การกักเก็บคาร์บอนในป่าบริเวณพื้นที่อุทยานแห่งชาติหมู่เกาะช้าง จังหวัดตราด ประเทศไทย

Carbon Sequestration in Forests in Chang Island National Park, Trat Province, Thailand

ณัฐนันท์ ทะแดง[1,2] และนาฏสุดา ภูมิจำนงค์[1,2]

Natthanan Tadang[1,2] and Nathsuda Pumijumnong[1,2]

บทคัดย่อ

วัตถุประสงค์ในการศึกษา คือ สำรวจโครงสร้างสังคมพืชและการกักเก็บคาร์บอนของป่าดิบชื้นและป่าชายเลนบริเวณพื้นที่เกาะช้าง จังหวัดตราด ทำการวางแปลง จำนวน 24 แปลง ผลการศึกษาพบไม้ทั้งหมด 97 ชนิด 37 วงศ์ และพบว่าพรรณไม้ต้นที่มีค่าดัชนีความสำคัญสูงสุด คือ ตะเคียนทราย รัก กระทังหัน หว้าเขา และมะเดื่อกวาง ตามลำดับ เพื่อทำการวิเคราะห์หาปริมาณคาร์บอนของส่วนต่างๆของต้นไม้ของพันธุ์ไม้บนพื้นที่เกาะช้าง โดยนำตัวอย่างส่วนต่างๆ ของต้นไม้ไปอบในตู้อบที่มีอุณหภูมิ 80 องศาเซลเซียส เป็นระยะเวลา 72 ชั่วโมง แล้วนำไปวิเคราะห์โดยวิธี dry combustion ผลการศึกษาพบว่า ปริมาณคาร์บอนที่มีการสะสมในส่วนต่างๆของต้นไม้มีค่าเฉลี่ยร้อยละ 46.33 ของน้ำหนักแห้ง ตะเคียนทราย มีค่าเฉลี่ยร้อยละสูงสุด 48.51 ของน้ำหนักแห้ง รองลงมา คือ พนอง หว้าเขา สร้อย และ ตาเสือ มีค่าเฉลี่ยร้อยละ 48.05, 47.93, 47.73 และ 47.61 ของน้ำหนักแห้ง ตามลำดับ

คำสำคัญ : การสะสมคาร์บอน ค่าดัชนีความสำคัญ เกาะช้าง

ABSTRACT

This study aimed to investigate the plant community structure and carbon storage of a moist evergreen forest and a mangrove forest on Chang Island, Trat Province. A total of 97 species and 37 families were identified. The resulting IVI (Important Value Index) showed the most important plants to be *Hopea avellanea* Heim, *Melanorrhoea usitata* Wall, *Calophyllum thorelii* Pierre, *Cleistocalyx operculatus* Merr. & Perry and *Ficus callosa* Willd., respectively. Samples of stems, branches, leaves and stilt roots of plant species in a mangrove forest were collected for analysis of the carbon content by the dry combustion method. The plant samples were dried at 80 ^{o}C for 72 hours. The carbon content was different between species with an average dry weight of 46.33%. *Hopea avellanea* exhibited the highest average carbon content followed by *Shorea hypochra*, *Cleidion spiciflorum, Carpinus londoniana* and *Chisocheton siamensis*, with dry weights of 48.51%, 48.05%, 47.93%, 47.73% and 47.61, respectively.

---

[1] คณะสิ่งแวดล้อมและทรัพยากรศาสตร์ มหาวิทยาลัยมหิดล นครปฐม 73170

Faculty of Environment and Resource Studies, Mahidol University, Nakhon Pathom 73170, Thailand

[2] The Center for Toxicology, Environmental Health and Management of Toxic Chemicals under Science & Technology Postgraduate Education and Research Development Office (PERDO) of the Ministry of Education, Thailand

Key Words : Carbon Sequestration, Important Value Index, Chang Island

E-mail : chichi_devil@hotmail.com

INTRODUCTION

Thailand is situated in tropical and subtropical climate zones and covered by plant and vegetation diversity.Thailand experienced a rapid decline in forested area during the last century (Tanaka et al, 2008). At the beginning of the 1900s, forests covered as much as 75% of Thailand, forest was decreased to 53% by 1961 and to 25% by 1982. Islands have specific ecosystems (Azarnivand et al., 2008). Their small size, insularity and remoteness, environmental factors and limited disaster mitigation capability make islands vulnerable to adversity. Islands are highly susceptible to climate change and global warming. However, forest ecosystems on islands can be used as a source of carbon sequestration that can help reduce global warming.

Terrestrial ecosystem, ocean, atmosphere and geological formations that contain fossil and mineral carbon are the four principal pools of global carbon. Carbon exchange among these pools is balanced because the amount of carbon fixed through photosynthesis is offset by the release of carbon through plant respiration and decomposition of organic residues (Schlesinger, 1995). Plants are a primary source of soil organic carbon (SOC) and CO_2 fixed during photosynthesis; these are then transferred to the soil through the stems, branches, leaves and roots (Veen et al., 1991; Trumbore, 1997). Tropical forests store an average of approximately 50% more carbon than other forests. Therefore, deforestation activities in tropical areas cause significant amounts of releasing carbon to the atmosphere. In the forest ecosystem, soil and plants are the main stocks of organic carbon. Chang Island is a tropical rain forest with a great diversity of plants and animals. Tropical forest areas around the world and Thailand, including Chang Island, face losing state forests due to human activities (Royal Forest Department, 2005). The problem of Chang Island is similar to other forest resources: people want to use this land for agriculture. Although the main cause for forest degradation is the conversion of forest land for agriculture by local people, the land use has recently changed due to tourist services. Construction of business buildings, luxury accommodations, roads and harbours is occurring on the island. This land use change has affected the ecological system on Chang Island. Therefore, studying ecosystems and carbon storage in the forest on Chang Island is very important both on the local and national scale.

Knowledge of the ecosystem is important both biologically and physically for its management. Studying carbon storage is necessary for natural resource management planning. This research will help better understand the limiting factors of plant association and distribution on Chang Island. In addition, it is important to promote further forest management and conservation of natural resources.

MATERIALS AND METHODS

1. Study site

The study area is located on Chang Island, Trat Province at 11º 57´-12º 10´N and 102º15´-102º 27´E (Figure 1). The island has a total area of approximately 212.404 km^2. It is length from north to south is 30 km and its width is 14 km. The tropical evergreen forests cover area of 178.649 km^2 and mangrove forests cover area of 2.300 km^2. Chang Island can have an average rainfall at approximately 4,000-6,500 mm. During the cool season, the average temperature is 20 °C.

2. Sampling and data analysis

In this study, the plant species of tropical evergreen forests and mangrove forests were collected with a 20 × 40 m^2 temporary sample plot for tropical evergreen forests and a 10 × 10 m^2 plot for mangrove forests. The plant sample collection consisted of plants from various communities and with different biomasses. To examine the different types of communities on Chang Island, the forest region was divided into 72 plots composed of 24 forest plots, 24 sapling plots and 24 seedling plots. Plots covered the elevation gradient and were well distributed on Chang Island. In each forest plot, each quadrate was designed into three different sizes. One 20 × 40 m^2 quadrate was used to investigate tree plants. One 4 × 4 m^2 quadrate and one 1 × 1 m^2 quadrate were used to investigate sapling and seedling plants (Kutintara, 1999).

Vegetation sampling

1) All trees with a diameter at breast height (DBH) ≥ 4.5 cm. or a girt at breast height (GBH) ≥ 14 cm. in 20 x 40 m^2 plots.

2) Saplings and shrubs with a diameter at breast height (DBH) less than 4.5 cm. but higher than 1.3 m. in 4 x 4 m^2 plots.

3) In a 1×1 m^2 plot, all trees that were shorter than 1.3 m. and had a diameter at breast height (DBH) of less than 4.5 cm. were counted.

3. Plant Community Analysis

The importance value index (IVI) describes the ecological importance of certain species and can indicate the species dominance and importance in an area (Kutintara, 1999).

$$IVI = RD + RF + RDo$$

The relative density (RD) is a comparison in the density of certain plant species with the total plant species in the community.

$$\text{Relative Density (RD)} = \frac{\text{Density (D) of Species} \times 100}{\text{Total Density of All Species}}$$

The relative frequency is a comparison of the frequency of certain plant species with the frequency of the total plant species in the community.

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency (F) of Species} \times 100}{\text{Total Frequency of All Species}}$$

The relative dominance is a comparison in the dominance of certain plant species with the total plant species in the community.

$$\text{Relative Dominance } (RD_o) = \frac{\text{Dominance } (D_o) \text{ of Species} \times 100}{\text{Total Dominance of All Species}}$$

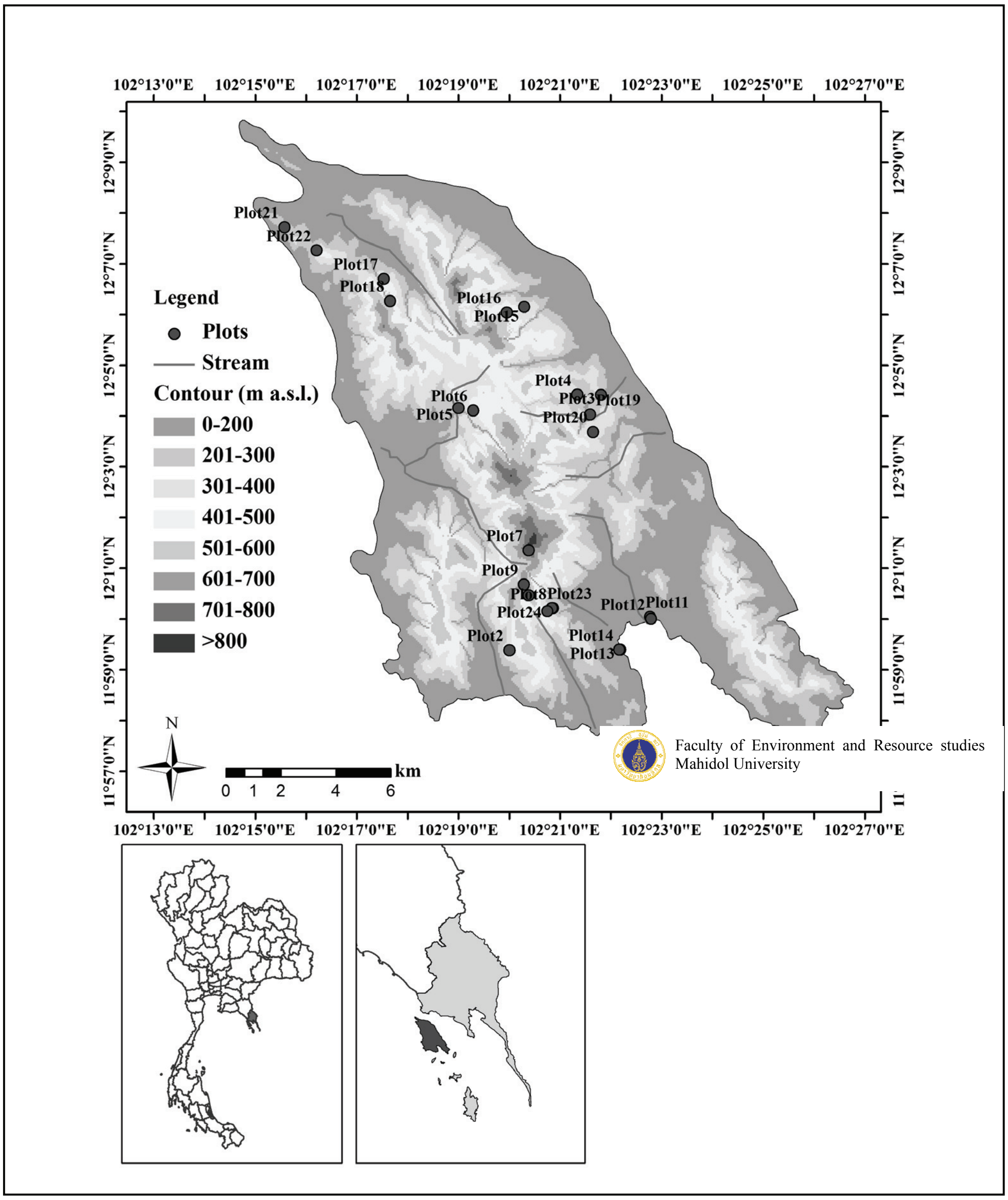

Figure 1 Map of Chang Island showing the location of study

4. Estimation of carbon content in trees

Tree samples, including the stem, branch, leaf and stilt root, of mangrove forest species were collected (three samples per plant species) 28 species by selecting the top three species from each plot based on their IVI. The samples were obtained with a diameter at breast height (DBH) ≥ 10 cm. to be representative of plants. These plant samples were dried at 80 ^{o}C for 72 hours or until their weight was stable. The samples were crushed. The carbon content was analysed by the dry combustion method (Meepol, 2010) with Multi N/C 2100S.

RESULTS AND DISCUSSION

1. Importance Value Index of Species in the Plant Community

Ninety-seven species and 37 families were identified on Chang Island. Ninety-three tree species, 37 species of samplings and 31 species of seedlings were found.

The importance of species toward the ecosystem in each plant community can be evaluated by considering the IVI. The results from this study revealed a dominant species in 24 plots and 97 species, which exhibited the top ten IVI values in study area (Table 1). The resulting IVI (Important Value Index) showed the most important plants to be *Hopea avellanea* Heim, *Melanorrhoea usitata* Wall, *Calophyllum thorelii* Pierre, *Cleistocalyx operculatus* Merr. & Perry and *Ficus callosa* Willd., respectively.

Table 1 List of the top ten high IVI value

No.	Species	Relative density	Relative frequency	Relative dominance	IVI
1	*Hopea avellanea* Heim	28.68	4.13	27.21	60.02
2	*Melanorrhoea usitata* Wall.	1.07	2.61	17.55	21.23
3	*Calophyllum thorelii* Pierre	6.67	4.13	3.91	14.71
4	*Cleistocalyx operculatus* Merr. & Perry	3.52	4.35	4.35	12.21
5	*Ficus callosa* Willd.	3.93	3.91	4.01	11.85
6	*Cleidion spiciflorum* Merr.	4.59	4.13	2.47	11.20
7	*Lithocarpus ceriferus* A. Camus	0.52	0.87	8.09	9.48
8	*Madhuca pierrei*Lam	3.08	3.70	1.96	8.73
9	*Memecylon geddesianum* Craib	4.04	3.70	0.91	8.65
10	*Garcinia hanburyi* Hook. f.	2.59	3.91	0.97	7.48

2. Carbon content of plants species in Chang Island National Park

The carbon content was estimated in the tree samples, which were collected at a diameter at breast height (DBH) ≥ 10 cm. The carbon content was analysed by the dry combustion method with Multi N/C 2100S. An average dry weight of 46.33% was found (Table 2).

Table 2 Carbon content (percent dry weight) of different species in the forest in Chang Island National Park

Species	Stem	Branch	Leaf	Stilt Root	Average
Mesua ferrea	43.44±0.56	45.93±0.74	45.60±4.13	-	44.99±1.80
Vatica odorata	43.49±1.29	42.89±1.99	44.70±0.11	-	43.69±1.12
Hopea avellanea	48.60±3.21	49.75±2.32	47.19±3.58	-	48.51±3.03
Calophyllum thorelii	44.37±1.02	48.87±0.37	46.04±1.51	-	46.42±0.96
Lithocarpus ceriferus	46.48±1.60	47.23±0.42	44.03±2.26	-	45.91±1.42
Tetrameles nudiflora	45.48±1.83	48.12±0.45	44.51±1.83	-	46.03±1.36
Ficus callosa Willd.	45.35±1.80	46.93±0.42	46.72±1.65	-	46.33±1.29
Memecylon garcinioides	46.28±1.98	46.00±3.07	42.09±1.10	-	44.79±2.05
Archidendron quocense	47.34±1.91	46.04±0.70	46.82±0.13	-	46.73±0.91
Shorea hypochra Hance	44.62±2.51	50.67±0.60	48.86±0.04	-	48.05±1.04
Unknown	44.79±1.65	44.62±0.21	48.38±0.72	-	45.93±0.85
Cleidion spiciflorum Merr.	45.55±1.12	46.21±0.77	52.03±1.12	-	47.93±1.00
Chisocheton siamensis	45.67±2.57	47.29±1.01	49.86±0.65	-	47.61±1.41
Cleistocalyx operculatus	44.36±1.58	44.19±2.33	46.53±2.72	-	45.03±2.20
Scaphium macropodum	45.07±1.49	-	47.91±1.72	-	46.49±1.60
Carpinus londoniana	47.52±1.97	47.64±1.31	48.04±1.93	-	47.73±1.73
Barringtonia macrocarpa	46.17±1.31	-	46.77±1.25	-	46.47±1.27
Madhuca pierrei Lam	45.51±1.48	46.69±0.66	49.76±0.41	-	47.32±0.84
Melanorrhoea usitata.	46.56±0.09	45.93±1.61	48.56±0.93	-	47.01±0.87
Madhuca grandiflora.	44.37±1.27	44.63±0.69	47.79±0.26	-	45.59±0.74
Brucea mollis	43.87±0.01	46.45±0.20	48.36±1.89	-	46.23±0.70
Sapium discolor Muell.	44.88±0.44	-	-	-	44.88±0.44
Rhizophora apiculata	47.52±0.42	48.21±0.83	46.86±0.29	43.35±0.18	46.491±0.43
Rhizophora mucronata	47.63±0.37	46.70±0.59	47.23±2.86	43.60±0.18	46.29±1.00
Bruguiera sp.	-	47.75±0.06	46.42±0.07	-	47.09±0.06
Xylocarous granatum	46.19±1.95	45.08±0.11	42.55±0.21	-	44.61±0.76
Lumnitzera sp.	-	52.38±2.96	39.63±0.11	-	46.01±1.53
Bruguiera cylindrica	47.72±0.28	44.74±0.21	48.30±4.99	-	46.92±1.83
Average	**45.72±1.37**	**46.84±0.98**	**46.72±1.42**	**43.48±0.18**	**46.32±1.23**

Note: Unknown means the species could not be identified.

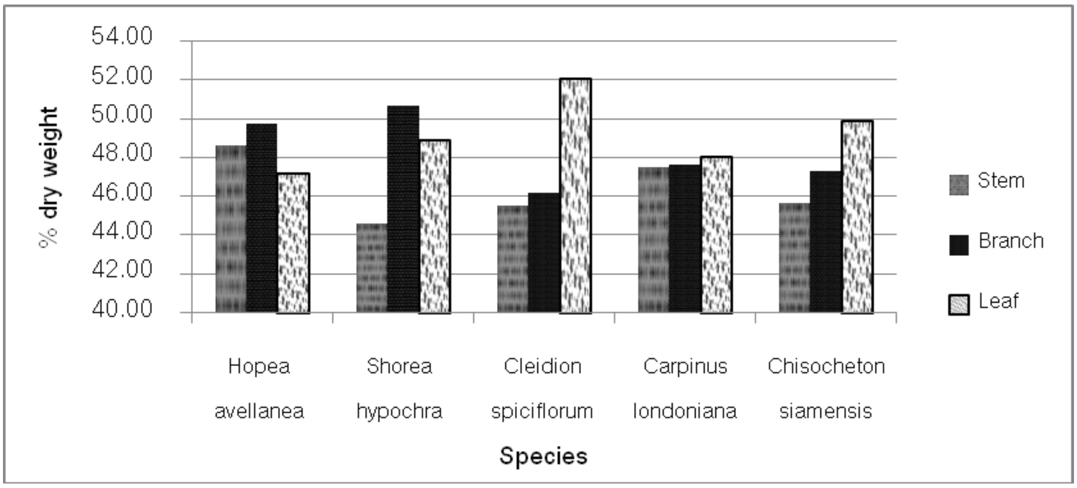

Figure 2 Illustration of the carbon content of the highest species

The samples of stems, branches, leaves and stilt roots in the mangrove forest were collected to analyse their carbon content by the dry combustion method. The results showed that the carbon content varied among species. *Hopea avellanea* exhibited the highest average and was followed by *Shorea hypochra*, *Cleidion spiciflorum* and *Carpinus londoniana*, *Chisocheton siamensis* with average dry weights of 48.51%, 48.05%, 47.93%, 47.73% and 17.61% respectively (Figure 2).

Meepol (2010) reported an average dry weight of 47.28% for *Rhizophora apiculata*, 47.74% for *Rhizophora mucronata*, 47.35% *Xylocarous granatum* and 48.24% for *Bruguiera cylindrical*. The carbon content in mangrove forests at Ranong Biosphere Reserve reported by Meepol (2010) were higher than the results in this study (Table 2). The mangrove forests at Ranong Biosphere Reserve were likely older and had larger diameters at breast height. The carbon content likely increases with age (Petsri, 2007) and remains almost constant with stand age (Nguyen et al., 2009). The mangrove forests in Chang Island National Park were damaged by storms. The amount of carbon storage in stems, branches, leaves and roots varied. Generally, the International Panel of Climate Change (IPCC) uses approximately 50% of dry forest biomass comprised of carbon. The results of this study found that the combustion gives an accurate value.

CONCLUSION

The forest in the study area included 93 tree species, 37 sapling species and 31 seedling species. The most important plants were *Hopea avellanea* Heim, *Melanorrhoea usitata* Wall, *Calophyllum thorelii* Pierre, *Cleistocalyx operculatus* Merr. & Perry and *Ficus callosa* Willd., respectively. The carbon content on Chang Island had an average dry weight of 46.33%. The stem samples had an average dry weight of 45.78%, whereas the branches contained an average dry weight of 46.80%. The leaf and stilt root samples exhibited an average dry weight of 46.74% and 44.34%, respectively. The highest carbon content of stems, branches, leaves and stilt roots was observed in *Hopea avellanea*, *Shorea hypochra*, *Cleidion spiciflorum, Carpinus londoniana* and

Chisocheton siamensis respectively. The carbon content is likely to increase with age and tree size and differs between species. For sustainability of Chang Island, it is therefore important to be aware of change in land use and urbanization which direly effected to carbon sequestration.

ACKNOWLEDGEMENT

This work was supported by a grant from the Center for Toxicology, Environmental Health and Management of Toxic Chemicals under the Science and Technology Postgraduate Education and Research Development Office (PERDO) of the Ministry of Education.

REFERENCES

Azarnivand, H., Joneidi, H., Jafari, Sh., Nikoo, M.A., Chahouki, Z. and Malekian, A. 2008. Study of effective ecological factors on distribution of vegetation types (Case study: Southern margin of Haj Aligholi Kavir, Damghan). Desert 15 (2010). 1-4 p.

Meepol, W. 2010. Carbon Sequestration of Mangrove Forests at Ranong Biosphere Reserve. **Journal of Forest Management.** 4(7) : 29-44 (2010)

Nguyen, T.K.C., Ikuo, N., Nguyen, T.L., Nguten, H.T., Mai, S.T. and Phan, N.H. 2009. Belowground carbon accumulation in young *Kandelia candel* (L.) Blanco plantations in Thai Binh River Mouth, Northern Vietnam. **Journal of Ecology & Development**. 107-117 (2009)

Petsri, S., Pumijumnong, N., Wachrinrat, C. and Thoranisorn, S. 2007. Aboveground Carbon Content in Mixed Deciduous Forest and Teak Plantations. **Journal of Environment and Natural Resources**. Vol.5 , No.1 : 1-10 (2007)

Royal Forest Department. 2005. Master plan report Pa thon nga chang sanctuary wildlife, Songkhla province. (In Thai).

Schlesinger, W.H. 1995. An overview of the carbon cycle. P. 9-25 In: R. Lal, J. Kimble, E. Levine and B. Stewart (eds.). Advances in Soil Science: Soils and Global Change. CRC Press Inc. Boca Raton FL.

Tanaka, N., Kume, T., Yoshifuji, N., Tanaka, K., Takizawa, H., Shiraki, K., Tantasirin, C., Tangtham, N. and Suzuki, M. 2008. A review of evapotranspiration estimates from tropical forests in Thailand and adjacent regions. **Journal of Agricultural and Forest Meteorology 148** : 807-819 (2008)

Trumbore, S.E. 1997. Potential responses of soil organic carbon to global climate change. Proc. Natl. Acad. Sci. 94:8284-8291.

Veen, J.A., E. Liljeroth and L.J.A. Lekkerkerk. 1991. Carbon fluxes in plant–soil systems at elevated atmospheric CO_2 levels. Ecol. Appl. 1:175-181.

Kutintara, U. 1999. **Ecology fundamental basics in forestry**. Kasetsart University Press, Bangkok, Thailand.