

DETERMINATION OF THE BIOMASS PRODUCTION AND
CARBON SEQUESTRATION CAPACITY OF WET – ZONE
FORESTS IN SRI LANKA

by

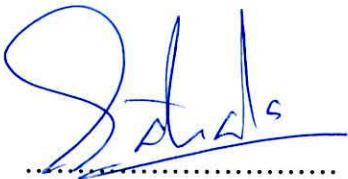
Wahala Mudiyanseelage Palitha Sampath Bandara Wahala



Thesis submitted to the University of Sri Jayewardenepura for the
award of the Degree of Doctor of Philosophy in forestry on 10th
May 2013.

DECLARATION

“The work described in this thesis was carried out by me under the supervision of Prof. Hemanthi Ranasinghe and Prof. H. S. Amarasekera (interim supervisor) of the Department of Forestry and Environmental Science at the University of Sri Jayewardenepura, Nugegoda, Sri Lanka and a report on this has not been submitted in whole or in part to any university or any other institution for another degree or diploma”



W M P S B Wahala

10th May 2013

SUPERVISORS' NOTE

"We certify that the above statement made by the candidate is true and that this thesis is suitable for submission to the University for the purpose of the evaluation."

Supervisor:



Prof. D.M.S.H.K. Ranasinghe
Department of Forestry and
Environmental Science
University of Sri Jayewardenepura

Date: 19/06/2013

Interim Supervisor:



Prof. H. S. Amarasekera
Department of Forestry and
Environmental Science
University of Sri Jayewardenepura

Date: 19/06/2013

ACKNOWLEDGEMENTS

This work would not be possible without the help and support of many individuals, many of whom I may forget to mention and I apologize if that occurs.

First, I would like to express my deepest gratitude and I am greatly honored to Prof. Hemanthi Ranasinghe, Professor of Forestry and Environmental Science of the Department of Forestry and Environmental Sciences, University of Sri Jayewardenepura, for being my internal supervisor and suggesting me this research topic that has national global importance. Without her suggestions, help and guidance my approach on this study would not be successful. She has been a great inspiration not only for this study but also for my entire academic career.

I wish to extent my gratitude to Prof. W.A.J.M. De Costa, Professor of Crop Science of the Faculty of Agriculture, University of Peradeniya, for providing me the expertise guidance and information, Hemispherical photography camera setup and the HemiView 2.1 Canopy Analysis computer software for this study, and specially for the facilitating me to carry out seedling level photosynthesis estimation at crop physiology lab of the agriculture faculty of University of Peradeniya.

I wish to express my heartiest gratitude to Prof. Hiran S Amarasekera, Professor of Department of Forestry and Environmental Sciences, University of Sri Jayewardenepura

for being the internal supervisor during Prof Hemanthi's Sabbatical leave period in year 2011. More than a supervisor, you were a spirit for me in many mile stones in my life.

I would like to extend my sincere thanks to Mr. I. D. Wijesinghe , Mr. Suresh Weththasinghe and Mr. Suranjan who are the technical officers in the department for their cooperation in providing me with the field equipments and to the rest of the staff of the Department of Forestry and Environmental Science, University of Sri Jayewardenepura. Also I wish to thank Mr. Gemunu , Mrs. Janakie , Mr. Aththanayake and other technical staff at the Faculty of Agriculture, University of Peradeniya for the support given me specially during the measurement of photosynthetic parameters of seedlings with LICOR 6400 portable photosynthesis measurement system.

I wish to give my special thank to Mr. Dharshana, and Dr. Thilantha Dammalage of the Faculty of Geomatics of Sabaragamuwa University of Sri Lanka, for their technical guidance during the development of vegetation indices using MODIS data with ENVI and ArcGIS computer softwares.

I am appreciative to those who have provided financial support for this work. This project was initially funded by the NSF grant no RG/2003/FR/01.

I am also grateful to the Forest Department of Sri Lanka and the Department of Wildlife Conservation of Sri Lanka for providing me the permission to carry out my field work at Forest Reserves and National parks.

I must thank to the Department of Meteorology, Sri Lanka for providing me the necessary data for the calculation which direct my study for the success.

I specially would like to thank Mr. Nilantha Vishwanath who gave me the finest support by giving me his own vehicle for the field work and all the supports gave me at the field.

I am grateful to pen these few words to thank Mr. Chithrasekera at Kanneliya and the forest officers at the field station and Wimale at Sinharaja who was the caretaker at Sinharaja field station during my work period at Sinharaja. Thank you for giving me accompanies and genuine and kind helps in many ways when I was at field alone. I would like to extend my sincere thanks to Prof. Swarna Piyasiri, the Dean, Faculty of Graduate Studies, Prof. Sadun Senerath, Chairperson, Board of Life Science for the assistance gave throughout the study period. I would also like to thank Mr. Risvi, and Ms. Sachintha at Faculty of Graduate faculty, University of Si Jayewardenepura for their friendly and keen administrative support done for me in various ways.

Last but not least, I would like to thank my mother and beloved family members, for their love and moral support rendered during the whole period.

Finally I am surprised and pleased to have an unseen spiritual support had with me all the time like the shadow of mine to overcome the various obstacles came out the way.

CONTENTS

DECLARATION	ii
SUPERVISORS'NOTE	iii
ACKNOWLEDGEMENTS	ii
CONTENTS	v
LIST OF TABLES	xiv
LIST OF FIGURES	xvi
DEDICATION	xxv
ABSTRACT	xxvi
<i>CHAPTER ONE : INTRODUCTION</i>	1
1.1 Carbon sequestration	2
1.2 Forests as a carbon sink	4
1.3 Natural forests in Sri Lanka	5
1.4 Objective of the study	7
1.4.1 Specific objectives	7

<i>CHAPTER TWO : LITERATURE REVIEW</i>	8
2.1 Global warming and climate change	8
2.2 The Consequences of climate change and climate variability	10
2.3 Kyoto Protocol	13
2.3.1 Clean Development Mechanism and current situation in Sri Lanka	14
2.3.2 REDD and REDD ⁺	15
2.4 Global carbon cycle	17
2.5 Carbon sequestration	18
2.5.1 Terrestrial ecosystems as a carbon sink	19
2.5.2 Forests as a carbon sink - Global estimates	22
2.5.3 Carbon sink in natural forests in global scale	23
2.5.4 Carbon sink in forest plantations in global scale	29
2.5.5 Forests as a carbon sink – Estimates in Sri Lanka	30
2.6 Net Ecosystem Exchange	34
2.6.1 Ecosystem respiration	35
2.6.2 Soil respiration	36
2.6.3 Methods to estimate net ecosystem CO ₂ exchange	36
2.7 Net Primary Production and Gross Primary Production	38
2.8 Photosynthesis – The primary process of biomass production	46
2.8.1 Plant respiration	47

2.8.2	Conditions required for photosynthesis	48
2.8.3	Photosynthetic properties of tropical forest trees	49
2.8.4	Photosynthetic light response curve	54
2.8.4.1	<i>Rectangular Hyperbola</i>	55
2.8.4.2	<i>Non-rectangular Hyperbola</i>	56
2.8.4.3	<i>Asymptotic exponential curve</i>	57
2.8.5	Estimation of canopy photosynthesis	58
2.9	Radiation Use Efficiency (RUE)	59
2.9.1	Canopy photosynthetic radiation use efficiency	60
2.9.2	Methods of determining the canopy RUE	65
2.9.3	Big leaf model	66
2.9.4	Two leaf model	67
2.10	Forest canopy structure and characteristics	68
2.10.1	Leaf Area Index	68
2.11	Forest canopy light environment	72
2.11.1	Gap fraction	73
2.11.2	Canopy radiation interception	74
2.12	Hemispherical photography	75
2.13	Remote sensing and vegetation indices	77
2.13.1	PRI and RUE estimation	78
2.13.2	Normalized Different Vegetation Index	79

2.13.3	Enhanced Vegetation Index	81
2.14	Tropical forest resource – Global situation	82
2.15	Forest resources in Sri Lanka	84
2.16	Wet zone forest types in Sri Lanka	86
CHAPTER THREE : MATERIALS AND METHODS		88
3.1	Site description	88
3.1.1	Sinharaja Forest Reserve	91
3.1.1.1	<i>Extent and Location</i>	91
3.1.1.2	<i>Topography</i>	91
3.1.1.3	<i>Geology and soil</i>	91
3.1.1.4	<i>Climate</i>	92
3.1.1.5	<i>Forest condition and main vegetation types in Sinharaja</i>	92
3.1.2	Kanneliya Forest Reserve	93
3.1.2.1	<i>Extent and Location</i>	93
3.1.2.2	<i>Topography</i>	94
3.1.2.3	<i>Geology and soil</i>	94
3.1.2.4	<i>Climate</i>	94
3.1.2.5	<i>Forest condition</i>	95
3.1.3	Knuckles Forest Reserve	95
3.1.3.1	<i>Extent and Location</i>	95
3.1.3.2	<i>Topography</i>	95

3.1.3.3	<i>Climate</i>	96
3.1.3.4	<i>Forest condition and main vegetation types in Knuckles forest</i>	96
3.1.4	Peak Wilderness Sanctuary	98
3.1.4.1	<i>Extent and Location</i>	98
3.1.4.2	<i>Topography</i>	100
3.1.4.3	<i>Geology and soil</i>	100
3.1.4.4	<i>Climate</i>	100
3.1.4.5	<i>Forest condition</i>	101
3.1.5	Horton Plains National Park	104
3.1.5.1	<i>Extent and Location</i>	104
3.1.5.2	<i>Topography</i>	104
3.1.5.3	<i>Geology and soil</i>	105
3.1.5.4	<i>Climate</i>	105
3.1.5.5	<i>Forest condition</i>	105
3.2	Rationale and principle of the study	109
3.2.1	Physiology of biomass production	110
3.2.2	Radiation interception by forest canopy (R_l)	111
3.2.3	PhRUE of forest canopies	112
3.3	Measurement of intercepted radiation using hemispherical photography	112
3.3.1	Equipments and software for the acquisition and analysis of hemiphotos	113
3.3.1.1	<i>Specifications of equipments</i>	113
3.3.1.2	<i>Hemi View 2.1 canopy analysis software</i>	114
3.3.2	Sampling design for hemispherical photography	115

3.3.3	Field protocol - Acquisition of hemispherical photographs	116
3.3.4	Analysis of hemispherical photographs	118
3.3.4.1	<i>Pre preparation of images</i>	118
3.3.4.2	<i>Align images</i>	119
3.3.4.3	<i>Lens selection</i>	120
3.3.4.4	<i>Site properties</i>	120
3.3.4.5	<i>Solar model</i>	120
3.3.4.6	<i>Image classification</i>	122
3.3.4.7	<i>Calculation settings</i>	123
3.3.5	Calculating results	124
3.4	Determination of RUE values for forest canopies	125
3.4.1	Photosynthesis measurements of seedlings	125
3.4.2	Determination of canopy level PhRUE	126
3.5	Modeling PhRUE from MODIS based PRI	127
3.5.1	Acquisition and processing of MODIS reflectance data to develop PRI	128
3.5.2	Deriving relationship between PRI and PhRUE	128
3.6	Development of vegetation indices	129
3.6.1	Normalized Difference Vegetation Index	129
3.6.2	Enhanced Vegetation Index	129
3.7	Estimation of biomass production rates from intercepted PAR and PhRUE	130
3.8	Estimation of carbon sequestration rates	130

3.9	Data analysis	131
3.9.1	Analysis of variance of canopy characteristics and light environment	131
3.9.2	Regression analysis	131
3.9.3	Development and analysis of VI's	132
<i>CHAPTER FOUR : RESULTS</i>		133
4.1	Radiation Interception by forest canopies	133
4.1.1	Variation of canopy PAR interception between different vegetation types	133
4.1.2	Variation of forest canopy PAR interception between study sites	136
4.1.3	Within site variation of canopy PAR interception	138
4.2	Leaf Area Index (LAI)	140
4.2.1	LAI variation between different vegetation types	140
4.2.2	Variation of LAI between study sites	141
4.2.3	Within site variation of LAI	143
4.2.4	LAI variation with elevational gradient	145
4.2.5	Relationship between LAI and fractional radiation interception by forest canopies	146
4.3	Canopy PhRUE and PRI	148
4.3.1	Canopy PhRUE and PRI model	148
4.3.2	Variation of PRI	150
4.3.2.1	<i>Variation of PRI between different vegetation types</i>	150
4.3.2.2	<i>Variation of PRI between different study sites</i>	151

4.3.3	Variation of canopy PhRUE	153
4.3.3.1	<i>Variation of canopy PhRUE between different vegetation types</i>	153
4.3.3.2	<i>Variation of canopy PhRUE between study sites</i>	154
4.4	Net Primary Productivity (NPP) of forest canopies	156
4.4.1	Variation of NPP between different vegetation types	156
4.4.2	Variation of NPP of between study sites	157
4.4.3	Within Site variation of canopy level NPP	159
4.5	Net biomass production rates	161
4.5.1	Net biomass production rates of different vegetation types	161
4.5.2	Net biomass production rates in different study sites	162
4.6	CO ₂ Sequestration rate	164
4.6.1	CO ₂ Sequestration rate of different vegetation types	164
4.6.2	CO ₂ Sequestration rates in study sites	165
4.7	Relationship between LAI and canopy NPP	167
4.8	Relationship between CO ₂ sequestration rate and VI's	168
4.8.1	Relationship between CO ₂ sequestration and NDVI	168
4.8.2	Relationship between CO ₂ sequestration and EVI	170
4.9	Total CO ₂ sequestration capacity in wet zone forests	171
CHAPTER FIVE : DISCUSSION		173
5.1	Significance of the study	173

5.2	Limitations of the study	174
5.3	Forest canopy characteristics and solar radiation interception	175
5.3.1	Variation of LAI	176
5.3.2	Total solar radiation interception by forest canopy	177
5.4	Photosynthetic Radiation Use Efficiency of natural forests	178
5.5	Relationship between PRI and PhRUE	179
5.6	NPP, net biomass production and carbon sequestration	180
5.7	Relationship between CO ₂ sequestration rate and VI's	182
<i>CHAPTER SIX : CONCLUSIONS AND RECOMMENDATIONS</i>		184
6.1	Conclusions	184
6.2	Recommendations	187
REFERENCES		189
ANNEXURES		228

LIST OF TABLES

Table 2.1: The worldwide capacity of potential CO ₂ storage reservoirs	18
Table 2.2: Biomass production and carbon sequestration in tropical forests	26
Table 2.3: An average Carbon Stocks for Various Biomes	27
Table 2.4: Estimations of biomass and soil carbon	28
Table 2.5: Annual GPP of OTTER	45
Table 2.6: Photosynthetic parameters of different forest ecosystems	51
Table 2.7: Radiation interception, biomass production and RUE of selected tree species over a period of 303 days.	63
Table 2.8: Some of the indirect methods to derive plant canopy LAI	70
Table 2.9: Natural forest types in Sri Lanka	84
Table 2.10: Area of natural forest by national forest type classes in 1992 & 1996	85
Table 3.1: Selected forest areas for the study in wet zone area in Sri Lanka	89
Table 3.2: Specifications of equipments used to acquire hemispherical photographs	113

Table 4.1: Estimated total CO₂ sequestration potential for selected natural vegetation types in wet zone area

172

LIST OF FIGURES

Figure 3.1: Study sites under different vegetation types in wet zone of Sri Lanka	90
Figure 3.2: Schematic diagram of a section of line transect	116
Figure 3.3: Hemi photo camera assembly (Self leveling mount, fisheye lens and camera)	117
Figure 3.4: Setting up camera assembly, prior to taking a hemispherical photograph under a low canopy height at Thotupola kanda transect in HPNP.	117
Figure 3.5: Edited hemiphoto image in Hemiview window	119
Figure 4.1: Distribution of total canopy interception of Photosynthetically Active Radiation (PAR) by different vegetation types in wet zone region. (•) represents the mean value .The box represents the middle 50% of the total PAR interception data. The line through the box represents the median the PAR interception. The whiskers extending from the box represent the upper and lower 25% of the PAR interception data and (*) represent the outliers.	134
Figure 4.2: Canopy PAR interception as a fraction of total above canopy incident PAR of different vegetation types in wet zone region. The box represents the	

middle 50% of the fractional PAR interception. (•) represent mean values. The line through the box represents the median of the fractional PAR interception. The whiskers extending from the box represent the upper and lower 25% of the fractional PAR interception and (*) represent the outliers.

135

Figure 4.3: Variation of total PAR interception by forest canopies of selected study sites under different vegetation types in wet zone region. The box represents the middle 50% of the total PAR interception data. The line through the box represents the median of PAR interception and (•) represents the mean value. The whiskers extending from the box represent the upper and lower 25% of the PAR interception data and (*) represents the outliers. ([M] = Montane vegetation type; [SM] = Sub montane vegetation type; [SE] = Semi evergreen vegetation type; [LW] = Lowland wet evergreen vegetation type).

137

Figure 4.4: Variation of total PAR interception by forest canopies of different elevational classes within 6 study sites (a) Sinharaja MAB; (b) Kanneliya FR; (c) Deanston area of Knuckles forest region; (d) Illukkumbura area of Knuckles forest region; (e) Peakwilderness sanctuary; (f) Horton Plains NP. The box represents the middle 50% of the total PAR interception data. The line through the box represents the median of PAR interception and (•) represents the mean value. The whiskers extending from the box

represent the upper and lower 25% of the PAR interception data and (*) represents the outliers. 139

Figure 4.5: Variation of LAI by different vegetation types in wet zone region. (•) represents the mean value. The box represents the middle 50% of the total LAI data. The line through the box represents the median of LAI. The whiskers extending from the box represent the upper and lower 25% of the LAI data and (*) represent the outliers of LAI data. 141

Figure 4.6: Variation of LAI of selected study sites under different vegetation types in wet zone region. The box represents the middle 50% of the LAI data. The line through the box represents the median of LAI and (•) represents the mean value of LAI. The whiskers extending from the box represent the upper and lower 25% of the LAI data and (*) represents the outliers. ([M] = Montane vegetation type; [SM] = Sub montane vegetation type; [SE] = Semi evergreen vegetation type; [LW] = Lowland wet evergreen vegetation type). 142

Figure 4.7: Variation of LAI between different elevational classes within 6 study sites (a) Sinharaja MAB; (b) Kanneliya FR; (c) Deanston area of Knuckles forest region; (d) Illukkumbura area of Knuckles forest region; (e) Peakwilderness sanctuary; (f) Horton Plains NP. The box represents the middle 50% of the LAI data. The line through the box represents the median of LAI and (•) represents the mean value. The whiskers extending

from the box represent the upper and lower 25% of the LAI data and (*) represents the outliers. Y axis label is same for all graphs. 144

Figure 4.8: Variation of LAI along elevational gradient in the wet zone of Sri Lanka. [S] represents the standard distance data values fall from the regression line; [CI] represents the confidence interval; [PI] represents the prediction interval, defined by lower and upper limits, which are calculated from the confidence level and the standard error of the prediction. 146

Figure 4.9: Relationship between LAI and fractional radiation interception by forest canopies in the wet zone of Sri Lanka. [S] represents the standard distance data values fall from the regression line; [CI] represents the confidence interval; [PI] represents the prediction interval, defined by lower and upper limits, which are calculated from the confidence level and the standard error of the prediction. 147

Figure 4.10: Regression line between remotely sensed PRI and corresponding PhRUE values estimated for subjectively selected sampling sites in wet zone area. [CI] represents the confidence interval; [PI] represents the prediction interval, defined by lower and upper limits, which are calculated from the confidence level and the standard error of the prediction. 149

Figure 4.11: Variation of mean values of remotely sensed PRI between different vegetation types in wet zone region. The box represents the middle 50% of the PRI. (•) represent mean values. The line through the box represents the

median of the PRI. The whiskers extending from the box represent the upper and lower 25% of the PRI and (*) represent the outliers. 151

Figure 4.12: Variation of mean values of remotely sensed PRI between different study sites in wet zone region. The box represents the middle 50% of the PRI data. The line through the box represents the median of PRI and (•) represents the mean value of PRI. The whiskers extending from the box represent the upper and lower 25% of the PRI data and (*) represents the outliers. ([M] = Montane vegetation type; [SM] = Sub montane vegetation type; [SE] = Semi evergreen vegetation type; [LW] = Lowland wet evergreen vegetation type). 152

Figure 4.13: Variation of mean values derived PhRUE between different vegetation types in wet zone region. The box represents the middle 50% of the PhRUE. (•) represent mean values. The line through the box represents the median of the PhRUE. The whiskers extending from the box represent the upper and lower 25% of the PhRUE and (*) represent the outliers. 154

Figure 4.14: Variation of mean values of PhRUE between different study sites in wet zone region. The box represents the middle 50% of the PhRUE data. The line through the box represents the median of PhRUE and (•) represents the mean value of PhRUE. The whiskers extending from the box represent the upper and lower 25% of the PhRUE data and (*) represents the outliers. ([M] = Montane vegetation type; [SM] = Sub montane vegetation

type; [SE] = Semi evergreen vegetation type; [LW] = Lowland wet evergreen vegetation type). 155

Figure 4.15: Variation of mean values of canopy level NPP between different vegetation types in wet zone region. The box represents the middle 50% of the NPP. (•) represent mean values. The line through the box represents the median of the NPP. The whiskers extending from the box represent the upper and lower 25% of the NPP and (*) represent the outliers. 157

Figure 4.16: Variation of mean values of canopy level NPP between different study sites in wet zone region. The box represents the middle 50% of the canopy level NPP data. The line through the box represents the median of canopy level NPP and (•) represents the mean value of canopy level NPP. The whiskers extending from the box represent the upper and lower 25% of the canopy level NPP data and (*) represents the outliers. ([M] = Montane vegetation type; [SM] = Sub montane vegetation type; [SE] = Semi evergreen vegetation type; [LW] = Lowland wet evergreen vegetation type). 158

Figure 4.17: Variation of canopy level NPP between different elevational classes within 6 study sites (a) Sinharaja MAB; (b) Kanneliya FR; (c) Deanston area of Knuckles forest region; (d) Illukkumbura area of Knuckles forest region; (e) Peakwilderness sanctuary; (f) Horton Plains NP .The box represents the middle 50% of the NPP data. The line through the box represents the median of NPP and (•) represents the mean value. The whiskers extending

from the box represent the upper and lower 25% of the NPP data and (*) represents the outliers. Axis label is same for all graphs. 160

Figure 4.18: Mean average net biomass production rate for different vegetation types in wet zone region. The box represents the middle 50% of the net biomass production rate and the vertical height of the box is proportionate to the sample size. (•) represent mean values. The line through the box represents the median of the net biomass production rate. The whiskers extending from the box represent the upper and lower 25% of the net biomass production rate. 162

Figure 4.19: Mean average net biomass production rate for different study sites. The box represents the middle 50% of the net biomass production rate and the vertical height of the box is proportionate to the sample size. (•) represent mean values. The line through the box represents the median of the net biomass production rate. The whiskers extending from the box represent the upper and lower 25% of the net biomass production rate. (*) represents the outliers. ([M] = Montane vegetation type; [SM] = Sub montane vegetation type; [SE] = Semi evergreen vegetation type; [LW] = Lowland wet evergreen vegetation type). 163

Figure 4.20: Mean average CO₂ sequestration rate for different vegetation types in wet zone region. The box represents the middle 50% of the CO₂ sequestration rate and the vertical height of the box is proportionate to the sample size.

(•) represent mean values. The line through the box represents the median of the CO₂ sequestration rate. The whiskers extending from the box represent the upper and lower 25% of the CO₂ sequestration rate. 165

Figure 4.21: Mean average CO₂ sequestration rate for different study sites. The box represents the middle 50% of the CO₂ sequestration rate and the vertical height of the box is proportionate to the sample size. (•) represent mean values. The line through the box represents the median of the CO₂ sequestration rate. The whiskers extending from the box represent the upper and lower 25% of the CO₂ sequestration rate. (*) represents the outliers. ([M] = Montane vegetation type; [SM] = Sub montane vegetation type; [SE] = Semi evergreen vegetation type; [LW] = Lowland wet evergreen vegetation type). 166

Figure 4.22: Variation of canopy level NPP with LAI wet zone of Sri Lanka. [S] represents the standard distance data values fall from the regression line; [CI] represents the confidence interval; [PI] represents the prediction interval, defined by lower and upper limits, which are calculated from the confidence level and the standard error of the prediction. 168

Figure 4.23: Relationship between CO₂ sequestration rates with NDVI in wet zone of Sri Lanka. [S] represents the standard distance data values fall from the regression line; [CI] represents the confidence interval; [PI] represents the prediction interval, defined by lower and upper limits, which are

calculated from the confidence level and the standard error of the prediction.

169

Figure 4.24: Relationship between CO₂ sequestration rates with EVI in wet zone of Sri Lanka. [S] represents the standard distance data values fall from the regression line; [CI] represents the confidence interval; [PI] represents the prediction interval, defined by lower and upper limits, which are calculated from the confidence level and the standard error of the prediction.

171

DEDICATION

To

Appachchi, Ammi & Panchi (Kasundhi)

Determination of the biomass production and carbon sequestration capacity of wet – zone forests in Sri Lanka

Wahala Mudiyanseelage Palitha Sampath Bandara Wahala

ABSTRACT

Despite the recognized potential of forests as an important sink to sequester carbon, accurate estimates of the carbon sequestration potential of different ecosystems or their component species are lacking, especially for the different forest types present in Sri Lanka. The primary objective of the study is to determine the carbon sequestration potential of selected important natural forest ecosystems in the wet zone of Sri Lanka. In this study, completely non destructive approach, based on the basic physiology of biomass production process was used to estimate the carbon sequestration potential as a rate in ecosystem scale. Monteith (1972, 1977) showed that the rate of biomass production is directly proportionate to the amount of radiation intercepted by the foliage canopy. The above relationship can be given as: $W = e R_I$, Where, W is the amount of total biomass (above and belowground biomass) produced and R_I is the amount of radiation intercepted by canopy. The proportionality constant, e is termed as Radiation Use Efficiency (RUE). These two variables (R_I and e) were determined explicitly for specific vegetation types using different approaches. R_I values were estimated using hemispherical photographs obtained from 337 sampling points representing 44 transect covering four major vegetation types in wet zone in Sri Lanka. RUE values were

derived by canopy level photosynthesis termed as photosynthetic RUE (PhRUE) (with generalized photosynthetic parameters) at selected locations and stand level PhRUE values were derived for each transect in each vegetation type, with the relationship developed between PhRUE and Photochemical Reflectance Index (PRI) which was developed using MODIS (Moderate Resolution Imaging Spectroradiometer) data using satellite image analysis program ENVI 4.5. The canopy level net primary production was highest in lowland wet evergreen forests which was represented by Sinharaja Forest Reserve and Kanneliya Forest Reserve (8.615 ± 1.902 c tons $\text{ha}^{-1} \text{yr}^{-1}$) and the lowest in Montane forests represented by Horton Plains National Park and upper reaches of the Peak Wilderness Sanctuary (1.535 ± 0.473 c tons $\text{ha}^{-1} \text{yr}^{-1}$). With regard to the net biomass production, the highest values were recorded in the lowland wet evergreen forests (18.02 ± 4.264 t $\text{ha}^{-1} \text{yr}^{-1}$) for Sinharaja Forest Reserve and 15.847 ± 2.258 t $\text{ha}^{-1} \text{yr}^{-1}$ for the Kanneliya Forest Reserve, while the value for the sub montane zone represented by the Peak Wilderness Sanctuary as 13.417 ± 1.841 t $\text{ha}^{-1} \text{yr}^{-1}$, Knuckles-Illukkumbura as 6.410 ± 4.690 t $\text{ha}^{-1} \text{yr}^{-1}$, Knuckles-Deanston area as 5.204 ± 2.091 t $\text{ha}^{-1} \text{yr}^{-1}$ and . Knuckles-Illukkumbura as 6.904 ± 0.965 t $\text{ha}^{-1} \text{yr}^{-1}$ represent the semi evergreen vegetation type and Montane zone represented by the Horton Plains National Park as 3.442 ± 0.957 t $\text{ha}^{-1} \text{yr}^{-1}$ and upper reaches of the Peak Wilderness Sanctuary (as 2.329 ± 0.169 t $\text{ha}^{-1} \text{yr}^{-1}$). Canopy level Radiation Use Efficiency (PhRUE), values varied with the forest type as well as the elevation. The highest levels of 0.0058 ± 0.0013 (mol CO_2 /mol PAR) were observed from Lowland tropical evergreen forests while the lowest values of 0.001007 ± 0.000290 (mol CO_2 /mol PAR) were observed from the montane forests. NDVI (Normalized Different Vegetation Index) and EVI

(Enhanced Vegetation Index) were also derived using MODIS data to develop model between CO₂ sequestration rate and these vegetation index as a tool to extrapolate values to estimate for known extents of selected vegetation types. This study was confined to the natural forests of the wet zone of Sri Lanka. The methodology used should be extended to the other forest types in Sri Lanka including dry mixed evergreen forests and mangroves to get a comprehensive understanding of the net primary production and carbon sequestration capacity of the natural forests in the country.