CARBON SEQUESTRATION AND ABOVEGROUND BIOMASS OF FIVE DOMINANT SPECIES IN MIXED DECIDUOUS FOREST, THUNG SALANG LUANG, NATIONAL PARK, THAILAND

Chattanong Podong[1,5,*], Roongreang Poolsiri[2], Klaus Katzensteiner[3], Patthra Pengthamkeerati[4] and Piyapong Tongdeenok[5]

[1] Department of Environmental and Energy, Faculty of Science and Technology, Uttaradit Rajabhat University, Uttaraidt, Thailand 53000
[2] Department of Sivilculture, Faculty of Forestry, Kasetsart University, Chatuchak, Bangkok, Thailand 10900
[3] Institute of Forest Ecology, Department of Forest and Soil science, University of Natural Resource and Applied Life Science, Gregor Mendel Straße 33, A-1190 Wien, Vienna, Austria
[4] Department of Environmental Science, Faculty of Science, Kasetsart University, Chatuchak, Bangkok, Thailand 10900
[5] Department of Conservation, Faculty of Forestry, Kasetsart University, Chatuchak, Bangkok, Thailand 10900
[*] e-mail chattanong@hotmail.com

Abstract

Plant photosynthesis process is accumulated carbon and stored as biomass in all parts of tree. Carbon sequestration rate has been measured for dominant species in secondary mixed deciduous forest, Thung Salang Luang National Park, Lower Northern part of Thailand and aboveground biomass carbon has been analyzed by CHN analyzer. The specific objective of this article is to measure carbon sequestration rate and aboveground biomass carbon potential of five dominant species as *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii*. The percentage of carbon content (except root) in the aboveground biomass of *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii* were 45.61, 46.31, 47.49, 46.42 and 46.17, respectively. Total aboveground biomass carbon stock per hectare for *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii* were 4,531.76 kg C ha^{-1}, 629.05 kg C ha^{-1}, 5.25 kg C ha^{-1}, 5.25 kg C ha^{-1} and 58.76 kg C ha^{-1} ,respectively.

Keywords: carbon sequestration, aboveground biomass carbon stock, secondary mixed deciduous forest, dominant species

Introduction

The continuing rise of atmospheric carbon dioxide (CO_2) concentration will most likely affect the stability of earth's climate system, the health of humans, and the sustainability of socioeconomic systems. Carbon dynamics in terrestrial ecosystems has been one of the major factors affecting CO_2 concentration in the atmosphere (IPCC, 2001). Quantification of the spatial and temporal variability of carbon sources and sink at regional to global scales has been challenging because land-atmosphere carbon exchange is influenced by many, including land use and land cover change, CO_2 fertilizer, nitrogen fertilizer and climate variability and change. Trees act as a sink for CO_2 by fixing carbon during photosynthesis and storing excess

carbon as biomass. The net long term CO_2 source or sink dynamics of forest change through time as trees grow, die and decay. In addition, human influences on forests can further affect CO_2 source or sink dynamics of forest through such factors as fossil fuel emissions and harvesting or utilization of biomass (Nowak and Crane, 2002). As tree grow and their biomass increases, they absorb carbon from the atmosphere and store it the plant tissue (Mathew et al., 2000) resulting in growth of different parts. Active absorption of CO_2 from the atmosphere in photosynthesis process and its subsequent storage in the biomass of growing trees or plants is the carbon storage (Baes et al., 1977). In terms of atmospheric carbon reduction, trees in urban areas offer the double benefit of direct carbon storage and stability of natural ecosystem with increased recycling of nutrient along with maintenance of climatic conditions by biogeochemical processes.

The study carried out by Thung Salang Luang National Park, Thailand. The specific objective of this study is to measure carbon sequestration rate and aboveground biomass carbon potential of these dominant plant species.

Methodology

Site description

The study was conducted in Thung Salaeng Luang National Park, located in Phitsanulok province, the Lower Northern part of Thailand, with latitude and longitudes of 16° 25/ - 16° 57/ N and 100° 37/ - 101° 00/ E. The site is mountainous and ranges in elevation between 400-1,003 m above sea level, surrounded by the five main watersheds such as Huai Klag Yai, Huai Klag Noi, Lam Nam Tum, Klong Chum Poo and Klong Wang Thong, so there are importance for producing water to Nan watershed. The geological formation of this study area is composed of sedimentary rock and metamorphic rock (Royal Forestry Department, 1990). The climate is tropical and sub-tropical with three distinct seasons such as: cold, hot and rainy. March to June are the hottest month with highest mean maximum temperature (29 °C), and November to February are the coldest months with highest mean minimum temperature (17 °C), and the mean temperature is 22 °C. The maximum rainfall occurs during the monsoon season May to October with mean rainfall 1,300-1,700 mm. (Figure 1). The study area covers the secondary forest in the Thung Salang Luang National Park.

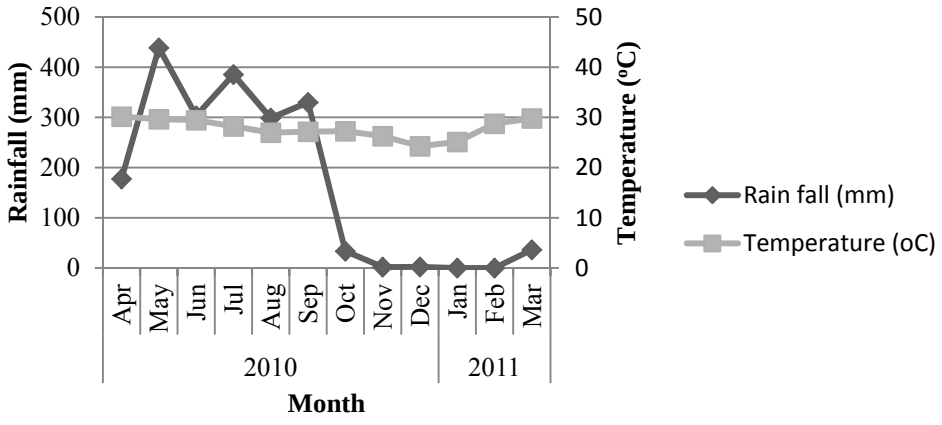

Figure 1 Monthly rainfall (mm) and temperature (°C) from April 2010 to March 2011 at Protection Unit 12 of Thung Salang Luang National Park. (Source: Royal Irrigation Department telemetering weather station

Field experiment

A one ha permanent plot (100 m x 100 m) was established in mixed deciduous forest at Thung Saleang Luang National park, lower northern, Thailand and subgridded into 100 quadrats (10 m x 10 m) for tree inventories. In each sub plot, all trees with Diameter Breast Height (DBH) > 4.5 cm were mapped. We then tacked the label number at the DBH level and collected the specimen which indentified in botanical name. Species compositions were examined. The data of inventories used for finding importance value index (IVI).

Dominant species study by importance value index (IVI)
Importance value index (IVI) of each sample plot was determined as follows: IVI = Relative density (%) + Relative frequency (%) + Relative dominance (%).

Aboveground biomass
The aboveground biomass in mixed deciduous forest was estimated by Equations 1-4 (Ogawa et al. 1965):

$$Ws = 0.02903(D^2H)^{0.9813} \quad (1)$$

$$Wb = 0.0033487(D^2H)^{1.0270} \quad (2)$$

$$Wl = (28.0/Wtc+0.025)^{-1} \quad (3)$$

$$WT = Ws+Wb+Wl \quad (4)$$

Where

Ws, Wb, Wl	=	dry weight of stems, branches and leaves of a tree, total biomass aboveground biomass (kg)
Wtc	=	Ws + Wb
WT	=	obtained by summing by the partial biomass (kg)

Carbon content in aboveground biomass
The carbon content of different biomasses such as stems, branches and leaves had been measured by taking 10 samples per fraction cover plot size area by estimation of carbon content using CHN Analyzer at Sivilculture department, Faculty of Forestry, Kasetsart University (Parkin Elmer 2400 series II CHNS/O). A certain amount of biomass samples had been collected from the particular stems , branches and leaves and after being properly dried at 80 ^{o}C for 48 hr to gain a constant weight, the sample had been analyzed carbon content by above ground calculation.

Results and Discussion

Dominant species study by importance value index (IVI)
A total plant composition in mixed deciduous forest. Thung Salang Luang National Park were 35 species. The dominant species of the trees were *Haldina cordifolia, Albizia odoratissima* and *Lagerstroemia duperreana*. The IVI values of trees were 132.91, 17.78 and 14.22, respectively. The dominant species of the saplings were the same similar to the seeding as, *Haldina cordifolia*, *Fermandoa adenophylla* and *Harrisonia perforata*. The IVI values of saplings were 102.31, 47.10 and 34.29, respectively. The IVI values of saplings were 113.74, 37.49 and 28.51, respectively (Table 1).

Table 1 Relative density, relative frequency, relative dominance and important value index of trees (DBH ≥ 4.5) in MDF plot

Tree group Scientific name	% Relative density	% Relative frequency	% Relative dominance	% IVI
Haldina cordifolia	49.34	78.62	4.94	132.91
Albizia odoratissima	5.58	7.27	4.94	17.78
Lagerstroemia duperreana	6.89	2.39	4.94	14.22
Fermandoa adenophylla	6.60	2.35	4.94	13.89
Croton roxburghii	5.00	1.15	4.94	11.08
Harrisonia perforata	3.35	2.62	4.94	10.91
Cratoxylum formosum	3.44	1.39	4.94	9.77
Dalbergia foliacea	3.49	1.13	4.94	9.57
Xylia xylocarpa	2.52	1.06	4.94	8.52
Antidesma sootepense	3.15	0.40	4.94	8.50

Aboveground biomass

The aboveground biomass of the tree such as stems, branches and leaves have been collected and dried at laboratory, and the dry biomass of different sections of the tree are presented in Table 2. The result of carbon analysis through CHN Analyzer is presented in Table 3. It is observed for *Haldina cordifolia* that average leaf, stem and branch contained 43.32, 47.49, and 46.01% carbon, respectively. For *Albizia odoratissima*, average leaf, stem and branch contained 46.34, 45.98 and 46.61 % carbon, respectively. For *Lagerstroemia duperreana*, average leaf, stem and branch contained 47.61, 47.96 and 46.88 %. For *Croton roxburghii*, average leaf, stem and branch contained 45.29, 47.53 and 45.68 %. Carbon content of the tree was established by the works of different Scientists and Researchers, the carbon in plant was approximately 50% of dry matter (The world bank. 1998). The carbon concentration of different tree parts was rarely measured directly, but generally assumed to be 50% of the dry weight (Losi et al. 2003). Losi et al. (2003) obtained that measured carbon content of dry sample was 47.8% for *Anacardium. excelsum* and 48.5% for *Dorstenia. panamensis*. West (2003) reported in paper that " Extensive studies in Australia recently of a variety of tree species showed above ground dry biomass generally contain 50% carbon. These proportions of carbon in aboveground biomass agreed closely with values of 49 and 47% reported from other parts of the world for *Pinus taeda* (Kinerson et al. 1977). The total carbon content presented in Table 4 of *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii* were 4,531.76, 629.05, 5.25, 5.25 and 58.76 kg, respectively. Negi et al. (2003) reported that carbon content in *Shorea robusta* tree was 46% .

Table 2 Total aboveground dry biomass of the tree

Tree	Total dry weight (ton/ha)			
	stem	**branch**	**leaves**	**biomass**
Haldina cordifolia	5143.87	4224.96	334.60	9703.43
Albizia odoratissima	782.41	531.11	46.91	1360.43
Lagerstroemia duperreana	161.69	93.57	91.16	346.42
Fermandoa adenophylla	199.86	118.17	11.36	329.39
Croton roxburghii	78.76	42.38	4.33	125.47

Table 3 Average result of carbon analysis of different parts of the tree

Tree	Parts of the tree	Carbon (%)
Albizia odoratissima	Leaf	43.32
	Stem	47.49
	Branch	46.01
Croton roxburghii	Leaf	46.34
	Stem	45.98
	Branch	46.61
Fermandoa adenophylla	Leaf	47.61
	Stem	47.96
	Branch	46.88
Haldina cordifolia	Leaf	46.24
	Stem	47.46
	Branch	45.57
Lagerstroemia duperreana	Leaf	45.29
	Stem	47.53
	Branch	45.68

The carbon content of the whole tree (leaf, stem, branch) of *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii* is shown in Table 4.

Table 4 Carbon content of the aboveground biomass

Tree	Parts of the tree	Carbon (%)	Total carbon content in tree species (kg ha^{-1})
Haldina cordifolia	Leaf	43.32	144.95
	Stem	47.49	2,443.03
	Branch	46.01	1,943.78
Total carbon content in tree		**45.61**	**4,531.76**
Albizia odoratissima	Leaf	46.34	21.74
	Stem	45.98	359.75
	Branch	46.61	247.55
Total carbon content in tree		**46.31**	**629.05**
Lagerstroemia duperreana	Leaf	47.61	43.40
	Stem	47.96	77.54
	Branch	46.88	43.86
Total carbon content in tree		**47.49**	**5.25**
Fermandoa adenophylla	Leaf	46.24	94.85
	Stem	47.46	53.84
	Branch	45.57	153.94
Total carbon content in tree		**46.42**	**5.25**
Croton roxburghii	Leaf	45.29	1.96
	Stem	47.53	37.44
	Branch	45.68	19.36
Total carbon content in tree		**46.17**	**58.76**

Carbon pool partition of secondary forest of *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii* is shown in Figure 2. It is estimated that annual above ground biomass carbon pools of dominant species were observed to yield in leaf partition maximum in *Haldina cordifolia*, *Fermandoa adenophylla*, *Lagerstroemia duperreana, Albizia odoratissima* and *Croton roxburghii* respectively, and stem partition maximum were *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii* respectively, and branch partition *Haldina cordifolia*, *Albizia odoratissima*, *Fermandoa adenophylla*, *Lagerstroemia duperreana* and *Croton roxburghii* respectively, and all partition maximum were *Haldina cordifolia*, *Albizia odoratissima*, *Fermandoa adenophylla*, *Lagerstroemia duperreana* and *Croton roxburghii* respectively.

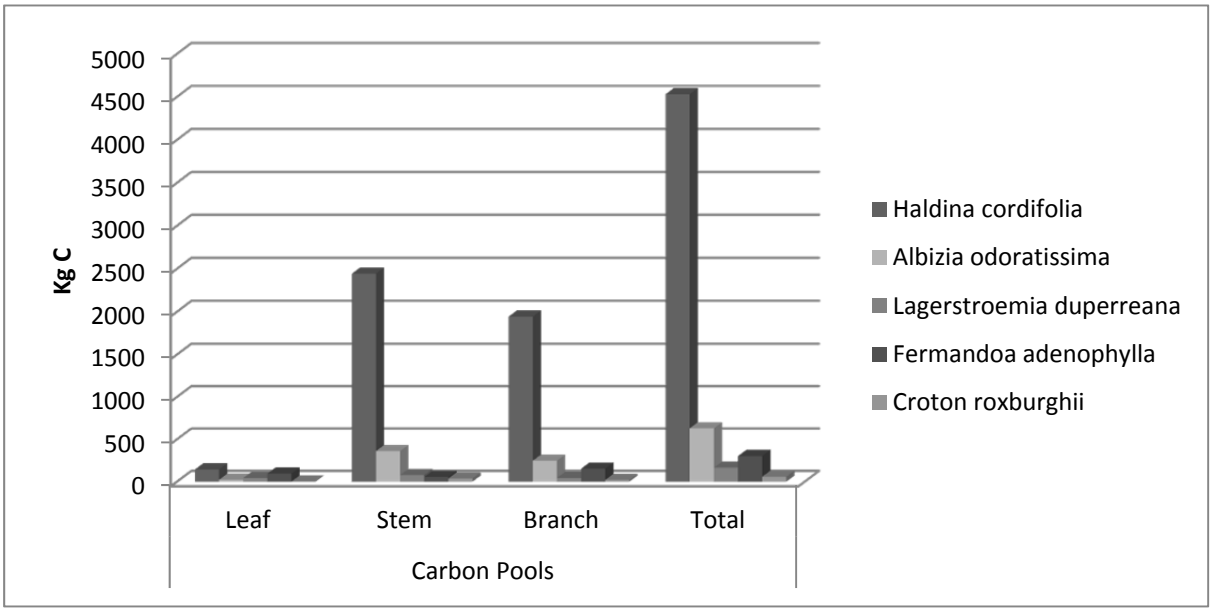

Figure 2 Portioning of above ground biomass carbon pools of dominant species such as: *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii*

Conclusion

This study demonstrated carbon sequestration rate and aboveground biomass carbon potential of five dominate species such as: *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii*. The article concludes that carbon sequestration rate from the ambient air as obtained by secondary forest at Thung Salaeng Luang National Park. Percentage of carbon content in the aboveground biomass of *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii* were 45.61, 46.31, 47.49, 46.42 and 46.17 respectively. Total aboveground biomass carbon stock per hectare for *Haldina cordifolia*, *Albizia odoratissima*, *Lagerstroemia duperreana*, *Fermandoa adenophylla* and *Croton roxburghii* were 4,531.76 kg C ha^{-1}, 629.05 kg C ha^{-1}, 5.25 kg C ha^{-1}, 5.25 kg C ha^{-1} and 58.76 kg C ha^{-1} respectively.

Acknowledgement

The research was supported by a CHE-Ph.D-SW-NEWU scholarship from the Commission on Higher Education, and by Uttaradit Rajabhat University. The Department of National Parks, Wildlife and Plant Conservation is thanked for giving permission to access and collect data from the study area.

References

1. Baes C.F, Goeller H.E, Olson J.S. and Rotty, R.M (1977) Carbon dioxide and climate: The uncontrolled experiment. *AM Sci*, 65: 310-320.
2. Intergovermental Panel on Climate Change (2001) Climate Change 2001: Synthesis Report. The press syndicate of the University of Cambridge, Cambridge, United Kingdom.
3. Kinerson, R.S., C.W. Ralston and C. G. Wells (1977). Carbon cycling ina loblolly pine Plantation. Oecologia 29: 1-10.
4. Losi CJ, Siccama TG, Condit R, Morales JE (2003). Analysis of alternativemethods for estimating carbon stock in young tropical plantations,Elsevier For. Ecol. Manag.184: 355-368.
5. Matthews E, Payne R, Rohweder M and Murray, S (2000) Forest ecosystem: Carbon storage sequestration. Carbon Sequestration in Soil, Global Climate Change Digest, 12 (2): 157-180
6. Nowak, D.J. and D.E. Crane (2002) Carbon storage and sequestration by urban trees in the United States. Environ. Poll. 116(3): 381-389.
7. Negi JDS, Manhas RK, Chauhan PS (2003). Carbon allocation in different components of some tree species of India: A new approach for carbon estimation. Current Sci. 85(11): 101-104.
8. Ogawa, H., K. Yoda, K. Ogino and T. Kira. 1965. Comparative ecological studies on three main types of forest vegetation in Thailand II. Plant Biomass. Nature and Life in Southeast Asia 4: 49-80.
9. WB (The World Bank) (1998). A practical guidance document for the assessmentof project level greenhouse gas emissions. Greenhouse gas assessment handbook, World Bank. 64:168.
10. West PW (2003). Tree and Forest Measurement, Springer Publisher. p.62.