UNIVERSITI PUTRA MALAYSIA

ASSESSMENT OF SOIL FERTILITY STATUS IN DIFFERENT ISOLATED LAND USE TYPES

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FH 2015 2

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,In Fulfilment of the Requirements for the Degree of Master of Science

September 2015

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Master of Science

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September 2015

Chairman : Arifin Abdu, PhD
Faculty : Forestry

Information on soil properties in different land uses is vital for the understanding of ecological information as a useful tool and guideline for further management and practices for soil management, since plants can absorb and utilize only a portion of the total nutrient content in soil. However, many doubts remain concerning the method of evaluating the success of human activities in restoring degraded land for sustaining soil fertility and productivity. Most of the available soil indices worldwide apply only to temperate soil. Hence, there is a need for suitable indices to quantify the quality of degraded land in the tropics. Soil Fertility Index and Soil Evaluation Factor as a tool in determining soil fertility status among the sites (forest plantation, oil palm plantation, secondary forest and pasture area) could provide crucial information regarding the current status of the soils and interpreted soil condition as a basic factor for recommending fertilizer application and soil management.

This study is divided into three chapters, corresponding to the following objectives: (1) to characterize the soil properties in five different land uses (forest plantation, *Pinus caribaea* and *Swietenia macrophylla*; secondary forest (SISFEC); oil palm plantation; and pasture area); (2) to determine soil fertility status using soil fertility index (SFI) and soil evaluation factor (SEF) of three different sites: *Pinus caribaea* plantation, *Swietenia macrophylla* plantation, and pasture area, including the analysis of the growth performance between *Pinus caribaea* and *Swietenia macrophylla* planted in the rehabilitated degraded land; and (3) to assess the soil fertility status using SFI and SEF of two different lands uses, secondary forest and oil palm plantation. This study was conducted under forest plantation (*Pinus caribaea* and *Swietenia macrophylla*), secondary forest (SISFEC), oil palm plantation, and pasture area at Universiti Putra Malaysia's Serdang Campus in Selangor, Malaysia.

To address the first objective, soil profiles were dug up to 100 cm depth and 50 cm width. Next, the soil was sampled according to soil horizons, and soil morphology was determined using field technique. To address the second

objective, composite samples were collected within the six study plots (20x20 m) at *Pinus caribaea* plantation, *Swietenia macrophylla* plantation and pasture area at depths of 0-20 cm (surface soil) and 20-40 cm (subsurface soil). For the third objective, soils were sampled at depths of 0-20 cm (surface soil) and 20-40 cm (subsurface soil) in six plots (20x20 m) in the secondary forest and oil palm plantation plot. The samples were air-dried, homogenized and sieved to pass a 2-mm mesh sieve for further analysis. Laboratory analyses included physico-chemical properties, sesquioxides content, charge characteristic, and mineralogical properties. Soil fertility status was evaluated using two indices, Soil Fertility Index and Soil Evaluation Factor. Data were analyzed using Statistical Package Social Science (SPSS) version 20.

Results obtained for the first objective found A horizon in all of the soil profiles. The soil color for all profiles ranged from reddish brown to dark brown (surface), which resulted from the decomposition of organic matter. The soils of all profiles were acidic, ranging from 3.6 to 5.2 in their acidity, with acidity levels increasing with depth. Cation exchange capacity and total carbon tended to decrease with depth, and higher in the secondary forest and pine plantation than in mahogany plantation, oil palm plantation and pasture area. Exchangeable K, Ca and Mg were higher in the topsoil than in the subsoil for most profiles. Exchangeable Al increased with depth and available P in the soil ranged from 0.72 to 1.98 mg/kg. The Alo, Ald, Feo and Fed increased with depth in all profiles. The clay mineral composition was dominated by 1:1 type kaolin minerals. The point zero of salt effect values tended to increase, while the σp values decreased with depth at all sites, indicating that the soils are highly weathered.

The assessment for the second objective found no significant differences ($p<0.05$) in the bulk density of the soils in the *Pinus caribaea* and pasture plots. In contrast, the topsoil of *Swietenia macrophylla* plots possessed lower bulk density ($p<0.05$) compared to the other plots. The pasture plot had higher ($p<0.05$) moisture content compared to that of *Swietenia macrophylla* and *Pinus caribaea* plots for both soil depths. The soils at the three experimental sites were slightly acidic, with pH ranging from 4.12 to 5.09 in the topsoil and 4.27 to 4.92 in the subsoil. Organic matter was found to be significantly higher ($p<0.05$) in the pasture than in *Swietenia macrophylla* and *Pinus caribaea* plots. *Pinus caribaea* plots showed significantly higher ($p<0.05$) level of total carbon at both soil depths compared to the other study plots. Exchangeable Ca, Mg and K were significantly higher ($p<0.05$) in the topsoil of *Pinus caribaea* compared to the other plots. Cation exchange capacity and effective cation exchange capacity of the soils were low. PCA results indicated that soil texture, OM, TC, TN, nutrient content and cation exchange capacity had a strong positive relationship, which explains the higher SFI value in the nutrients in the soil especially the topsoil in *Pinus caribaea* than the other study plots. In contrast, pasture plot had higher SEF, followed by *Pinus caribaea* and *Swietenia macrophylla* plantation plots.

The results for the third objective showed that clay composition was the highest in the oil palm plantation for both surface and subsurface soil. The pH value in surface and subsurface soil for oil palm plantation is higher than in secondary forest. Soil in oil palm plantation exhibited higher organic matter content compared to secondary forest. The total carbon and nitrogen were higher in the oil palm plantation at surface soil. The cation exchange capacity was highest in the oil palm plantation for both surface and subsurface soils. The exchangeable Ca, Mg, K were higher in the oil palm plantation for surface and subsurface soil. Exchangeable Al for surface soil was also higher in the oil palm plantation. The value of Soil Fertility Index was higher than Soil Evaluation Factor value for both depths in the oil palm plantation compared to secondary forest.

In conclusion, all of the soils (forest plantation, *Pinus caribaea* and *Swietenia macrophylla*; secondary forest (SISFEC); oil palm plantation; and pasture area) were very acidic, highly weathered and considered poor in soil nutrient content, which exhibited Ultisols and Oxisols characteristic. The physico-chemical properties were the main factor that contributed to nutrient resources and soil fertility. The soil fertility status of the *Pinus caribaea* plantation was superior to that of the *Swietenia macrophylla* plantation and pasture area, which indicated that forest plantation is a proper technique for rehabilitating and replenishing soil fertility of degraded land. Soil fertility was affected by the types of crops or trees that grow in the soil, as their characteristics affect their nutrient uptake. The oil palm plantation soil showed the highest Soil Fertility Index value compared to secondary forests. Moreover, soil fertility was affected by different types of soil management, parent materials, and climatic conditions.

Abstrak thesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENILAIAN STATUS TANAH KESUBURAN BERBEZA JENIS KEGUNAAN TANAH TERPENCIL

Oleh

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September 2015

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Maklumat tentang ciri tanah di bawah tanah yang berlainan adalah penting untuk memahami maklumat ekologi sebagai alat yang berguna dan garis panduan bagi pengurusan dan amalan lain bagi pengurusan tanah kerana tumbuh-tumbuhan boleh menyerap dan menggunakan hanya sebahagian daripada kandungan nutrien di dalam tanah. Walau bagaimanapun, banyak keraguan kekal mengenai bagaimana untuk menilai tahap kejayaan aktiviti manusia dalam mengembalikan tanah yang bergred rendah untuk mengekalkan kesuburan tanah dan produktiviti. Kebanyakan indeks tanah di dunia adalah nikmat yang terdapat di tanah beriklim sederhana. Oleh itu, terdapat keperluan untuk indeks yang sesuai untuk mengukur kualiti tanah yang telah didegradasi di kawasan tropika. Indeks Kesuburan Tanah dan Faktor Penilaian Tanah sebagai alat dalam penentuan status kesuburan tanah di antara tapak (ladang hutan, ladang kelapa sawit, hutan sekunder dan kawasan padang rumput) boleh memberi maklumat asas mengenai status semasa tanah dan keadaan tanah ditafsirkan sebagai asas untuk mengesyorkan penggunaan baja dan pengurusan tanah.

Kajian ini dibahagikan kepada tiga bab yang sepadan dengan objektif-objektif berikut: (1) untuk mencirikan sifat-sifat tanah lima kegunaan tanah yang berbeza (ladang hutan (*Pinus caribaea* dan *Swetienia macrophylla*), hutan sekunder (SISFEC), ladang kelapa sawit, dan kawasan padang rumput, (2) untuk menentukan status kesuburan tanah dengan menggunakan indeks kesuburan tanah (SFI) dan faktor penilaian tanah (SEF) daripada tiga lokasi berbeza ladang*Pinus caribaea*, ladang*Swietenia macrophylla*, dan kawasan padang rumput. (3) untuk menilai status kesuburan tanah menggunakan SFI dan SEF dua tanah yang berbeza menggunakan kajian hutan sekunder dan ladang kelapa sawit. Kajian ini telah dijalankan di bawah hutan perladangan (*Pinus caribaea* dan *Swetienia macrophylla*), hutan sekunder (SISFEC), ladang kelapa sawit, dan kawasan padang rumput di Universiti Putra Malaysia Kampus Serdang, Selangor, Malaysia.

Untuk menangani objektif pertama, profil tanah telah digali untuk kedalaman 100 cm dan 50 cm lebar. Seterusnya tanah telah disampel mengikut ufuk tanah. Morfologi tanah telah ditentukan dengan menggunakan teknik lapangan.

Untuk menangani objektif kedua, sampel komposit telah dikumpul dalam tempoh enam plot kajian (20x20 m) di ladang *Pinus caribaea*, ladang*Swetienia macrophylla* dan kawasan padang rumput pada kedalaman 0-20 cm (tanah permukaan) dan 20-40 cm (tanah sub-permukaan) kedalaman. Bagi objektif ketiga, tanah telah disampel pada kedalaman 0-20 cm (tanah permukaan) dan 20-40 cm (tanah sub-permukaan) di enam plot (20x20 m) hutan sekunder dan plot ladang kelapa sawit. Sampel adalah udara-kering, homogenized dan disaring untuk lulus jaringan penuras 2 mm untuk analisis lanjut. Makmal analisis kesedaran meliputi sifat fiziko-kimia, kandungan sesquioxides, caj ciri dan sifat-sifat mineralogi. Status kesuburan tanah telah dinilai menggunakan dua indeks; iaitu Indeks Kesuburan Tanah dan Faktor Penilaian Tanah. Data dianalisis dengan menggunakan Pakej Statistik Sains Sosial (SPSS) versi 20.

Keputusan yang diperolehi bagi objektif pertama menunjukkan horizan A didapati dalam semua profil tanah. Warna tanah untuk semua profil adalah antara coklat kemerahan ke coklat gelap (permukaan) disebabkan oleh penguraian bahan organik. Tanah daripada semua profil adalah berasid antara 3,6-5,2 dan nilai keasidan meningkat dengan kedalaman. Kapasiti pertukaran kation dan jumlah karbon cenderung berkurang dengan kedalaman dan lebih tinggi di dalam hutan dan pain perladangan menengah berbanding perladangan mahogani, perladangan kelapa sawit dan kawasan padang rumput. Kation tukar ganti K, Ca dan Mg adalah lebih tinggi dalam tanah atas daripada di tanah bawah bagi kebanyakan profil. Kation tukar ganti Al meningkat dengan mendalam dan boleh didapati P dalam tanah adalah antara 0,72-1,98 mg / kg. Kadar Alo, Ald, FeO dan Fed meningkatkan dengan mendalam dalam semua profil. Komposisi mineral tanah liat dikuasai oleh 1: 1 jenis mineral kaolin. Titik sifar nilai kesan garam cenderung meningkat, manakala nilai σp menurun dengan mendalam di semua tapak, yang menunjukkan bahawa tanah adalah sangat terluluhawa.

Penilaian objektif untuk kedua menunjukkan ketumpatan pukal tanah diplot*Pinus caribaea* dan padang rumput tidak menunjukkan perbezaan yang signifikan ($p < 0.05$). Sebaliknya, tanah atas plot *Swietenia macrophylla* mempunyai ketumpatan pukal yang lebih rendah ($p < 0.05$) berbanding dengan plot lain. Plot mempunyai padang yang lebih tinggi ($p < 0.05$) kandungan lembapan berbanding dengan plot *Swietenia macrophylla* dan *Pinus caribaea* untuk kedua-dua tanah depths.The tanah di tiga tapak eksperimen adalah sedikit berasid dengan pH antara 4,12-5,09 dalam lapisan tanah atas dan 4.27 untuk 4.92 dalam tanah bawah. Bahan organik didapati lebih tinggi ($p < 0.05$) di padang berbanding dengan yang di plot*Swietenia macrophylla* dan *Pinus caribaea*. *Pinus caribaea* menunjukkan plot ($p < 0.05$) tahap jauh lebih tinggi daripada jumlah karbon di kedua-dua kedalaman tanah berbanding dengan plot kajian lain. Kadar tukar ganti Ca, Mg dan K adalah lebih tinggi ($p < 0.05$) dalam tanah atas *Pinus caribaea* berbanding plot lain. Kapasiti pertukaran kation dan kapasiti pertukaran kation berkesan tanah adalah rendah. Keputusan PCA menunjukkan bahawa tekstur tanah, OM, TC, TN, kandungan nutrien dan keupayaan pertukaran kation mempunyai hubungan positif yang kuat yang menjelaskan bahawa nutrien dalam tanah disimpan di dalam tanah *Pinus caribaea* menunjukkan nilai SFI yang lebih tinggi berbanding dengan plot kajian lain, terutamanya untuk tanah atas. Sebaliknya, padang rumput plot mempunyai SEF lebih tinggi, diikuti oleh *Pinus caribaea* dan plot ladang *Swietenia macrophylla*.

Keputusan bagi objektif yang ketiga menunjukkan bahawa komposisi tanah liat adalah yang tertinggi di ladang kelapa sawit untuk kedua-dua permukaan dan tanah bawah permukaan. Nilai pH di permukaan dan bawah permukaan tanah untuk perladangan kelapa sawit adalah lebih tinggi daripada di hutan sekunder. Tanah di ladang kelapa sawit dipamerkan kandungan bahan organik yang lebih tinggi berbanding dengan hutan sekunder. Jumlah karbon dan nitrogen lebih tinggi dalam perladangan kelapa sawit di tanah permukaan. Kapasiti pertukaran kation adalah paling tinggi dalam perladangan kelapa sawit untuk kedua-dua permukaan dan bawah permukaan tanah. Ca ditukar, Mg, K adalah lebih tinggi di ladang kelapa sawit untuk permukaan dan bawah permukaan tanah. Tukar Al untuk permukaan tanah adalah lebih tinggi di ladang kelapa sawit. Nilai Indeks KesuburanTanah adalah lebih tinggi daripada nilai Faktor Penilaian Tanah untuk kedua-dua kedalaman dalam ladang kelapa sawit berbanding hutan sekunder.

Kesimpulannya, semua tanah (ladang hutan (*Pinus caribaea* dan *Swetienia macrophylla*), hutan sekunder (SISFEC), perladangan kelapa sawit, dan kawasan padang rumput) adalah sangat berasid, sangat terluluhawa dan dianggap lemah dalam kandungan nutrien tanah, yang dipamerkan ultisol dan ciri oksisol. Ciri-ciri fiziko-kimia adalah faktor utama yang menyumbang kepada sumber nutrien dan kesuburan tanah. Status kesuburan tanah ladang *Pinus caribaea* adalah lebih bahawa daripada kawasan ladang dan padang rumput, *Swetienia macrophylla* yang menunjukkan bahawa perladangan hutan adalah teknik yang betul untuk memulihkan dan menambahkan semula kesuburan tanah dihina. Kesuburan tanah terjejas oleh jenis tanaman atau pokok-pokok yang tumbuh di dalam tanah, kerana ciri-ciri mereka menjejaskan pengambilan nutrien mereka. Tanah ladang kelapa sawit menunjukkan nilaitertinggi Indeks Kesuburan berbanding hutan sekunder. Selain itu, kesuburan tanah terjejas oleh jenis pengurusan tanah, bahan induk, dan keadaan cuaca.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation and many thanks to my supervisor, Assoc. Prof. Dr. Arifin Abdu whom educated me on the techniques of handling research and has equipped me with various skills in the field that I have explored for the past two years of my study. Under his supervision, I had been given freedom to ponder and with that deliberate and manifest my thoughts in the research ad also publication.

Special thanks to Prof. Dr. Shamshudin Jusop and for his valuable advice, guidance, comments and support. Here, I also would like to express my sincere gratitude to Prof. Dr Toshinori Okuda who has been my home professor at Hiroshima University, Japan in research mobility program. Without his supervising guidance and knowledge, I could not accomplish my training with flying colors.

Thanks also to the Faculty of Forestry, UPM and Department ofLand Management, Faculty of Agriculture, UPM that has equipped me with the necessary facilities and materials for me to carry out my research work. In my daily work, I have been blessed with a friendly and cheerful group of fellow comrades. Thanks to all my friends. Special thanks to my beloved parents (Abdul Malik bin Osman and Hula Bee binti Abdul Rejab) my beloved siblings (Mohd Syafiq and Siti Nor Najihah) and my wife (Nur Ain) for their moral support, advices and word of spirits., the countless contributors who had been my pillar of strength enduring the ups and downs along me throughout my studies.

I certify that a Thesis Examination Committee has met on to conduct the final examination of Mohammad Nazrin bin Abdul Malik on her thesis entitled "ASSESSMENT OF SOIL FERTILITY STATUS IN DIFFERENT ISOLATED LAND USE TYPES" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrometer
AA	Auto Analyzer
ANOVA	Analysis of Variance
Al	Aluminum
Ca	Calcium
CEC	Cation Exchange Capacity
DBH	Diameter of breast height (1.3 m from the ground)
ECEC	Effective cation exchange capacity
FAO	Food and Agriculture Organization
g	Gram
HSD	Honestly Significant Different
ha	Hectare
ITTO	International Tropical Timber Organization
kg	Kilogram
K	Potassium
m	Meter
mg	Milligram
N	Sodium
OM	Organic matter
P	Phosphorus
PCA	Principal Component Analysis
pH_k	Acidity in water
pH_w	Acidity in KCl

PZSE	Point of Zero Salt Effect
ppm	Part per millions
r^2	R-squared
SPSS	Statistical Package Social Science
SF	Secondary forest
SFI	Soil Fertility Index
SEF	Soil Evaluation Factor
TC	Total carbon
TN	Total Nitrogen
UPM	Universiti Putra Malaysia
σ_p	Residual charge at PZSE

CHAPTER 1

INTRODUCTION

1.1 General Background

Tropical rainforests in Malaysia is one of the richest terrestrial ecosystems on Earth in terms of structure and species diversity (Whitmore, 1998). Although occupying only 6% of the Earth's land surface, Malaysia's rainforests provide habitat for more than 50% of the world's living plant and animal species (Archard *et al.*, 2002; Mayaux *et al.*, 2005). These forests are also homes to indigenous peoples and act as pharmacopeias of natural products. Furthermore, Shukla *et al.* (1990) stated that tropical rainforests have a prominent role and main influence in ameliorating and maintaining global climate change by reducing the accumulation of greenhouse gases on a large regional and global scale. These forests, however, are also the most threatened ecosystem globally today due to human activities. According to Food Agriculture Organization, FAO (1995), tropical rainforests play a vital role in timber production, biological conservation, and soil and water conservation.

As Malaysia has been growing to be one of the most developed countries in Southeast Asia, there is a corresponding increase in human population and demand for foods. O'Callaghan (1996) stated that land-use change is caused by biophysical modification or human demands that resulted from changed natural, economic or political conditions. Indeed, Whitmore (1998) found that for each year, an average of 15.4 million hectares of tropical rainforests in Malaysia was destroyed and another 5.6 million hectares were logged. A total of 4.6 million of forests (22.8% of the total forested area) were degraded from logging activities. According to Potts *et al.* (2005), many forest areas in Malaysia have been cleared due to urban development and timber logging. In Malaysia, most of forestlands have been cultivated with economically crucial crop, such as oil palm and rubber, which has led to vast forest destruction (Abdullah *et al.*, 2008). Moreover, Southeast Asian tropical rainforests were rapidly converted to secondary forests, adversely affecting soil fertility and resulting in declining soil quality (Adachi *et al.*, 2005).

Throughout the world, land degradation is a major concern in environmental protection, as forests are converted for agricultural use, residential area, livestock production and urbanization. Jomo *et al.* (2004) found that timber harvesting, crop plantation and shifting cultivation in Malaysia are the main causes of land degradation. These human actions are changing the environmental landscape in catastrophic ways, where changes in both the physical and chemical properties of soil reduce soil productivity and fertility. Consequences of these changes are seen in degraded soils that are exposed to erosion, nutrient depletion, decrease in land productivity, increase in soil compaction, and higher risks of landslides. The last phenomenon is especially prominent during the North-east monsoon season, in which Malaysia frequently received continuous heavy rainfall, causing flooding and, in many situations, landslides.

Soil is an important foundation in the ecosystem and acts as growing medium that supplies nutrients to plants. Soil is derived from rocks that have undergone the weathering process, which is controlled by five factors: climate, parent material, topography, vegetation and time. There are many types of soil on the Earth, which are classified in soil taxonomy. According to Soil Survey Staff (1999), soil can be categorized into 12 orders: Histosols, Entisols, Inceptisols, Alfisols, Ultisols, Oxisols, Spodosols, Vertisols, Aridisols, Mollisols, Andisols, and Gelisols, based on USDA soil taxonomy. Ultisols and Oxisols – highly weathered, acidic and low in fertility – are the two soil orders that occupy most tropical regions, especially in Malaysia, and it was estimated to comprise about 72% in total area of Malaysia. Ultisols are more common than Oxisols globally, but Oxisols covers more area in tropical regions than Ultisols. Global distribution of Ultisols and Oxisols is summarized in Table 1.1. Ultisols and Oxisols are considered as highly weathered soils, acidic and low fertility. (Hakim, 2006: Fageria and Baligar, 2008).

Table 1.1: Distribution of Ultisols and Oxisols

Order	Global area (millon ha)	% of total global area	In the tropic (million ha)	% total tropical area
Ultisols	1347	9.3	749	20.4
Oxisols	840	5.8	833	23.0

Source: Fageria and Baligar (2008)

Schoenholtz *et al.* (2000) discussed that soil is proven as one of the most important element on Earth for the growth of plants and human's daily life. Soil properties, which include physical, chemical, and biological properties, play a vital in maintaining the soil's health. These properties have been used as indicators of soil quality in evaluating the impact of agricultural practices on soil fertility and soil degradation status (Lal and Steward, 1995). Soil indices can be used to illustrate the productivity or function of soil sustainability (Griffiths *et al.*, 2010). Many soil fertility indices for temperate regions are available, but a limited number of suitable soil indices currently exist for measuring the quality of tropical soil, with particularly scarce soil fertility indices available for forest and agriculture lands. Few soil indices can be applied to evaluate both forest and agricultural land because the two lands are treated differently – while forest plantation does not apply fertilizer in order to restore the condition of the forest to its original state, agriculture plantation, such as oil palm plantation, uses fertilizer four times a year for maintaining crop production.

Ultisols and Oxisols in Malaysia are considered as low fertility, and as such, heavy fertilizer application is used to make them more productive. Fertilizer application can ameliorate the soil's chemical and biological properties, but it is difficult to alter its physical properties. Verinumbe (1990) reported that even if chemical properties are favorable, unsuitable soil physical properties can lead to stunted growth or plant death. Studies by Villar *et al.* (2004) and Susyan *et al.* (2011) indicated that in order for soil to function well, integration between physical, chemical and biological properties is essential for maintaining soil quality and sustaining forest and land productivity.

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1.2 Problem Statement

Generally, soils in Malaysia are mostly Ultisols and Oxisol, which are considered to be highly weathered, acidic and low-fertility. Shamshuddin and Fauziah (2010) indicated that although Ultisols and Oxisols are low in fertility, they can be extremely productive with application of fertilizer and liming. On the other hand, improper management will abandon the soil to unproductivity and infertility. As a result, plants will be the most affected living thing and will not be able to function well with less nutrients in the soil.

Decreased soil fertility and increased soil compaction are the consequences from the conversion of natural forest to other types of land use. In order to restore soil fertility on degraded land, many initiatives have been implemented, such as forest plantation, agriculture (oil palm plantation), secondary forest and pasture area. In order to improve soil fertility through accumulation of organic matter, fast growing exotic species is usually used for monoculture forest plantation. Since most studies are concerned about the evaluation of growth performance of planted trees, less attention is given to such other soil properties as physical and chemical properties and soil fertility status. Most plantation management managers assume that the success of tree growth reflects the restoration of degraded forestland toward a healthier and higher fertility status (Leng *et al.*, 2009; Heryati *et al.*, 2011c).

There are several previous studies on the soil properties of tropical rainforests in Malaysia that have been conducted by Arifin *et al.* (2012), Akbar *et al.* (2010), Ishizuka *et al.* (2000), Karam *et al.* (2011), Ohta and Effendi (1992a and 1992b), and Tanaka *et al.* (2009). Most of these studies focused on forests soil, such as planted forest, secondary forest and rehabilitation forest. As such, the comparative study about agricultural (oil palm plantation) and forest (secondary forest) lands in isolated area which is surrounded by development remain limited.

The purpose of this study was to provide fundamental information and current land status of the isolated areas in which soil properties studies are lacking, considering that different land use management and vegetation are used for agricultural and forest lands especially in isolated area. Isolated land use reflects the facts that this study area is surrounded by development which effect the nutrient cycle, soil fertility and other environmental factors. This land information can be utilized by land managers, researchers and farmers for the determination of better soil management, such as fertilizer application for environmental and economically benefits. Moreover, this essential information can help for environmental management, such as sedimentation and erosion management in isolated land use types.

By using soil indices, such as Soil Fertility Index (SFI) and Soil Evaluation Factor (SEF), as a tool in determining soil fertility status in the study sites – forest plantation (*Pinus caribaea* and *Swietennia macrophylla*), secondary forest (SISFEC), oil palm plantation, and pasture area – fundamental information can be synthesized about the current status of the soils. These soil indices are suitable for assessing both forest and agriculture lands as they focus on soil chemical properties. With the use of the soil indices, the fertility and health of different land use in tropical areas become easier to determine. These indices can be further used as a benchmark to differentiate and illustrate the current status of soils in different land uses. Hence, this study is crucial for the understanding of the soils in Malaysia, particularly in Universiti Putra Malaysia, that have undergone various forms of land use changes.

1.3 Objectives of the Study

The general objective of this study was to assess the soil properties of different isolated land use types in UPM area.The specific objectives of this research were to:

1. Characterize the soil properties of five different lands uses: forest plantation (*Pinus caribaea* and *Swietennia macrophylla*), secondary forest (SISFEC), oil palm plantation, and pasture area.
2. Determine soil fertility status using soil fertility index (SFI) and soil evaluation factor (SEF) of three different sites: *Pinus caribaea* plantation, *Swietenia macrophylla* plantation, and pasture area. Assess soil fertility status, using SFI and SEF, of two different lands uses, i.e., secondary forest and oil palm plantation.

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