



FACULTY OF RESOURCE SCIENCE AND TECHNOLOGY

**SOILS UNDER ENRICHMENT PLANTING: ASSESSING SOIL PROPERTIES
OF REFORESTATION SITES AT GUNUNG APENG FOREST RESERVE**

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(Plant Resource Science and Management)
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Final Year Project Report



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**Soils under Enrichment Planting: Assessing Soil Properties of Reforestation Sites at
Gunung Apeng Forest Reserve**

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This project is submitted in partial fulfillment of the requirement for the degree of
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LIST OF ABBREVIATIONS

%	Percentage
AvP	Available phosphorus
C	Carbon
EC	Electrical conductivity
FAO	Food and Agriculture Organization
N	Nitrogen
SOM	Soil Organic Matter
TN	Total nitrogen

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Soils under Enrichment Planting: Assessing Soil Properties of Reforestation Sites at Gunung Apeng Forest Reserve

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ABSTRACT

Reforestation is a reestablishment or replanting of trees and understored the plants at a site immediately after the disturbances that are cause by deforestation. The importance of reforestation is to reduce the amount of soil erosion and compaction, to minimize the exposure of the mineral soils and to help in improving the soil quality as well as to sustain soil fertility. Recently, reforestations mainly focus on mono planting species as dipterocarps species because it is the most dominant forest species. Besides, more nutrients can be found in mono planting species compared to mixed planting species. However, some study conducted had stated that the growth performance at mix planting species was better and more productive than mono planting species. Hence, questioning whether soil properties plays an important factor in determining the growth and survival rate of trees planted at different planting technique. Therefore, the main objective for this study is to identify the soil properties under reforestation sites with different planting technique (mono and mix planting). The study was conducted at Gunung Apeng Forest Reserve, Serian, Sarawak. Soil sampling was conducted at depth of 0 – 10 cm and 30 – 40 cm for both mono and mix plots respectively. The chemical and physical properties of the soil were analyzed and that include bulk density, soil texture, soil hardness, soil pH and acidity, soil organic matter (SOM), electric conductivity (EC), total nitrogen (N), and available phosphorus (AVP). The analysis was conducted via Student's t-test. The result shows that both mono and mix planting species are similar in term of soil morphology and some physicochemical properties. Hence, the information on the soil properties at both planting plots is important in order to determine the suitability of the tree species planted for reforestation purposes. However, further investigation focusing on selected soil properties is necessary in order to determine the ideal planting technique used for different type of tree species.

Keywords: Nutrients, planting technique, reforestation, soil morphology, soil properties.

Soils under Enrichment Planting: Assessing Soil Properties of Reforestation Sites at Gunung Apeng Forest Reserve

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ABSTRAK

Penanaman semula hutan adalah menubuhkan atau menanam semula pokok dan tumbuhan di tapak kawasan serta merta selepas berlakunya gangguan yang disebabkan oleh pemusnahan hutan. Kepentingan penanaman semula hutan ini adalah bertujuan untuk mengurangkan hakisan dan kepadatan tanah, untuk mengurangkan pendedahan terhadap tanah mineral dan untuk membantu dalam memperbaiki kualiti tanah dan juga untuk mengekalkan kesuburan tanah. Kini, penanaman semula hutan lebih tertumpu kepada penanaman secara mono sebagai spesies dipterocarp kerana ianya adalah spesies hutan yang paling dominan. Selain itu, nutrisi lebih banyak dijumpai pada penanaman secara mono berbanding dengan penanaman secara campur. Akan tetapi, beberapa kajian menyatakan bahawa kadar pertumbuhan pokok pada spesies tanaman campur lebih bagus dan produktif berbanding dengan penanaman secara mono. Oleh itu, mempersoalkan bahawa apakah ciri-ciri tanah memainkan factor yang penting dalam menentukan pertumbuhan dan kadar kewujudan pokok yang ditanam pada teknik tanaman yang berbeza. Oleh itu, objektif utama untuk kajian ini adalah untuk mengenalpasti ciri-ciri tanah di dalam kawasan penanaman semula berdasarkan teknik tanaman yang berbeza (mono dan tanaman campur). Kajian ini dijalankan di Hutan Simpan Gunung Apeng, Serian, Sarawak. Sampel tanah diambil di kedalaman 0 – 10 cm dan 30 – 40 cm untuk kedua-dua plot tersebut. Sifat kimia dan fizikal tanah dianalisa dan itu termasuklah ketumpatan tanah, tekstur tanah, kekerasan tanah, pH dan keasidan tanah, bahan organik tanah, elektrik konduktiviti, jumlah nitrogen dan kandungan fosforus yang sedia ada. Data analisis dianalisa menggunakan kaedah Student's t-test. Keputusan yang diperolehi menunjukkan bahawa kedua-dua plot tanaman mono dan tanaman campur adalah sama dari segi morfologi tanah dan sedikit berbeza untuk ciri-ciri fizikokimia. Oleh itu, maklumat mengenai ciri-ciri tanah untuk kedua-dua plot tanaman tersebut adalah penting untuk mengenalpasti kesesuaian spesies pokok yang ditanam di kawasan penanaman semula hutan simpan. Akan tetapi, penyelidikan lanjut berteraskan ciri-ciri tanah yang terpilih adalah perlu untuk mengenalpasti teknik tanaman yang lebih sesuai digunakan untuk spesies tanaman yang berbeza.

Kata kunci: Nutrisi, teknik tanaman, penanaman semula hutan, morfologi tanah, ciri-ciri tanah.

1.0 INTRODUCTION

Tropical forests are the most important natural resource on earth because of its biodiversity and environmental values. Programs that involve conservation, protection and production are very important in order to ensure the sustainability of the forest quality and productivity. In 1989, it is estimated that the total area of the natural forests in Malaysia is 19.49 million ha or approximately 56.3% (Mok, 1992). Mok (1992) also state that the major role of forest is maintaining the stability and quality of the environment by protecting soil and water resources, conserving biological diversity and preserving cultural, recreational and other intrinsic values of the forest which can enhance the quality of people's life.

In Sarawak, 70% of the total land area is still cover with natural forests (Mok, 1992). Out of the percentage, only 4.5 million ha have been constituted as the Permanent Forest Estate (PFE), 256 000 ha of Totally Protected Areas (TPA) and about 3.96 million ha State Forest. The rest of land area are mostly deconstruct for development and plantation purposes. Most of the land area has undergoes deforestation because of several reasons but mainly due to the high demand of timber thus, leading to an increase in logging activity. As stated by Jaya (2002), logging leads to reducing water quality as well as the diversity and the productivity of the biological communities. In addition, Laurance (1999) had studied that the loss of tropical forests not only will destroy the indigenous culture but also diminish the forest natural products.

In recent years, logging and agriculture development especially in oil palm plantation and timber plantations have contribute the most in deforestation of the tropical rainforests (Jong *et al.*, 2001). This is because the tropical rainforests in Southeast Asia has high value of timber and rich in biodiversity (Hattori *et al.*, 2013).

In addition, Ichikawa (2007) shared that the main cause of deforestation nowadays is because of the development in agriculture where people tend to destroy the natural forest for the purposes of commercial logging and swidden agriculture. According to Angelsen (1995), there is no any clear definition of deforestation. However, Ayoubi *et al.* (2011) mentioned that deforestation results in lowering the soil quality and decrease productivity thus, leading to land degradation (Karam *et al.*, 2012). So, to overcome those issues several activities are being conducted including forest rehabilitation, forest plantation or reforestation and afforestation.

Karam *et al.* (2012) also suggested that forest rehabilitation is one of the best ways in order to reduce the loss of soil nutrients and poor vegetation stock (Arifin *et al.*, 2010). Besides, another alternative ways suggested by Karam *et al.* (2012) is forest plantation or reforestation where the soil fertility can be maintain and degraded land can be restored to its original condition. Reforestation is defined as a “re-establishment of trees and understored plants at a site immediately after the removal of the natural forest cover” (ITTO, 2002). It is one of the methods that can help in improving the soil quality and sustain the soil fertility aside from sustaining world ecosystem. The important of reforestation is to reduce the amount of soil erosion and compaction and also minimized the exposure of the mineral soils.

Currently, the most applied method in forest rehabilitation is by enrichment planting. Enrichment planting is a method of introducing valuable species at degraded forests without eliminating the already existed species (Karam *et al.*, 2012). Hattori *et al.* (2013) also state that enrichment planting is a primary method used in accelerating regeneration and rehabilitating the degraded forests. Several techniques have been introduced in replanting the forest nowadays and this includes mixed planting and mono planting species. Recently, reforestation mainly focusing on mono planting

species as dipterocarp species and it is the most dominant forest species (Hattori *et al.*, 2013). In addition, it is also recommended as it may provide an optimal shade conditions for the growth of dipterocarp seedlings. The environmental characteristics plays an essential roles in the tropical rainforests ecosystem and also important for the growth performance of the planted seedlings (Hattori *et al.*, 2013). These characteristics include microclimate, light conditions and soil quality.

However, the soil properties in both mixed and mono planting species is varied. According to Palmiotto *et al.* (2004), it is stated that the nutrient limitation in mixed dipterocarp species can mostly be found compared to the mono planting species. This means that there is fewer nutrients found in the mix planting species compare to mono planting species. This is might be due to the high diversity on mix planting species (Velden *et al.*, 2014). Based on previous study by Carnus *et al.* (2006), mixed planting species it is more productive than mono planting species if only the species planted is adapting well to the site conditions and the functional characteristics such as lights, water and soil nutrients of the planted species are sufficiently different. Norisada *et al.* (2005) also stated that the growth performance for mixed planting species is better than mono planting species.

So, the questions is that whether the soil properties plays an important role in determining the growth and survival rate of trees planted at different planting techniques. Hence, the objective of this study was to identify the soil properties under reforestation site with different planting technique (mono and mix dipterocarp species) at Gunung Apeng Forest Reserve, Serian, Sarawak. This is to determine the suitable dipterocarp species planted at different planting technique for reforestation purposes.

2.0 LITERATURE REVIEW

2.1 Deforestation and land degradation of tropical rainforest

Tropical rainforest in Malaysia according to WWF (n. d) are mostly dominated by *Dipterocarpaceae* family, hence creating the term ‘dipterocarp forests’ which occurs on dry land with the altitude of about 900 m above the sea level. It is classified into three types that are low dipterocarp forest (LDF) for 300 m above sea level, hill dipterocarp forest (HDF) for the elevation of 300 m to 750 m above the sea level and upper dipterocarp forests for 750 m and above (WWF, n. d). However, in Sarawak, it is known as mixed-dipterocarp forest (MDF). Total land area cover in Malaysia are 330, 433 square kilometers (sq. km), of which include both Sabah and Sarawak for 73,620 sq. km and 123, 985 sq. km respectively (Jomo, Chang and Khoo, 2004).

However, the amount of the rainforest existence nowadays is decreasing as many of the forests are being developed for the sake of good life of people. WWF (n. d) stated that some state governments even have halted land clearing for agricultural purposes. Besides, a constant disturbance may affect the biodiversity, topography and climate changes. Rainforests functions as to enhance the sustainability of the environment and ecosystem. Unfortunately, more trees are being cut down and lead to land degradation.

There are several criteria that affecting the soil quality which include holding and release of water to plants, streams and subsoil, also nutrients and other chemicals, to promote sustain growth, to maintain suitable soil biotic habitats and lastly to respond to the management and able to resist degradation. However, due to the human activity and greed such as logging activity, for timber hunting purposes, many natural

tropical forest has been disturbed whether for future development or for plantation purposes.

2.2 Reforestation of the degraded forest and its effort in Sarawak

The International Tropical Timber Organization or also known as ITTO (2002) stated that reforestation is a re-establishment of tree after some disturbances. In Sarawak, from year 1979 until 1995, there is an increase in the progress of reforestation. The purposes of reforestation according to FAO (2002) are to grow tropical exotic hardwood species, especially in Sarawak such as *Acacia mangium*, *Gmelina arborea* and *Paraserianthes falcataria*. The listed species is somehow only begun as an experiment and as an alternative to overcome the poor performance of species planted in Sarawak from the years before. However other species is also added on the list such as *Swietenia macrophylla*, *Durio zibenthinus* and *Shorea macrophylla* to help in increasing the tree performance but needs a longer rotation for the shifting cultivation of the reforestation (FAO, 2002).

Reforestation product actually can be harvested for export purposes, not only for protective and protection purposes (Woon & Haron, 2002). Hence, proving that reforestation is important for current and future purposes especially its benefits toward the ecosystem and environment. According to Forest Department Sarawak (2014), timber is one of the most valuable products that highly in demand. The problem arise nowadays is that more tree are being cut down and left effect brings to the deforestation. So, to overcome those issues, Forest Department Sarawak (2014) had encountered by re-planting the tree species in that area. Eventually, the benefits gain from the replanting trees is enough to supply for the future use. Moreover, it is also

because of the high demand on the forest product especially in timber, firewood and even food.

2.3 Planting Technique used in the reforestation of tropical forest

Based on Hattori *et al.* (2013) studied, it is stated that by planting an indigenous species brings out benefit in term of timber and food consumption. Indigenous species are a species that is not the main species planted in the particular area but the other species. In tropical rain forest, “environment characteristics such as microclimate, soil qualities and light conditions play essential roles in the ecosystem” (Hattori *et al.*, 2013).

The most common technique used in reforestation or any forest rehabilitation is by an enrichment planting (Karam *et al.*, 2012). The purpose of enrichment planting is to introduce new species in degraded forests without eliminating the existed species. Besides, in mixed dipterocarp forests under the enrichment planting, the nutrient limitations are mostly found (Palmiotto *et al.*, 2004) as compared to mono planting. However, Norisada *et al.* (2005) stated that the growth performance for mixed planting species is better than mono planting.

2.4 The importance of soil properties at the mixed and mono dipterocarp forest

The soil properties plays a major role here it act as an indicator for the determination of forest productivity. In mixed and mono dipterocarp forest, the species distribution and the topography are different. Mixed dipterocarp forest is usually the lowland area whereas mono dipterocarp forest is on tropical area. Besides, Carnus *et al.* (2006) mentioned that mixed species plantations may be more productive than mono planting species with conditions if only the species planted is

adapted well to the site conditions and the functional characteristics of the planted species are sufficiently different.

Palmiotto *et al.* (2004) stated that most of the lowland rain forest exists in Borneo is mixed dipterocarp forest (MDF). In MDF, the species composition and the forest structure are related with the small scale edaphic and topographic gradients. Besides, the soil nutrients availability is also directly influences with the species distribution and the community composition. Hence, indicate that the soil nutrients in the mixed forest are different compare to the mono species planting. For mono planting species, since it has high density (Velden et al., 2014) and consists of only a single type of species, hence the condition of mono planting species are classified as more to humid tropics evergreen (Hart, Hart & Murphy, 1989).

3.0 MATERIALS AND METHODS

3.1 Description of the study site

The location of the soil sampling will be conducted at Gunung Apeng Forest Reserve, Serian, Sarawak with latitude and longitude of N00°55'24.7'', E110°38'32.2'' (Figure 1). Gunung Apeng Forest Reserve is a reforestation site for the purpose of conservation. The size of the total area at Gunung Apeng Forest Reserve is 1800 ha. It establishes in 2005 with the cooperation of Japan-Malaysia Association and Sarawak Forestry Department. According to Jaya (2002), Gunung Apeng Forest Reserve was gazetted on May 8, 1958 under the Forest Ordinance 1953.



Figure 1: Location of the study site (Gunung Apeng Forest Reserve).

Based on Sarawak Soil Classification system, type of soil in the study site is Grey-White Podzolic soil. The soil derived from non-calcareous sedimentary rocks which consisting of fine and whitish sandstone. Reforestation site of Gunung Apeng Forest Reserve is classified as one of the secondary forest. Before it re-establish as reforestation site, logging activity and some paddy cultivation were being conducted.

Species found in the area include *Dryobalanops beccarii* (Kapur bukit), *Shorea macrophylla* (Engkabang jantung), *Shorea parvifolia* (Meranti sarang punai) and

Shorea falcifera (Balau Kuning) and some local fruit trees. Additional information of Gunung Apeng Forests Reserve is the climate in the area is classified as a tropical wet with a subtropical wet bio zone with the annual rainfall of 3500 mm and temperature at the range of 23°C to 33°C.

3.2 Soil sampling

Both mono and mixed dipterocarp species plot which has a size of 50 m x 50 m is divided to four subplots which comprised of 25 m x 25 m each (*Figure 2*). Hence, there will be 4 subplot created in one plot labelled with A, B, C and D. Besides, one subplot consists of 25 trees means there is 100 trees in each plot of mono and mix dipterocarp species respectively (*Figure 3*). The planting technique used is by line planting technique with the distance of 5 m x 5 m. Species planted at mono plot are *Dryobalanops beccarii* while for mixed plot, it consists of *Dryobalanops beccarii* together with other species such as *Shorea macrophylla*, *Shorea parvifolia*, and *Shorea falcifera*.

Composite soils were collected from the depth of 0 – 10 cm and 30 – 40 cm respectively at each subplot resulting in 8 composites. Since there were 4 plots, thus there are 32 of composite soils in total. The soil sample was collected on each subplot randomly on the planting lines by using soil auger. As for physical analysis sample, core ring were used to take sample at three random points on each subplot, thus results in 96 samples. After that, it is then taken to the laboratory for further analysis.