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The Use of Remote Sensing and Geographic Information System to Determine the Spatial Distribution of *Melaleuca cajuputi* as a Major Bee Plant in Marang, Terengganu

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By

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

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Dedication

This thesis is dedicated to my wonderful parents, Ashraf and Abbas, who have raised me to be the person I am today. You have been with me every step of the way, through good times and bad. Thank you for all the unconditional love, guidance, and support that you have always given me, helping me to succeed and instilling in me the confidence that I am capable of doing anything I put my mind to. Thank you for everything.

Mohammad Mehdi Saberioon

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

The Use of Remote Sensing and Geographic Information System to Determine the Spatial Distribution of *Melaleuca cajuputi* as a Major Bee Plant in Marang, Terengganu

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11th SEPTEMBER 2009

Chair: **Professor Dato' Makhdzir Mardan, PhD**

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In Malaysia, honey is chiefly obtained from species of honeybees known as *Apis dorsata* and to a lesser extent *Apis cerana*. Honey from *Apis dorsata* is a supplementary source of income to many rural poor in the district of Marang, Terengganu. The colonies of *A. dorsata* are found to nest in aggregates on tall bee trees (tree emergent) in the open, as well as, nesting singly in concealed locations when nesting low, especially in the submerged forest of *Melaleuca cajuputi* as in the vast hectare (> 200,000 hectares) of *Melalueca* forest along the coastal areas of Terengganu. So, Melaleuca forest mapping and flower mapping can be reliable methods for determining this species distribution as the main source of nectar and pollen for these aforementioned honey bees. In ecology, biomass can be defined as accumulation of living matter which is useful as a biophysical index for mapping of flower in forest. In this study, we used SPOT-5 and RADARSAT-1 for inventory of Melaleuca forest in Marang and developed Above Ground Biomass (AGB)

estimation model as indirect index for obtaining and producing distribution of *Melaleuca cajuputi* flowers. Also, *Apis dorsata* colonies distribution and motorbike parking points of honey hunters were collected using GPS in field survey to determine distribution of colonies and improve searching ability in *Apis dorsata* colonies harvesting by honey hunters in the study area.

The Melaleuca forest, located in Marang, Terengganu, Malaysia which is lying in upper left latitude 5°17'15.473"N, and longitude 103°05'25.021"E and lower right latitude 4°37'55.236" N, longitude 103°45'47.568"E was chosen for this research. SPOT-5 was enhanced, classified and vectorized using image processing software for the purpose of Melaleuca forest mapping. Based on the image analysis of the SPOT-5 image the Melaleuca forest were classified as five classes *Melaleuca Cajuputi*, *Acacia auriculiformis,* non-vegetation, water bodies and Cloud/haze/Shadow. The analysis showed that *Melaleuca cajuputi* covered 76,061.73ha (61.72%), *Acacia auriculiformis* 24,484.32ha (19.88%), non-vegetation 9,991.76ha (8.11%), water bodies 2,203.47ha (1.79%) and Cloud/Haze/Shadow 10,491.86ha (8.51%) with an overall classification accuracy of 91.79% while the statistics value obtained from kappa coefficient was more than 0.86 which is relatively quite good results for image processing.

Based on Melaleuca forest inventory, 10 plots of 10m ×10m were established to measure the AGB along with two stand parameters namely the DBH and height. The measurements were analyzed to determine the descriptive statistics of each plot using SPSS software. AGB was later regressed against the radar backscattering coefficient, derived earlier from

the RADARSAT-1 images, to establish the regression fit. Once the regression fit model was obtained, the radar backscattering coefficient data were converted to the AGB mapping. The accuracy of AGB was evaluated using the accuracy assessment in ERDAS IMAGINE v 9.1.

The relationship between AGB and radar backscattering is described with the linear regression equation of AGB=238.73+ (15.4) × σ° (R^2 = 0.89) for flowering season and AGB=170.843+ (13.82) × σ° (R^2 = 0.81) for non-flowering season. The range of measured AGB was similar to the overall range in AGB from radar backscattering. Through the model of AGB value estimation, AGB mapping on Melaleuca forest can be done with each pixel holding its own AGB value. This study found that remote sensing can be used to estimate AGB in forest stands and also to produce AGB map in Melaleuca forest. Then, flowering map was derived from AGB classified map in two different seasons of flowering and non-flowering. Finally, all maps and information were transferred and overlaid in Arc/GIS v 9.1 to find probability and searching ability of *Apis dorsata* colonies by honey hunters.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah sarjana sains

Penetuan Kawasan Sabalan *Melaleuca cajuputi* Sebagai Pokok Lebah Utama Menggunakan Penderiaan Jauh dan Sistem Maklumat Geografi di Marang, Terengganu

Oleh

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Fakulti: Pertanian

Di Malaysia, sebahagian besar madu asli dihasilkan oleh spesis lebah yang dikenali sebagai *Apis dorsata* dan selebihnya daripada spesis lebah *Apis cerana*. Madu lebah *Apis dorsata* menyumbang pendapatan tambahan kepada ramai golongan miskin di daerah Marang, Terengganu. Koloni-koloni lebah *Apis dorsata* umumnya membuat sarang secara berkelompok pada dahan pohon-pohon tinggi di kawasan yang lapang. Namun, spesis lebah ini juga boleh ditemui bersarang rendah di kawasan-kawasan terlindung terutamanya hutan pohon gelam (*Melaleuca cajuputi*) seperti yang terdapat di sepanjang pinggir pantai Terengganu. Oleh itu, permetaan hutan Gelam (Melaleuca) dan pemetaan bunga merupakan satu kaedah yang boleh diguna pakai bagi menentukan taburan spesies ini sebagai sumber utama nektar (nectar) and tiub debunga (pollen) bagi madu lebah yang telah dinyatakan sebelum ini. Dari sudut ekologi, jisim biologi boleh didefinasikan sebagai pengumpulan benda hidup atau berkemunkinan benda hidup dimana ia beguna sebagai indeks biofizikal bagi pemetaan bunga dalam hutan. Dalam kajian ini, SPOT-5 dan RADARSAT-1 digunakan bagi pemetaan taburan hutan gelam (*Mellaleuca cajuputi*) di

Marang dan penghasilan model penganggaran jisim biologi atas tanah (AGB) sebagai index tidak lansung yang digunakan untuk memperoleh dan menghasilkan taburan bungaan *Mellaleuca cajuputi* di hutan berkenaan. Selain daripada itu, peninjauan tapak kerja dengan penggunaan GPS bagi pengumpulan data mengenai taburan koloni *Apis dorsata* dan titik-titik tempat letak motosikal pemburu madu, dengan ini penentuaan taburan koloni dan perbaikian keupayaan pencariaan koloni *Apis dorsata* untuk dituai oleh pemburu madu di kawasan kajian dapat dilakukan.

Hutan gelam yang terletak di Marang, Terengganu dari garis lintang 4°37'55.236"U ke 5°17'15.473"U dan garis bujur 103°05'25.021"T ke 103°45'47.568"T telah dipilih sebagai tapak kajian ini. SPOT-5 yang digunakan bagi tujuan pemetaan hutan ini dipertingkatkan, diklasifikasikan, dan divektorkan dengan bantuan perisian pemprosesan imej. Imej yang terhasil pada skrin radar SPOT-5 memaparkan lima kawasan berbeza di hutan gelam tersebut. Lima kawasan tersebut adalah kawasan tumbuhan *Melaleuca cajuputi*, tumbuhan *Acacia auriculiformis*, kawasan tidak bertumbuhan, kawasan berair, dan awan/jerubu. Analisis menunjukkan bahawa Ttumbuhan *Melaleuca cajuputi* meliputi kawasan seluas 76,061.73 hektar (61.72%) daripada keseluruhan keluasan hutan berkenaan, diikuti oleh tumbuhan *Acacia auriculiformis* dengan keluasan 24,484.32 hektar (19.88%). Keluasan-keluasan kawasan tidak bertumbuhan dan kawasan berair adalah 9,991.76 hektar (8.11%) dan 2,203.47 hektar (1.79%) masing-masing, manakala 10,491.86 hektar (8.51%) merupakan tompok-tompok awan. Ketepatan pengelasan yang dilakukan adalah sebanyak 91.79% manakala nilai statistik kappa adalah 0.86, menandakan bahawa pemprosesan imej tersebut adalah agak baik.

Berdasarkan kepada taburan hutan gelam, sebanyak 10 plot berdimensi 10m x 10m setiap satu dibuat untuk mengukur AGB dan dua parameter iaitu DBH dan tinggi. Ukuran-ukuran yang diperolehi dianalisis dengan menggunakan perisian SPSS untuk mendapatkan gambaran terperinci setiap plot tersebut. Nilai-nilai AGB kemudiannya diregresi terhadap nilai-nilai penyebaran balik radar yang diperolehi melalui imej RADARSAT-1 untuk mendapatkan regresi yang sesuai (regression fit). Apabila model regresi yang sesuai antara koefisien penyebaran balik radar diperolehi, data koefisien penyebaran balik radar ditukarkan kepada pemetaan AGB. Ketepatan AGB dinilai dengan menggunakan taksiran ketepatan yang terdapat pada ERDAS IMAGINE v 9.1.

Hubungan lelurus antara AGB dan penyebaran balik radar dapat dihuraikan dengan mengunakan persamaan regresi AGB = 238.73 + (15.4) × $\sigma\circ$ dengan R^2 yang tinggi (0.89) pada musim bunga dan AGB=170.843+ (13.82) × $\sigma\circ$ dengan R^2 = 0.81 pada bukan musim bunga. Julat pengiraan AGB adalah sama dengan julat keseluruhan AGB dari penyebaran balik radar. Melalui model penganggaran nilai AGB, pemetaan AGB pada hutan gelam boleh dilaksanakan dengan setiap piksel diwakili nilai AGB nya sendiri. Kajian ini menyatakan bahawa sistem penderiaan jauh (remote sensing) boleh digunakan untuk menganggarkan AGB di kawasan hutan dan juga dapat menghasilkan peta AGB hutan gelam. Seterusnya, peta pembungaan (flowering map) telah dihasilkan daripada peta pengelasan AGB pada dua musimiaitu musim bunga dan bukan musim bunga. Akhir sekali, semua peta-peta dan maklumat telah dipindahkan dan dilapis-lapiskan di Arc/GIS v

9.1 bagi memperoleh kebarangkaliaan dan keupayaan pencariaan koloni *Apis dorsata* oleh pemburu madu.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follow:

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DECLARATION

I declare that the thesis is my original work expect for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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MOHAMMAD MEHDI SABERIOON

DATE:

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LIST OF ABBREVIATIONS

AGB	:	Above Ground Biomass
AOI		Area of Interest
β_1	:	Intercept of Regression
B_0		Slope of Regression
CCRS		Canada Center for Remote sensing
CNES		Centre National d'études Spatiales
Cv		Coefficient of Variation
DBH	:	Diameter at Breast Height
df		Degree freedem
DN		Digital Number
ENVI		Environmental for Visualizing Images
ESRI		Environmental Systems Research Institute
EMR		Electric Magnetic Radiation
etc		et cetera
FAO	:	Food and Agriculture Organization

FCC		False Color Composition
FW		Fresh Weight
GPS	:	Geographic Positioning System
GIS		Geographic Information System
GCPs		Ground Control Points
H	:	Height
ha		Hectare
HRG		High Resolution Geometrical
I_j		Incidence Angle
j^{th}		Range Pixel
JUPEM		Jabatan Ukur dan Pemetaan Malaysia
k		Kappa Coeficient
log		Logarithm
MLC		Maximum Likelihood Classification
MIR		Mid Infrared
NIR		Near Infrared

NDVI		Normalized Difference Vegetation Index
P		Total Number of Pixels in All the Ground Truth Class
Pixel		Picture Elements
RS		Remote Sensing
r		Regression
R^2		Regression Square
R-G-B		Red-Green-Blue
RSO		Rectified Skew Orthomorphic Projection
ROI		Region of Interest
SAR	:	Synthetic Aperture Radar
SPOT		Satellite Pour l'Observation de la Terre
SNSB		the Swedish National Space Board
SSTC		the Belgian Scientific, Technical and Cultural Services
TM		Thematic Mapper
σ°		Sigma Nought

X_{kk}	Confusion Matrix Diagonal

CHAPTER 1

INTRODUCTION

1.1 Introduction

Forest is an important natural resource that plays a major role in supporting the livelihood of human like in providing material goods, such as fuel wood, commercial timber, non-wood products, and water for irrigation and drinking, preventing landslides or debris flows, providing protection from strong winds and purifying the atmosphere. It is a trove of biodiversity and genetic resource, as well as provider of other environmental services and a key player in poverty alleviation (F.A.O., 2005; Myers, 1992; Sellers, 1985).

Rainforest gets rainfall more than 150 cm/yr and it gives rise to twenty five different types, including evergreen lowland forest, evergreen mountain forest, tropical evergreen alluvial forest, and semi-deciduous forest. All rainforests, however, can be broadly classified as either tropical or temperate rainforests. The global distribution of equatorial rainforest is closely tied to the warm, moist climates that occur near to the Equator (Figure 1.1) (Adams & Ridge, 1994).