DEVELOPMENT OF SITE-SPECIFIC ALLOMETRIC EQUATION FOR ESTIMATING BIOMASS OF MIXED MATURE MANGROVE FOREST AT SUNGAI PULAI RESERVE FOREST GELANG PATAH, JOHOR

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By

MUHAMMAD SOFEE BIN MUHAMMAD

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DEDICATION

~ In the name of Allah the Beneficial and Compassionate ~

Thank you Allah s.w.t., The Almighty God who had given me the strength and blessing me with the patience, will and good health during the preparation of the final year project.

Firstly, deepest appreciation and thanks to my supervisor, Professor Dr. Hazandy Bin Abdul Hamid for his comments, advice, idea, encouragement and guidance. It was a great experience and moments of project implementation under his supervision, which guide me to the perfection and what I can say just I love you Prof..

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ABSTRACT

Allometric equations are normally established for estimating aboveground tree biomass and others tree part biomasses in order to avoid any destructive samplings in the future. However, the establishment of site specific allometric equations is needed to estimate accurately the tree biomass in an area. Two compartments were chosen in mixed mature, compartment 16 and 421B, Sungai Pulai Forest Reserve, Gelang Patah, Johor by using judgement sampling method and 1 ha of four inventory plots (50m x 50m) was established in each compartment. Diameter at breast height (D) and height (H) of each individual tree in the plot were taken. Species was identified and grouped based on different diameter classes. The establishment of site-specific equation was done by destructively sampling of 30 trees. Weighing and recording of fresh sample data were done *in-situ*. 100 gram of fresh sample for plant part; leaves, stems, branch and twigs were collected and brought back to the laboratory for oven-dry process and dry weight was calculated. Five allometric equations comprising independent variables D, H as well as wood specific gravity (p) were derived by using power function model and compared to the best fit model for aboveground mangrove biomass (M) with published common equation. Regression analysis revealed that the coefficient of determination (R^2) ranged from 0.6333 to 0.9429 for model using D and ranged from 0.6336 to 0.9481 by using model D^2H. However, model using D and p gives R^2 value at 0.9579. The results of correlations between observed and predicted values showed that eq (5) using p parameter was likely yield greater r-square values (0.958) compared to Eq. (1) using D (R^2=0.9428), Eq (2) using D^2H component (R^2=0.9481), Eq (3) using D Total (R^2=0.9429) and eq (4) using D^2H Total with (R^2=0.9481). Simulation of each model (equation) was also made to the 1400 individual data comprising different tree species from tree census. Comparison of wood specific gravity (p) parameter and other develop models as shown by eq (5) (p and D) was found to be accurate which is the value near to 1 (0.9983). Therefore, quadratic of (p and D) found to be the best model for estimating aboveground biomass in this mangrove forest. This finding also revealed that the small number of samples could be reliable if the wood density or wood specific gravity is included in the model for estimating the aboveground biomass of mangrove species.

ABSTRAK

Penganggaran biojisim atas tanah dan juga biojisim untuk bahagian-bahagian pokok yang lain boleh menggunakan kaedah persamaan allometrik. Hutan Simpan Sg. Pulai telah dipilih untuk menjalankan pembangunan persamaan khusus dengan kaedah pensampelan tebangan bagi 30 sampel pokok. Sebanyak dua kompartmen telah dipilih dengan menggunakan kaedah persampelan tebangan iaitu menggunakan empat plot inventori dibuka (50m x 50m) di kawasan seluas 1 hektar. Data yang telah di ambil adalah ukuran diameter pada paras dada (D) dan tinggi (H) pokok serta spesies-spesies yang berada di kawasan paya bakau. Kerja-kerja penimbangan dan merekod data sampel segar juga di jalankan secara *in-situ*. Setiap 30 pokok yang telah dipilih dan ditebang akan diambil sebanyak 100 gram sampel segar merangkumi daun, batang, cabang dan ranting untuk dibawa ke makmal bagi menjalankan proses pengeringan untuk mendapatkan bacaan berat yang kering. Setelah menggunakan parameter D, H serta graviti spesifik kayu (p) maka terhasil lima persamaan allometrik yang dihasilkan dengan menggunakan `power funtion' dan kemudiannya membaningkan dengan persamaan yang terbaik untuk menganggarkan biojisim spesies yang berada di dalam hutan paya bakau (M). Analisis regresi juga menunjukkan nilai penentuan (R^2) bagi kelima-lima model tersebut mempunyai nilai berjulat dari 0.6333 hingga 0.9429. Keputusan korelasi di antara nilai diperolehi dan nilai yang dijangka menunjukkan persamaan (5) menggunakan (p dan D) telah menghasilkan nilai yang lebih besar (0.958) berbanding pers. (1) menggunakan komponen D (0.9428), pers. (2) menggunakan komponen D^2H (0.9481), pers. (3) menggunakan jumlah keseluruhan D (0.9429) dan pers (4) menggunakan keseluruhan D^2H (0.9481). Model ini juga telah digunakan menggunakan 1400 pokok dan mendapati perbandingan parameter ketumpatan kayu dan lain-lain model menunjukkan pers. (5) (p dan D) adalah lebih tepat kerana ia menggunakan ketumpatan kayu yang nilai R^2 hampir dengan nilai kehampiran 1 (0.9983). Oleh itu, kuadratik (p dan D) telah mendapati adalah model yang terbaik untuk menganggarkan biojisim atas tanah di dalam hutan bakau ini. Kajian ini juga telah membuktikan bahawa sampel yang kecil boleh digunakan untuk membangunkan model bagi menganggarkan nilai biojisim atas tanah asalkan parameter ketumpatan kayu atau grafviti spesifik kayu turut disertakan.

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APPROVAL SHEET

I certify that this research project report entitled "Development of Site-Specific Allometric Equation for Estimating Biomass of Mixed Mature Mangrove Forest at Sungai Pulai Reserve Forest Gelang Patah, Johor'' by Muhammad Sofee bin Muhammad has been examined and approved as a partial fulfillment of the requirements for the Degree of Bachelor of Forestry Science in the Faculty of Forestry, Universiti Putra Malaysia.

_____

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

ANOVA	Analysis of variance
ANCOVA	Analysis of covariance
B	Biomass
D	Diameter / DBH
DBH	Diameter at breast height
H	Height
Km	Kilometre
M	Biomass
p	Wood specific gravity / Wood density
REDD	Reduced Emission from Deforestation and Land Degradation
R^2	Coefficient of determination
T/R	Above ground biomass to below ground biomass ratio
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER 1

INTRODUCTION

1.1 General Background

Forests store large amounts of carbon in the wood and roots of their trees. The carbon numbers, along with information about the uncertainty of the measurements, are important for countries planning to participate in the Reducing Emissions from Deforestation and Land Degradation (REDD+) program. Previous studies had estimated the carbon stored in forests on local and large scales within a single continent, but no systematic way of looking at all tropical forests existed.

Scientists typically use a ground-based technique (tree census) to measure the size of the trees, which gives a good estimate of how much carbon they contain. The estimation of the carbon storage or stocks mostly comes from the biomass estimation of the forests. Recently, biomass and carbon sequestration function of forests is of great concern due to the global warming phenomenon, and hence managing forests with a proper system would play a vital role in mitigating global warming in the future. Estimation of biomass in stands provides the basic data for forest ecosystem management.

From the total ecosystem carbon pools (aboveground and belowground), mangrove carbon pools are the highest of any other major land cover types. Ecosystem carbon pools of mangrove in Indo-Pacific region are more than double

those of most upland tropical and temperate forests (Donato et al., 2012; Kauffman et al., 2011 Laffoley and Grimsditch, 2009).

1.2 Problem Statement

There are generic equations stratified by ecological zones for estimating aboveground biomass exist (e.g. Brown and Iverson, 1992; Brown et al., 1997; Brown et al., 1989; Chave et al., 2005). However, these equations might not accurately be used for estimating tree biomass in a specific forest-type or region (Chave et al., 2009; Kenzo et al., 2009a; Segura and Kanninen, 2005). There equations specifically developed for large canopy trees such as dipterocarp (e.g. Basuki et al., 2009; Kato et al., 1978), tropical secondary forest (e.g. Hashimoto et al., 2004; Kenzo et al., 2009b), mixed secondary forest (e.g. Ketterings et al., 2001), logged-over forest (e.g. Kenzo et al., 2009a), plantation forests (e.g. Heriansyah et al., 2007; Heryati et al., 2011; Miyakuni et al., 2004; 2005) and mangrove forests (e.g. Clough and Scott, 1989; Comley and McGuinness, 2005; Fromard et al., 1998; Hazandy et al., 2014; Imbert and Rollet, 1989; Komiyama et al., 2005; Ong et al., 2004; Poungparn et al., 2002). Hence, it is better to develop specific equations due to the fact that measurement accuracy is crucial to ensure that biomass estimation is not over- or under-estimated. Therefore, this study sought to develop specific allometric equation for mangrove species for accurately estimating of tree.

1.3 Research Question

Is the allometric equation developed in this study for estimating biomass of mixed mature mangrove forest comparable with common equation developed by Komiyama et. al. (2005)?

1.4 Objectives

Due to the importance in the estimation of aboveground biomass, this study was undertaken to line up with the following objectives.

i. To develop the site-specific allometric equation for estimating aboveground biomass of mixed mature mangrove forests by using destructive sampling method.
ii. To compare the developed equations with the existing generic equations.

1.5 Hypothesis

There are various equations for estimating aboveground biomass can be developed from observed biomass, diameter, height and wood density. The developed equations in this study can be cross-checked with generic existing equation commonly used by many in estimation aboveground biomass of mangrove forest. This study will also reveal that a small sample size for

developing allometric equation can also be reliable if certain important determinant is included in the model such as wood density or wood specific gravity

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