attracts a growing number of local and international visitors. However, many studies revealed that recreational activities have provided various impacts on natural ecosystems. Human activities such as the trampling and camping activities are the most widespread and can readily lead to recreational degradation of natural ecosystems [2–4]. Given the intricacy of protected area ecosystem, ecotourism activities may result in ecosystem disturbance, thus affecting vegetation growth and surface profile.

Disturbance can be natural or in anthropogenic forms which may influence the structure of forest stands. However, natural disturbances, normally, do not influence the forest ecosystem to the greater extent. Conversely, when it comes to the human intervention to forest ecosystem, it will have possible changes to the biodiversity and its surroundings drastically. Thus, study should be considered to produce information and knowledge to manage, to reduce or to sustain the present forest areas. Protected area is believed to be one of the ways to conserve forest area, but somehow ecotourism activity that developed within its place may affect the forest stand patterns. Many studies have suggested that the ecotourism activities provide influences on the richness, diversity and ecological interaction in many forest areas on earth [5–8].

The forest environment is a part and vital for propagation and growth for many kinds of vegetation including herbs, shrubs, bamboo, palm, trees and others. Besides that, vegetation condition in the forest is sensitive toward some levels of disturbance which affect the growth of stand structure within forest ecosystem. Extensive ecotourism activities can cause disturbance which may result in temporal and spatial changes in the morphology of the canopy structure of the forest. A study [9] mentioned that forest stand structure influences the quantity, spectral quality and temporal and spatial variability of solar radiation received by the understory. Some levels of disturbance to the surrounding vegetation may reflect or change the light condition. Forest canopy structure comprises the complex spatial arrangement of foliage, branches and the stem of trees, which influence a wide range of biophysical and ecological processes to the properties of the understory environment in a forest ecosystem [10, 11]. Studies have shown that a strong relationship exists between forest canopy structure and understory light transmittance [12, 13]. In addition, light is one of the most important factors regulating survival and growth of understory trees where light is an essential component in photosynthetic process for trees and other plants.

Among popular activities that occur in Pahang National Park are hiking, trampling and camping. These activities may provide impact to the soil condition and suitability for tree growth. As part of maintenance, trail condition and camping area should be maintained to ensure a minimal ecological disturbance to the protected area and to preserve natural conditions. These were implemented by the park managers to minimize impacts on environment and natural resources. According to Wimpey and Marion [14], formal trails could be developed by the park managers to provide recreational opportunities to visitors, and hence they

are planned and designed to direct visitors to areas less prone to disturbance. Trails and camping area should be routed, constructed and maintained to concentrate foot traffic and related impacts to minimize the areal extent of trampling damage such as to soil and vegetation. The high use of trails may cause soil compaction and increase in bulk density. Compression of the soil structure leads to a reduction in air and water movement, reduced water infiltration and a decreased water retention, except for coarse-textured soils [6, 15].

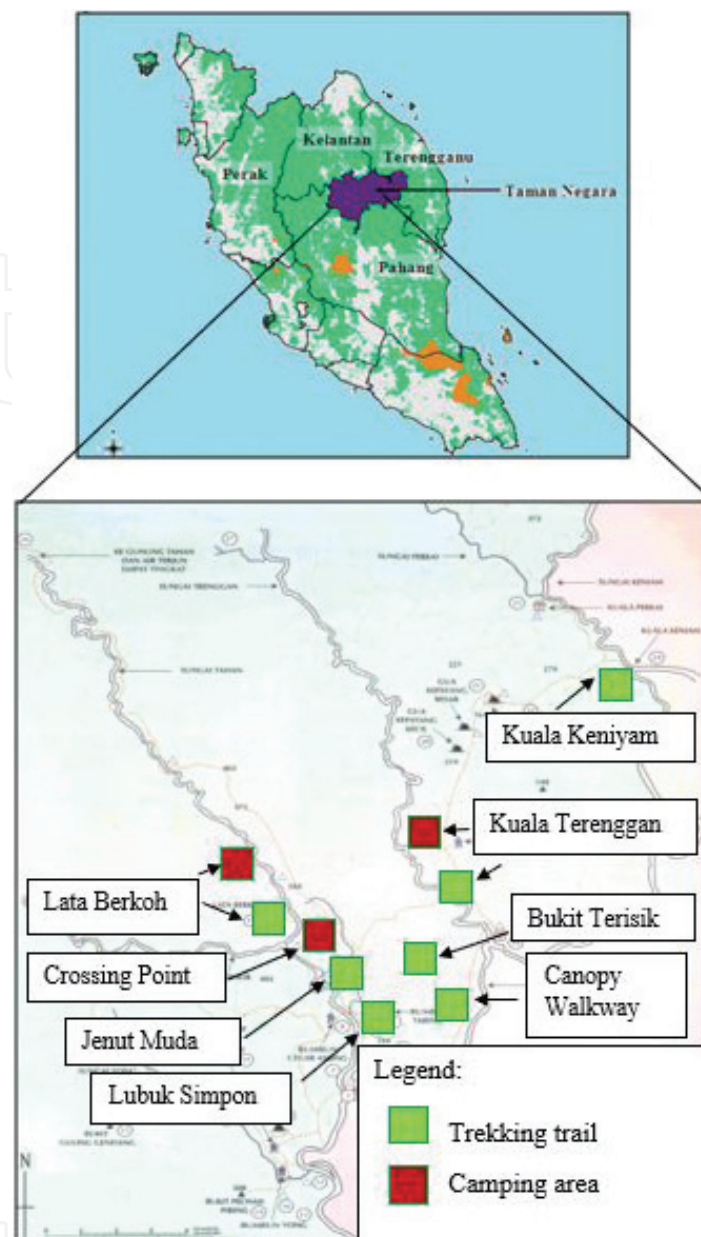
A study on ecotourism impact is needed in Pahang National Park which involves environmental factors such as light intensity and soil compaction that result from ecotourism activities. A comprehensive study that scientifically examines the impacts of recreational practices on the light intensity and soil compaction is still lacking. Therefore, a study is required to provide information for the development of effective management plan for recreational activity. Hence, in general, this study aimed at investigating the influence of ecotourism activities (i.e., trekking and camping) on light intensity and soil compaction of Pahang National Park.

## 2. Materials and methods

### 2.1. Study area and data collection

This study was carried out in Pahang National Park (approximately latitude 4° 19' N, longitude 102° 23' E) near Jerantut, Pahang. The elevation ranges between 120 and 200 m above sea level. Pahang National Park covers a total forested area of 2477 km<sup>2</sup>. The topography consists mainly of lowland, undulating and riverine areas. Data were collected in eight locations of forest in Pahang National Park including Kuala Kenyam, Lata Berkoh, Crossing Point, Bukit Terisik, Canopy Walkway, Lubuk Simpon, Jenut Muda and Kuala Terenggan (**Figure 1**). A study by Suratman [16] indicated that the weather in Pahang National Park is characterized by permanent high temperatures ranging from 20°C at night and 35°C in the day with high relative humidity (above 80%). The rainfall at this park is ranging from 50 to 312 mm throughout the year of 2012. The topography consists mainly of lowland, undulating and riverine areas. The overall vegetation in Pahang National Park is lowland dipterocarp forests which are characterized by high proportion of species in the family of Dipterocarpaceae and Euphorbiaceae as dominant families. Hydrologically, Pahang National Park consists of two headstreams of Tahan River and Tembeling River with the presence of riparian tree species mainly Keruing neram (*Dipterocarpus oblongifolius*) along the bank of these two rivers.

This study adopted a standard experimental procedure for studying recreational trampling on vegetation as proposed by Cole and Bayfield [17] with some modifications. Their study has derived conclusions by comparing the vegetation in trampled sites with the vegetation of untrampled site. For study site selection, Department of Wildlife and Protected Parks of Malaysia (DWNP), the custodian of Pahang National Park has listed out a few suggested study sites within this park. Thus, the selected study sites as in **Figure 1** were chosen with respect to the safety concern by the DWNP. With regard to the restriction, the data collection activities were focused to the main recreation areas, i.e., seven sites for trekking trail and three sites for camping



**Figure 1.** Map of Pahang National Park and distribution of study plots.

area. The imbalance number of study sites between trekking trail and camping area was due to the limited number of camping area within Pahang National Park. On the selected study sites, the plots for trekking activity were established on the middle of the trekking trail sites, while the plots for camping activity were developed on the middle of the camping area sites. In this study, a total of 28 plots for trekking trail and 12 plots for camping area (each plot 20 m × 25 m in size, as workable units) which consist of 4 plots of each for undisturbed and disturbed area, respectively, were established. Therefore, the accumulated total study area was 2 ha. For undisturbed area, the plots were located 10 m away from disturbed area plots and were selected randomly either on the left or the right side. All undisturbed condition plots were marked as natural areas while the disturbed condition plots either trekking trail or camping area.



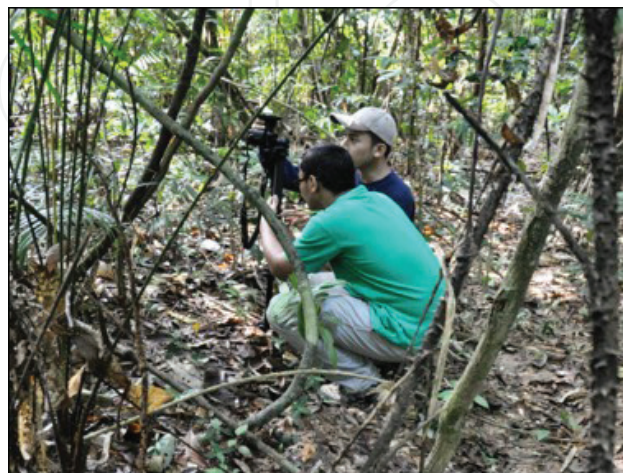
The field measurement activities within 10 study sites of the park began in August 2014 and ended in November 2015. The forest inventory, light intensity and soil compaction measurements were recorded for each site over a 2-week working time of a particular month along the stated field study duration. However, data collection activities were entirely depending on the weather condition of Pahang National Park. Methods of light intensity and soil compaction measurements are explained in the next subsequent section.

## 2.2. Measurement of light intensity under tree canopy

To determine the light intensity in the forest understory, nine points were laid out randomly in each plot. The measurements of light intensity were made at each point using the hemispherical photography (**Figure 2**). All hemispherical photographs were taken with Nikon Coolpix 4500 digital camera (Nikon, Tokyo, Japan) fitted with a Nikon FC-E8 fisheye converter (**Figure 3**). The camera was mounted on a monopod at the height of approximately 1 m above the ground. The camera and lens were leveled with the aid of a spirit level and oriented to magnetic north. Lhotka and Loewenstein [13] suggested that the measurements were made under overcast conditions, usually in the late morning hours. The digital images were processed based on a procedure developed by Ishida [18]. All images were analyzed to calculate the percentage of diffuse light intensity under the canopy (SOC percentage) using RGBFisheye ver.2.01 (Gifu, Japan).

## 2.3. Measurements of soil compaction using static cone penetrometer

Measurements of soil resistance were conducted using a hand-held cone penetrometer which is known as static cone penetrometers. This tool was used to measure soil resistance to vertical penetration of a probe or cone as in **Figure 4**. Soil compaction is often characterized by changes in soil bulk density, typically expressed in  $\text{Mg/m}^3$  or  $\text{g/cc}$ . Soil density is also related to soil resistance, which can be measured using a penetrometer much more rapidly than bulk density can be obtained [19]. Some soils are difficult to sample consistently due stony, light-textured or highly friable soils by hammer-type bulk density samplers using corers and rings. Therefore,



**Figure 2.** Measuring of light intensity through hemispherical photography.



**Figure 3.** Camera and Nikon FC-E8 fisheye converter.

cone penetrometers are commonly used to measure soil compaction because of their easy, rapid and economical operation [20].

In this study, hand penetrometer Eijkelkamp was used to measure soil compactions. Five points were sampled randomly and assessed in each plot. The measurement of soil compaction using a static cone penetrometer measures the force required to push a metal cone through the



**Figure 4.** Measuring of soil compaction through penetrometer.

soil at a constant velocity. The force is expressed in Newton (N). The manometer values recorded were then converted into mega pascals (MPa) using the following formula:

$$\text{cone resistance} = (\text{manometer reading})/(\text{base are of cone})$$

(1)

where manometer is in Newton and base area of cone is in cm.

As the penetrometer was being pushed down to the soil, the compaction value was recorded for each sample in a plot in a datasheet. While the methods for static cone penetrometer operation have been standardized, there are some precautions for its usage. Static penetrometer must be moved through the soil at a constant velocity (i.e. pressure); different rates of insertion by different operators can yield variable results [21].

All data in this study were managed using Microsoft Excel worksheets, and all statistical analyses were performed using R Statistical Software Version 3.2.0 and Rcmdr Packages [22].

### 3. Results and discussion

#### 3.1. Light intensity

**Table 1** shows a summary of light intensity percentage for three study sites. From the analysis of variance (ANOVA), it was found that there is a significant difference in the means of light intensity between the three study sites ( $p < 0.05$ ). This suggests that ecotourism activities have significantly influenced to the amount of light penetration within forest understory. Next, a multiple comparison test (i.e., Tukey’s test) indicated that there is no significant difference in the means of light intensity between camping area vs. trekking trail and camping area vs. natural area ( $p > 0.05$ ). However, the light intensity in the trekking trail is significantly greater than in natural area (18.87% vs. 13.13%). The mean value recorded for trekking trail is the highest among three study sites (**Table 1**). Therefore, trekking and hiking activities are influencing the trend of light intensity within the forest area of Pahang National Park.

This study also recorded the composition of tree species in all study sites. Information on the uniformity of tree species in all study sites is crucial to the study as ecological adaptations of

Study site	No. of sample	Percentage of light intensity (%)	Minimum light intensity (%)	Maximum light intensity (%)
Camping area	54	17.06 ± 11.74 <sup>a,b</sup>	3.16	49.30
Trekking trail	126	18.87 ± 12.91 <sup>b</sup>	3.39	64.24
Natural area	180	13.13 ± 10.11 <sup>a</sup>	2.35	71.32

*Note:* All values for percentage of light intensity are mean ± SD. Means with same letter indicate no significant difference at  $p < 0.05$ .

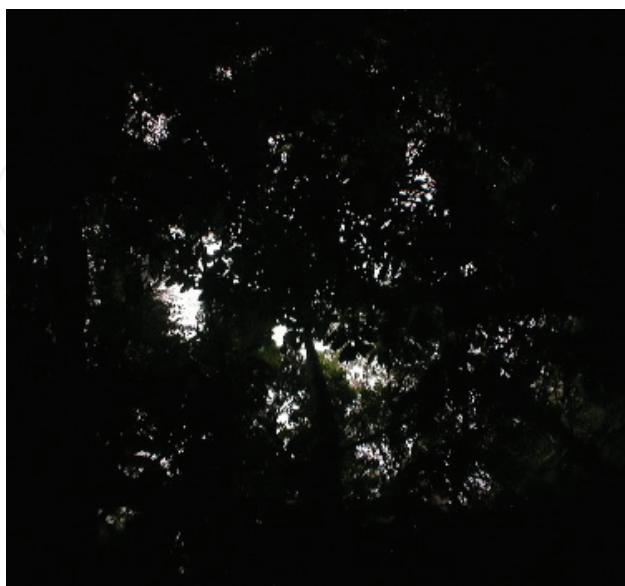
**Table 1.** Descriptive statistics for light intensity between camping area, trekking trail and natural area of Taman Negara Pahang.



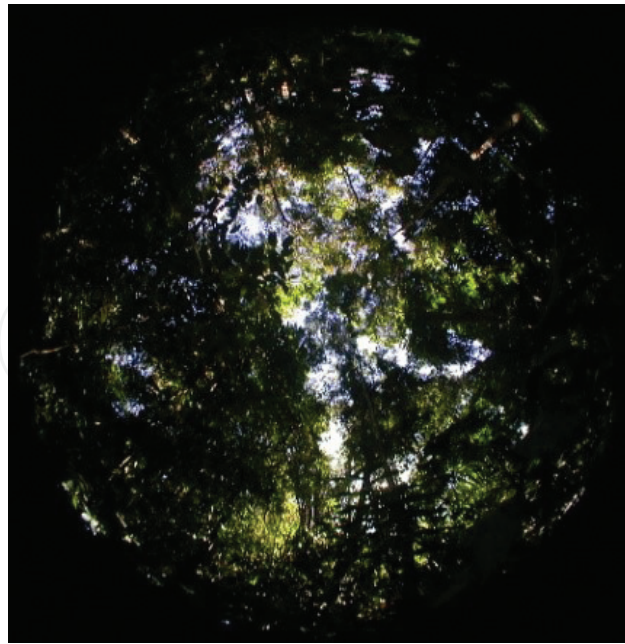
tree species and its environment could also influence the changes of light intensity in a forest area. The condition of the tree canopy structure that comprises of the complex spatial arrangement of foliage, branches and the stem of trees totally depends on the tree species, ecological interaction of the species and corresponding competitiveness. From the analysis of importance value index (IVI), it was found that the dominant tree species occurred in these three study sites were similar where Perah (*Elateriospermum tapos*) and Meranti tembaga (*Shorea leprosula*) are among the tree species with highest IVI [23]. According to Curtis and McIntosh [24], the tree species with highest IVI exist in the greatest number or the greatest size where they produce the greatest effect on the tree community and its surrounding. Hence, in this study it was observed that tree species was not so much different in natural area; trekking trail and camping area and the value of light intensity shall be compared and pooled as in **Table 1**.

In the current situation, very few published studies have characterized the light intensity in tropical forest resulted from anthropogenic influences using hemispherical photographs. Then, values obtained from this study are discussed and ecologically compared with the other studies elsewhere. Tree requires light to grow, and thus light may influence the regeneration dynamics [25, 26]. The bigger size of canopy openness will then allow some amounts of light penetration directly into the forest floor and trigger the tree seed germination [27]. **Figures 5–8** show the variations in canopy opening as captured through hemispherical photograph from three study sites of Pahang National Park. All the photographs were then analyzed using RGBFisheye software to obtain the percentage value of diffuse light intensity that is captured by the camera.

As comparisons with study by Beaudet and Messier [25] on light transmission recorded in the Duchesnay Forest Station and Mousseau Forest, Québec (Canada), which dominated by tree species of *Acer saccharum*, *Betula alleghaniensis* and *Fagus grandifolia* stands. The description



**Figure 5.** Digital image taken from hemispherical photograph for natural area.



**Figure 6.** Digital image taken from hemispherical photograph for trekking trail.



**Figure 7.** Digital image taken from hemispherical photograph for camping area.

about the studied area is that the stands had been logged, using the selection system and while the control area was uncut forests. The gap light index (GLI) values obtained from the previous study were ranged from 3.1 to 37.2% for cut forests and 3.0 to 16.5% in the control forests. The trend GLI values of light transmission for this previous study show the higher percentage in



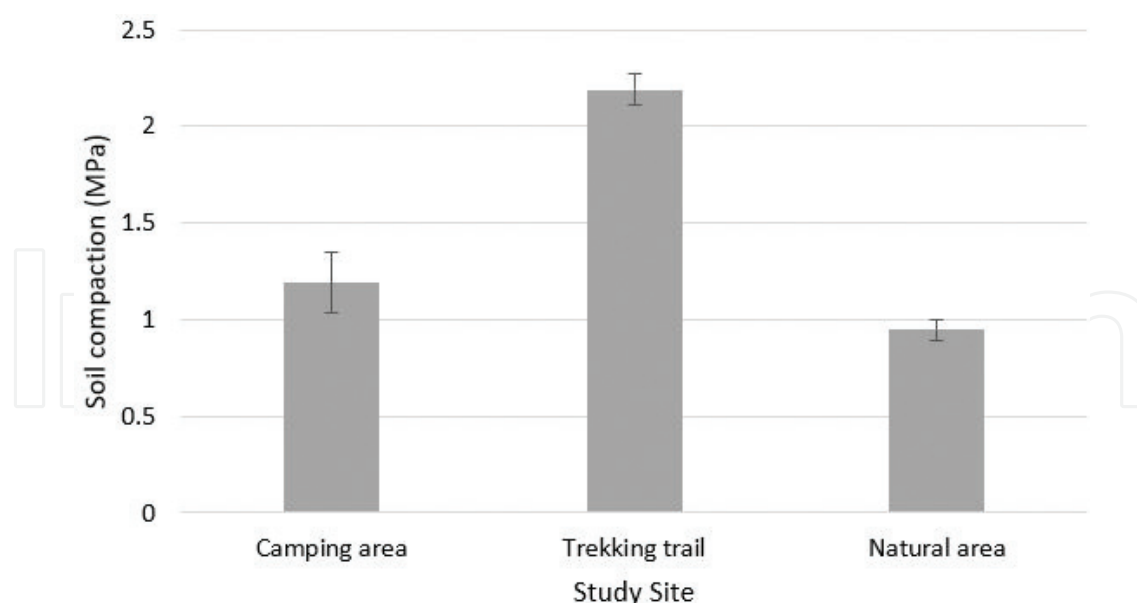
**Figure 8.** Digital image taken from hemispherical photograph for open area.

the cut forests than the control forests. Thus, this trend shows that human activity (i.e. cutting forest) is affecting the light condition within a forest area. According to **Table 1**, camping area and trekking trail are slightly higher in the percentage of light intensity than the natural area. Canham et al. [28] also in their study at the United States and Costa Rica found that the GLI values for closed canopy of five study sites were ranged 0.5–5.2% and the GLI values for canopy opening were ranging between 36.8 and 67.6% at the same sites.

In recent study, through the field observation, trekking trail is frequently used by the visitors, and this will affect the tree growth and influence the tree structure. The lack of large tree structures may result in the less number of big canopy and lead to the greater light intensity in the forest understory that is captured by the hemispherical photography, while in camping area, the light intensity remains stable between disturbed and undisturbed conditions. However, there was an argument that the damage on forest stands and its diversity may not be solely affected from human intervention especially in the protected area. Other aspects such as biotic and abiotic elements may have also been contributing factors influencing the situation [29–31], which is not the intention of this study that focused on the physical aspects of human intervention through ecotourism activities to the forest area. Nevertheless, from the statistical analysis, it was found that the ecotourism activities especially to the hiking and trampling activities have caused the canopy openness and allow the greater light penetration to the forest floor.

### 3.2. Soil compaction

Soil compaction measures the penetration resistance of soil in Pahang National Park as reflected from ecotourism activities. From the analysis, the mean of penetration resistance of



**Figure 9.** Soil compaction for camping area, trekking trail and natural area of Pahang National Park.

soil for camping area, trekking trail and natural area was 1.19, 2.19 and 0.95 MPa, respectively (**Figure 9**). From ANOVA, it was found that the means of penetration resistance between three study areas were varied significantly ( $p < 0.05$ ). This may suggest that the ecotourism activities have significantly influenced to the soil compaction of Pahang National Park. Therefore, a multiple comparison test (i.e. Tukey's test) was performed indicating that there is no significant difference in the means of soil compaction between camping area and natural area ( $p > 0.05$ ). However, the soil compaction in the trekking trail is significantly greater than in natural area and camping area as shown in **Figure 9**.

All the penetration resistances of soil compaction in this study were comparable with penetration resistance in study by Ampoorter et al. [32] where they found the value of 0.36 MPa at the ground surface to 2.51 MPa at 80 cm depth for undisturbed conditions in two sandy forests of Putte (the Netherlands). According to other previous studies [33, 34], tree root growth for many plants becomes restricted when soil penetration resistance exceeds 2.00 MPa and stops at resistances greater 3.00 MPa. Many previous studies were agreed that a range of 2.00–3.00 MPa of soil compaction is affecting the pattern of tree growth, but study in oak forests in the northern half of France by Wei et al. [35] found the higher soil compaction detected on skid trails, which does not necessarily mean that it will have significant effects on ground flora. This is because flora could survive with penetration resistance to the ground up to 2.5 MPa. Thus, compacted soil may influence the trend of tree development. Eventually, it will affect the tree diversity and species composition within a forest area.

Despite that Pahang National Park is a protected area, the status of soil compaction sounds vital information for management of the park. While this study observed the trekking trail is frequently used by the tourists for purpose of enjoying the nature, jungle trekking, mountain hiking, bird watching, picnic by the river, visiting the cave, wildlife hide, etc. Besides that, a



social study by Ibrahim and Hassan [36] found Pahang National Park is among of popular ecotourism destinations in Malaysia where in 2008 approximately more than 40,000 international tourists arrived at this park. The local, domestic and ASEAN tourists were approximately more than 20,000 who visited Pahang National Park in the same year. Majority of stated tourists were staying at the provided hotel and chalet around of Kuala Tahan. This may suggest that camping areas were the lesser used by the visitors to do their activities within the forest area as their interest to enjoy the nature and get back to hotel or chalet for overnight. Therefore, trekking trail was recorded higher soil compaction than the camping area and natural area. The degree of soil compaction is totally depending on disturbance type and visit frequency [37].

#### 4. Conclusion

Pahang National Park is visited by many local and international tourists, which through their activities would lead to the implications on forest conditions. Therefore, measurement of light intensity and soil compaction assessed in Pahang National Park will surely shed new insight on protected forest management in Malaysia. This study revealed that ecotourism activities have a significant influence on light intensity and soil compaction within three study sites. Based on the findings, there was significant difference between natural area and trekking trail. Study also found there is no significant difference on camping area vs. natural area and camping area vs. trekking trail for light intensity, while in the context of soil compaction, from the multiple comparison test, there was a significant difference between camping area and trekking trail and natural area and trekking trail. No significant difference found between camping area and natural area. Thus, trekking trail was found the most influenced by the ecotourism activities compared to the camping area. And the natural area was classified as the undisturbed condition and used as the control plots. It is clear that to fill the void in our knowledge, study should be done to learn more about the trend of ecotourism influence to the forest area of Pahang National Park. The number of sample for camping area needs to be increased, and relationship between the frequency of visitors and the influences on variables should be looked thoroughly.

#### Acknowledgements

We thank the Ministry of Higher Education (MoHE) for supporting this study through Fundamental Research Grant Scheme (FRGS). We would like to thank the Department of Wildlife and National Parks (PERHILITAN) for granting permission to use Pahang National Park for the study area. Special thanks go to Professor Dr. Yap Bee Wah, a statistician of Universiti Teknologi MARA (UiTM), for her support and explanation on the statistical parts, and finally to my research assistants who aided during the field data collection.

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