THE EFFECT OF RECREATIONAL TRAIL ON THE DISTRIBUTION OF SELECTED HERBACEOUS PLANTS AND SOIL COMPACTION IN TAMBUNAN RAFFLESIA CENTER, TAMBUNAN, SABAH.

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DECLARATION

The materials in this thesis are original except for quotations, excerpts, summaries and references, which have been duly acknowledged

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ABSTRAK

THE EFFECT OF RECREATIONAL TRAIL ON THE DISTRIBUTION OF SELECTED HERBACEOUS PLANTS AND SOIL COMPACTION IN TAMBUNAN RAFFLESIA CENTER, TAMBUNAN, SABAH.

Hutan Simpat Rafflesia Tambunan mempunyai satu kemudahan pelancongan am yang dikenali sebagai Pusat Rafflesia Tambunan. Objektif kajian ini adalah untuk menentu serta menilai mampatan Tanah, komposisi tumbuhan herba sepanjang rintis rekreasi dalam hutan tanah tinggi. Kaedah yang digunakan dalam kajian adalah a) kaedah penentuan *soil bulk density*, dan b) kaedah *point frequency*. Hasil kajian ini telah mendapati rintis rekreasi memberi kesan negatif ke atas ekosistem hutan tanah tinggi, walau bagaimanapun ia hanya sehingga 25 cm dari pusat rintis. Dalam kajian ini, mampatan tanah sepanjang rintis adalah 0.55 gcm^{-3} dan menurun kepada 0.32 gcm^{-3} di luar rintis. Kajian ini juga menunjuk kesan negatif rintis ke atas Pothos sp. dan Anadendrum sp. Di luar rintis rekreasi, kesan negatif ini adalah tidak begitu ketara. Di samping itu, kajian ini menunjukkan bahawa Pothos sp. kerap ditemui di sepanjang rintis dan merupakan tumbuhan herba yang dominan berbanding dengan Anadendrum sp. Kesan rekreasi rintis ke atas aroid adalah tidak ketara. Dari kajian ini, aktiviti pelancongan sepanjang rintis rekreasi menghasilkan kesan negatif ke atas hutan tanah tinggi kerana ia meningkatkan mampatan Tanah serta mengubah taburan tumbuhan-tumbuhan herba yang tertentu. Ciri-ciri semulajadi seperti kecuraman rintis serta keadaan lopak akan meningkatkan lagi kesan negatif rintis rekreasi ke atas ekosistem hutan tanah tinggi. Untuk ini, mempelbagaikan tarikan pelancongan di TRC merupakan satu cara mitigasi terhadap isu ini.

ABSTRACT

THE EFFECT OF RECREATIONAL TRAIL ON THE DISTRIBUTION OF SELECTED HERBACEOUS PLANTS AND SOIL COMPACTION IN TAMBUNAN RAFFLESIA CENTER, TAMBUNAN, SABAH.

Tambunan Rafflesia Forest Reserve has a facility known as Tambunan Rafflesia center which caters for mass tourism. The objective of this research is to determine effect of recreational trail by looking at soil compaction and distribution of selected herbaceous plants along a recreational trail in lower montane forest. The methods used in this research are a) soil bulk density study, and b) point frequency method. The findings of this research confirm that recreational trail has a negative impact on the lower montane forest ecosystem, but only up to about 25 cm from trail center. From this research the soil bulk density along recreational trail is 0.55 gcm^{-3} and reduces to about 0.32 gcm^{-3} off the trail. This research also shows that there is a negative impact on Pothos sp. and Anadendrum sp.. due to the recreational trail. Off the recreational trail, the impact on the aroid is not noticeable. Furthermore, this research shows that Pothos sp. is frequently found along the recreational trail and is more dominant than Anadendrum sp.. From this research, tourism activity along recreational trail has a negative impact on highland forest as it increases the soil compaction and changes the distribution of certain herbaceous plants. The natural features such as the trail steepness and waterlogged condition enhance recreational trail impact onto the forest ecosystem. As such, diversification of TRC's tourists' attractions is a possible mitigation towards this issue.

ABBREVIATIONS

MOCET	:	Ministry of Culture, Arts and Tourism.
TRC	:	Tambunan Rafflesia Center
TRFR	:	Tambunan Rafflesia Forest Reserve
OT	:	Other (non-selected herbaceous plant)

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CHAPTER 1

INTRODUCTION

Ecotourism is booming in Asia and a number of countries have embarked on enthusiastic ecotourism development programs to reinforce its economical benefits. However, ecotourism explode and employ environmentally sensitive area such as park or conservation reserves. Peters (1999) claimed that this area is just beginning to be studied and there are very few researches been done.

1.1 Tourism development and Impact

The demands of ecotourism in Malaysia have been increasing steadily for some years. More conservation areas, which are high in faunal and floral values, are opening up for the tourist to meet these demands. Therefore, the priority for ecotourism relates to ecological management that must be taken into consideration so that the damage caused by the industry will be minimal, remediable and within its carrying capacity.

In order to use the concept in carrying capacity in the management of forested area, we need to understand the impact of trail under different forest conditions. Among the extremely vital factors to decision making in determining the policy of their management are the soil and vegetation responses to various levels of recreational use. Study has been done by Peters (1999) on "The Impact of Recreational Trial Usage On Forest Ecosystem" and Pamin (2005) on "Experimental research on the effect of human trampling on different vegetation types in Sukau, lower Kinabatangan" relates to the management of soil and vegetation responses.

However, nothing has been done on highland forest in Sabah. The ecosystem type of the study site done by Peters (1999) is on lowand forest ecosystem and Pamin (2005) is on the floodplain forest. Thus, from the available research, it is difficult for the findings to be use in highland for management purposes of ecotourism in such environment.

1.2 Research Objectives

This research project will look into the impact of recreational trail usage on lower montane forest by

a) determining the level of soil compaction and composition of herbaceous plants along recreational trails in highland forest ecosystem.

b) suggesting possible mitigation approaches

This research is limited to the existing recreational trails found in Rafflesia Forest Reserve, District of Tambunan that has been designated as a tourist destination.

1.3 Justification and Significance of this Study

Studied has been done in lowland Dipertocarp forest by Peters (1999) and Riverine forest by Pamin (2005), but there is a lack of study been done on lower montane forest. Understanding the impacts of recreational trail affecting lower montane ecosystem is vital in developing management strategies in lower montane ecosystem. Thus, it is vital for the decision maker to know the ecological factors for a viable decision-making in determining the policy of their management.

CHAPTER 2

LITERATURE REVIEW

To comprehend the impact of recreational trails on the lower montane forest ecosystem, it is necessary to understand the features of this resource as well as the tourism activities carried out on this resource. The relationship between tourism development and the natural environment is vital to be established, since the forest is used as a backdrop for ecotourism. The connecting element for both tourism development projects and natural environment will be recreational trails.

2.1 Natural Resources and Human Activities

Human Activities have always required the use of certain elements of the natural resources. For recreation purposes, natural resources that are normally in use will be a forested area. This will include its river, ridge, landscape and many more. The activities that surrounds the use of these elements can vary from as simple as a walk to a more complicated activities like physical race using technologically unique equipment. Ham (1992) observed that in a single site, several tourism-related themes can be created. In Costa Rica, Ham (1992) stated that Guayabo National Monument the guided walk along its recreational trail can be divided into two parts, namely a) natural history, and b) archaeological work. These varieties will lead to a change in the movement pattern of tourist. Wong *et al.*, (1996) found corresponding relationship between the pattern of tourist movements and tourist resources.

Nevertheless, in whatever form the resources are used, it will lead to the development of tourism.

2.2 Tourism Development and Its Influences to the Natural Environment

Tourism by general definition relates industrial activities surrounding people traveling for the purpose of acquiring a new experience. Generally, there are two forms of tourism, noted simply as a) Old Tourism, and b) New Tourism. Malaysia has been utilizing tourism for over twenty years as a source for foreign earning. Throughout the past years, there have been much economic benefits due to tourism. In fact, tourism is important to Malaysia economy as it ranked third or fourth most important sector in the overall economy. Nevertheless, it is only recently have Malaysia recognized its industry being more for the "New Tourism".

There are several ways to categories the form of tourism available in a particular nation. An interesting aspect of "New Tourism" is that it relates to regions closer to the equator and is normally participated by matured travelers that are keen to acquire specific experience. In such form, information intensive niche product goes hand-in-hand with skilled human resources. Considering these characteristic of "New Tourism", the natural environment becomes a place to visit where the appreciation of environmental function is done through actual interaction with the resources itself. According to Kobayashi (1998), this ecological impact is a significant element in determining the quality of visitor experience.

2.2.1 Tropical Rain Forest as the Backdrop of Ecosystem

The tropical rainforest ecosystem is earth's most complex biome in terms of species diversity. It is supporting well over half the globe's species of plants and animals on only a little over five percent of the total land area which is found between 10° N and 10° S latitude. It has abundant precipitation and year round warmth. There is no

annual rhythm to the forest but rather sunlight is a major limiting factor. The condition of high precipitation contributes to the soil and vegetation properties of the forest.

In an average year, the climate in a tropical rainforest is very humid because of all the rainfall. A tropical rainforest gets about 1,500 to 2,000 mm of rain per year (Edwards, 1994). The tropical rainforests is shallow, very poor in nutrients and almost without soluble minerals. Study has been done in the Amazon rainforest and it is found that 99% of nutrients are held in root mats. Thousands of years of heavy rains have washed away the nutrients in the soil obtained from weathered rocks. The rainforest has a very short nutrient cycle. Nutrients generally stay in an ecosystem by being recycled by various species of decomposers like insects, bacteria, and fungi make quick work of turning dead plant and animal matter into nutrients. Plants take up these nutrients the moment they are released.

Tropical rainforest studies can be complex. This is because tropical rainforest is influence by many natural and anthropogenic factors, such as soil geological formation, topography, climate, plant and animal life history, human development projects and management interventions. Although inexhaustible, such understanding is vital for park management. In fact, land cover information is suggested by How & Chon (2004) to be used as a convenient way to create a baseline data for tourism management.

2.2.2 Catergories of Forests in Sabah

Generally, the tropical rainforest in Sabah's is divided into three general categories. There are the coastal and riverine forest, lowland forest and montane forest. These forests are different not just in soil properties and topography but also plant properties.

2.2.2.1 Coastal and Riverine Forest

Coastal forest includes mangrove forest, freshwater swamp forest, riverine forest and beach vegetation. These types of habitats are found from zero to 100 feet above sea level. The vegetation distribution is all along the coast and on major rivers in Sabah. Generally the soil type in this area is mud (Edwards, 1994).

A variety of strategies have been developed by plant species in the struggle to reach light or to adapt to the low intensity of light beneath the canopy. One approach is to have a variety of photosensitize pigment like a) Chloroplast (green pigment), and b) chromoplast.

Mangrove forests and swamp forests are important breeding grounds for fish and provide nesting and roosting sites for wetland birds such as egrets and herons. They are critical for the survival of Borneo's famous Proboscis Monkey.

2.2.2.2 Lowland Forest

There are three categories of habitat. According to Whitmore (1998), the lowland Dipterocarp forest is found between 30-300 meters above sea level, uphill Dipterocarp forest is found 300 - 600 meters above sea level and highland Dipterocarp Forest is found between 600 - 900 meters above sea level. Dipterocarp forests are among the most diverse ecosystems on earth, and are home to most of Sabah's unique and famous wildlife species, such as orangutan and rhinoceros. Most commercial logging is carried out in these forests. There are special lowland forest types. These special forests may be low in stature, but are rich in unique plant species.

Soil properties in this kind of forest are better than coastal and riverine forest. Generally, soils are composed of organic matter, water, air and mineral. Soil is the

product from the weathering of bed rocks (mineral) and the decomposition of organic material such as leaf litter and organism. This process is rapid in warm, humid especially in lowand but not in montane area. The texture of soil changes with the climate and topography of the area. This will influence the relative portion of clay, silt and sand in the soil (Edwards, 1994).

Seedlings are common features in a lowland forest. To a certain extend, these seedling can depict the health of a forest. As such, fungus in these areas function more as a decomposer.

2.2.2.3 Montane Forest

Montane forest is sub-divided into lower montane Forest (3,000 - 4,500 feet above sea level) and upper montane Forest (4,500 - 11,000) feet above sea level). Upper montane habitat type in Sabah is basically restricted to Mount Kinabalu and Trus Madi mountains. Many rare and restricted range species occur in these unique habitats. From the many types of aroids found in lower montane forest ecosystem, plants from the genus *Anadendrum* and *Pothos* are common. According to Mayo *et al.*, (1997), these species are distributed widely on the island of Borneo. In addition, Mayo *et al.*, (1997) indicate that the *Anadendrum* and *Pothos* genus are not restricted to highland areas, and ecologically are normally climbers. The difference between these genuses is that *Anadendrum* can be found on rocks while *Pothos* are rarely found on rocks. Among the aroid that can be found in this area are *Anadendrum* and *Pothos* (Boyce, Sulaiman & Lintong , 2002). *Pothos found in* lowland to lower montane forest 270-1340m, Hill to upper hill forest. 700-870m, Hill forest. 470m, Upper hill forest. 900m. *Anadendrum* found in Upper hill forest. 840m, Hill forest. 700m.

Seeding in keranggas forest behaves differently a bit from lowland forest. Of course, fungus may create symbiotic relationship with plants in highland as a support for the changes in seeding behavior in plant around lower montane forest. Here, the function of fungus is to get roots to the plant and to act as seedling fibrous roots. This works fine for a symbiotic relationship.

The importance of the *Rafflesia* Information Center as a tourist destination is home to an icon of Sabah. In 2003, the management of the VJR which emphasized growth of the center and tourism is one of the activities.

2.2.3 Rafflesia Forest Reserve

Rafflesia Forest Reserve is known as the Class VI Virgin Jungle Reserve (VJR) under the gazette of Sabah Forest Enactment on the 14th March 1984. It is approximately 356 hectare and is under the management responsibility of Mukim Sinsuron, Tambunan District Forestry Office. The reserve is located within the district of Tambunan and is about 58 km east from Kota Kinabalu and 25 km from Tambunan town.

The area is composed of sandstone, shale and siltstone, the sandstone being coarse-grained, often quartzitic and with many characteristics of greywacke. In the south, amplitude of the hills is in excess of 300 m and slopes are normally greater than 25°. Ridge crest and valley bottoms are narrow and landslips are common. The hills here are formed of interbedded sandstone and mudstone. In fact, the VJR is generally well-drained owing to its hilly terrain.

The soil type of the forest reserve is mainly Trusmadi Association. The Trusmadi Association occurs above about 1,200 m on the Crocker. The range is composed of sandstone, shale and siltstone, the sandstone being coarse-grained,

often quartzitic and with many characteristics of greywacke (Javino et al., 2004) thus this shows that the soil porosity is very hig as compare to lowand forest. These rocks outcrop on many of the steep mountain slopes and also on ridge crests but over large areas soils are formed on mixed colluvium derived from these rocks. Dipterocarp forest covers the lower slopes of the association below about 1,350 m and also extends upwards beyond this height in sheltered valleys. It gives way an oak/conifer forest dominated by Fagaceae and Lauraceae species. Above 1,950 m, low trees and shrubs are covered by leafy hepatics and mosses in what can be described as a moss forest. Species include Ericaceae, Podocarpaceae, Fagaceae, Theaceae, Lycopodiaceae, Burmaniaceae, Myrsinaceae, Guttiferae and Myrtaceae. Generally, the reserve is made up largely of lower montane forest. The main canopy height is about 30-35 m tall. Emergent species are *Shorea platyclados, Agataluensis, Lithocarpus lucidus, Palaquium gutta* and *Shorea smithiana*. Other common tree species are *Prinea limpato, Syzygium* sp., *Quercus kinabaluensis, Hydnocarpus kunstleri* and *Gonystylus* sp. Climber like *Dinochloa* sp., *Scindapsus* sp., *Piper* sp., etc., some rattan and ginger on the forest floor. However, lower kerangas montane forest also develops especially on ridges in the eastern and southern part of the reserve. The main canopy is about 15-20 m tall. Most of the trees are of pole sized (A. Latiff et al., 2001). Among the common tree species are *Adinandra collina, Syzygium* sp., *Schima wallichii, Elaeocarpus stipularis, Litsea* sp. and *Weindlandia* sp. Rotan irit (*Calamus* sp.) and the ginger *Alpinia* sp. were found on the forest floor.

Figure 2.1 shows the general aerial view of *Rafflesia* Forest Reserve model developed by the Sabah Forestry Department. The reserve is easily accessible by road (Kota Kinabalu-Tambunan road). This forest reserve is popular due to its *Rafflesia* Information Center. The *Rafflesia* Information Centre is located next to the Penampang - Keningau road.

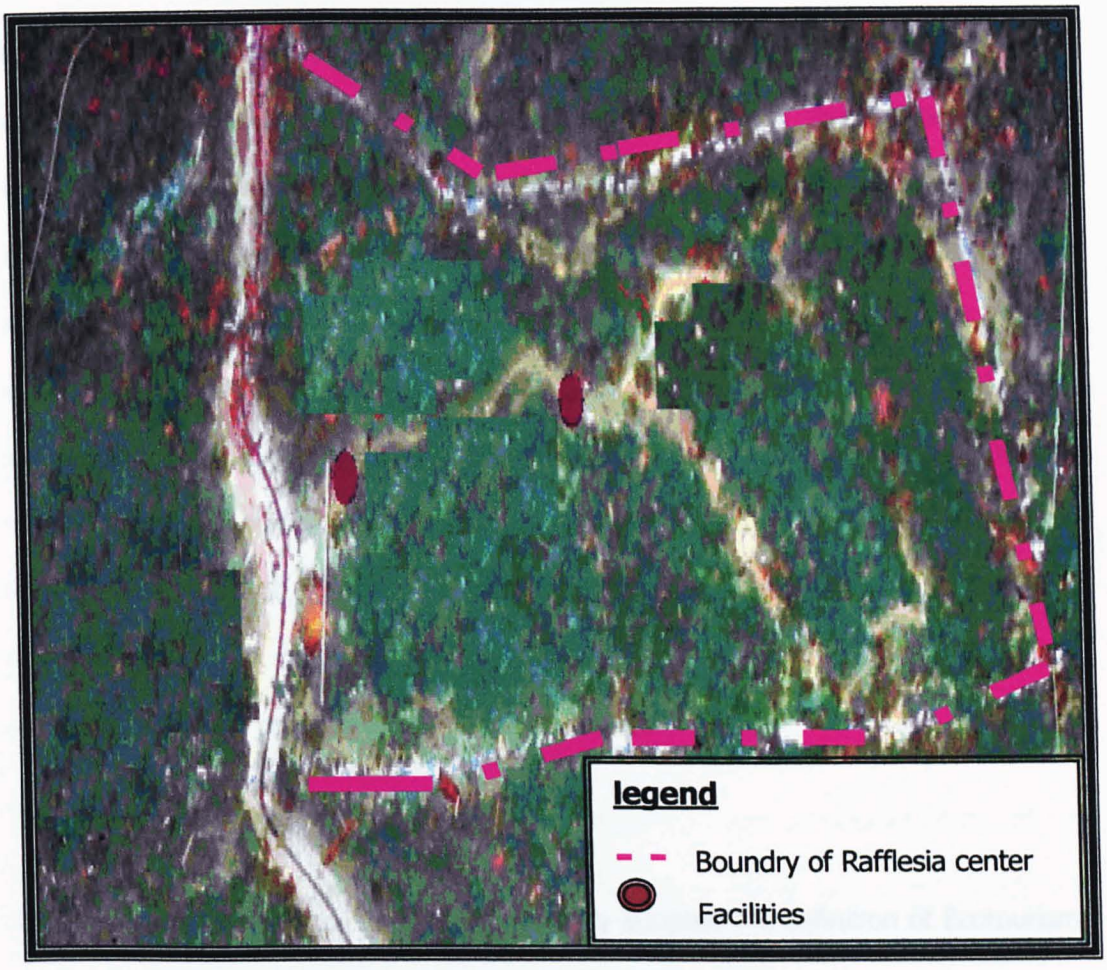

Figure 2.1: Aerial view of *Rafflesia* Forest Reserve.

In Figure 2.1, the pink colour dotted line outlines the boundary of the *Rafflesia* Information Center. The yellow box indicates the main building of the center while the larger brown dots represent major facilities along trails. Along the recreational trails, there were several facilities found. These facilities included, a) an entry gate, a view-points hut, and several benches. These facilities were all built at the discretion and specification that was endorsed by the Sabah Forestry Department.

2.2.3.1 The Development of Nature-related Tourism

Another term used to associate "New Tourism" is sustainable tourism. Sustainable tourism relates to the use of the tourism facilities in a manner that does not degrade

the experience or the facility itself. This will allow the industry to continue. Tourism and the natural environment can form a symbiotic relationship. This can be achieved by infrastructure; and the hardening of sites to carry more tourists whilst conserving developing purpose built tourist resort complexes; investment in and careful design of tourism the natural environment. A form of this sustainable tourism is what is called as Ecotourism. Thus, there is a strong case for promoting 'sustainable' forms of tourism such 'ecotourism', as a way of fostering harmony between people and nature through tourism. Generally, Ecotourism was a term coined backed in 1986 to indicate the type of tourism that does not conflict with environmental issues. Unfortunately, such principles would appear to be at variance with the economic arguments in favor of mass tourism. (Inskeep, 1996)

2.2.3.2 The Malaysian Approach

Malaysia is quite visionary since it had not only adopted the definition of Ecotourism, it had also formulated the concept into a national plan. National Ecotourism Plan was prepared by MOCAT (1996) with the intention to develop this new form of tourism. This document is complete with guidelines relating to the development of facilities in accordance to the forest condition. There are some indications about guidelines on trails in these areas. In Sabah, a state that is recognized for its ecotourism offering, the localized guidelines are extracts of the Malaysia eco tourism master plan. According Kutliew (2002), Malaysia is among the world leader of ecotourism.

2.2.3.3 Legal Framework For A New Form Of Tourism

Encouragement of the development in Ecotourism does not stop at the publication of the National Ecotourism Plan. Under the 8th Malaysia Plan, Ecotourism is one of the areas that are prioritized for research through IRPA, managed by the MOSTI. This could lead to the development of new policies or procedures for the sustainable

development of ecotourism. The purpose of conducting extensive research on ecotourism was because the natural vegetation of any area is dictated by a combination of several factors such as topography, altitude, geology, soils, climate and water supply (Mackinnon *et al.*, 1996). Mackinnon *et al.* (1996) stated that areas of plant richness can be associated with soil types. This will further support the existing laws for environmental conservation since Kobayashi (1998) stated that damages will be avoided through the control of visitors to stay on the developed facilities like trails.

Among available laws that relates to conservation of an environment are like a) Sabah Parks, b) Sabah Wildlife Enactment, c) Sabah Forestry Enactment, and d) Sabah Biodiversity Enactment. At the state level, there are several other laws to support the effort of ecotourism, which include a) Land Ordinance (Cap.68) b) Conservation of Environment Enactment 1996 and c) Water Resources Enactment 1998. All of these laws, plus the ones that support tourism such as Sabah Tourism Promotion Corporation Enactment 1981, were designed for sustainable use of Malaysia's natural resources, through tourism.

For the developed country, legal support goes even to the laws that relate to trail use. Such laws prohibited the use of certain trails during specific period to avoid unnecessary and uncontrollable negative impact. This is linked to the concept of Carrying Capacity. Why carrying capacity is important in nature tourism. Peters (1999) stated that the carrying capacity is important to determine the maximum load of an area to accommodate tourist. The carrying capacity is determined by the limits of environmental tolerance of human intrusion. The carrying capacity is the limit of trampling by human that will have an impact on the ecological system. Yet it is

difficult to assess carrying capacity without understanding the forest that is being used for tourism.

2.2.3.4 Natural Environment Damages Due To Tourism Activities

Mass tourism refers to the turnover of the travelers partaking in tourism environment. This require huge land mass to sustain or level out the concentration of the travelers. In Sabah, mass tourism is normally concentrated in parks that are near to the city. Among some of the parks that experience mass tourism include a) Tunku Abdul Rahman Park, and b) Mount Kinabalu.

Impact of tourism activities on natural environment is inevitable. Mass tourism can bring about damages on the natural environment. Peters (1999) and Pamin (2005) found that environmental damages can be caused by the heavy use of recreational trails.

2.3 Ecological Impacts along Recreational Trail

But like all other industries, there are positive impact in social and negative in conservation area due to the use of Ecotourism. Recreational use of Parks and conservation areas, such as trail, observation tower, entrance gate and other facilities build may experience human trampling of the soil and plants. Peters (1999), Alessa & Earnhart (2000) and Pamin (2005) found that the trampling effect will result in a) soil compaction, and b) changes in root hair, which decrease in vegetation cover and diversity. Peters (1999) and Pamin (2005) demonstrated that the characteristic of soils on older sections of trail were more compacted than newer. Literature review show that more studies has been done on lowland area. Therefore recreational trail produce negative ecological impact in lowland forest, while highland is not established since it has various combinations of uphill, downhill and flat sections,

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