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A Comparative Study of Carbon Sequestration Potential in Aboveground Biomass in Primary Forest and Secondary Forest, Khao Yai National Park

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1. Introduction

Climate change is a topic that has been widely discussed and debated over recent decades. Scientists have reached a general agreement that the lower atmosphere and the Earth's surface are definitely getting warmer. The Intergovernmental Panel on Climate Change (IPCC) reported that a gradual but accelerating increase of atmospheric greenhouse gases has occurred since 1750 as result of human activities and among the anthropogenic greenhouse gases, CO_2 is the most important. The global atmospheric concentration of CO_2 has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005 (Alley et al., 2007). Temperature has risen by about 0.3-0.6^{o}C since the late 19th century. If CO_2 emissions were maintained at 1994 levels, its concentration would increase to about 550 ppm by the end of the 21st century (Chakraborty et al., 2000). Thailand is a member of the United Nation Framework Convention on Climate Change (UNFCCC), which is negotiated by the nations of the world in June 1992 (Michaelowa and Rolfe, 2001). The targets of the UNFCCC is to reducing CO_2 emissions from the rate reported for 1990 during the five-year period from 2008 - 2012. This agreement is called the Kyoto Protocol which Thailand has ratified since August 28, 2002. There are two alternatives to reduce CO_2, these include decreasing fossil fuel consumption and increasing carbon sink through forestry activities. According to Article 3.3 of the agreed Kyoto Protocol, some CO_2 sources and sinks of forests shall be used to meet the commitments (UNFCCC, 1997). The sources and sinks to be used were measured as verifiable changes in carbon stocks in each commitment period (Terakunpisut et al., 2007; Forest research, 2011).

Forestry sectors are known as an important natural brake on climate change since they play an important role in the global both as a carbon sink and source because of their large biomass per unit area of land (Gibbs et al., 2007). The carbon in forests originates from the atmosphere and is accumulated in terms of the organic matter of soil and trees, and it continuously cycles between forests and the atmosphere through the decomposition of dead organic matter (Alexandrove, 2007). Thus, changing carbon stocks in forests can affect the amount of carbon in the atmosphere. If more carbon accumulates in forest through

photosynthetic process, the forest will be a sink of atmospheric carbon. If the carbon stocks in forests decrease and release carbon into the atmosphere, the forests will become a source of atmospheric carbon. The carbon stocks of forests can change in two ways, on the one hand as a result of changes in forest area and on the other hand as a result of changes in carbon stocks on the existing forest area. Broadmeadow and Matthews (2003) report that approximately 1.6 GtC per year have released into the atmosphere as CO_2 from deforestation during 1990s, but at the same time forest ecosystems is believed to have absorbed between 2 – 3 GtC per year.

Tropical forests have an importan role for carbon sequestration in a much higher quantity than any other biome (Gorte, 2009) and also as a main carbon source to the atmoshere in areas that have undergone deforestation or unsustainable management (Malhi et al., 2006). The amount of carbon storage in the world's tropical forests which cover 17.6 x 10^6 km^2 are approximately 4.28 x 1011 tonne C in vegetation and soils (Lasco, 2002). Figure 1 shows the total world's tropical forests. In Asia, tropical forests are accounted for about 15.3 per cent in the world (UNCTAD Secretariat, n.d.). However, these forest ecosystems are facing the problem from deforestation and forest degradation in the tropics and Southeast Asia has been no exception. Lasco (2002) indicates that in 1990 deforestation rate in Southeast Asia was around 2.6x106 ha/ year. In addition there is liitle information on the carbon sequestration in natural forest ecosystems in Southeast Asia. To understand carbon sources and sinks, it is essential to estimate the biomass for these forests. Thus, the aim of this study was to estimate and compare the aboveground biomass and carbon stock between primary forest and secondary forest in the area of Khao Yai National Park.

2. Materials and methods

2.1 Study areas

This study was carried out at Khao Yai National Park. It covers a large complex area in Nakhon Ratchasima, Saraburi, Prachinburi and Nakhon Nayok Provinces. This National

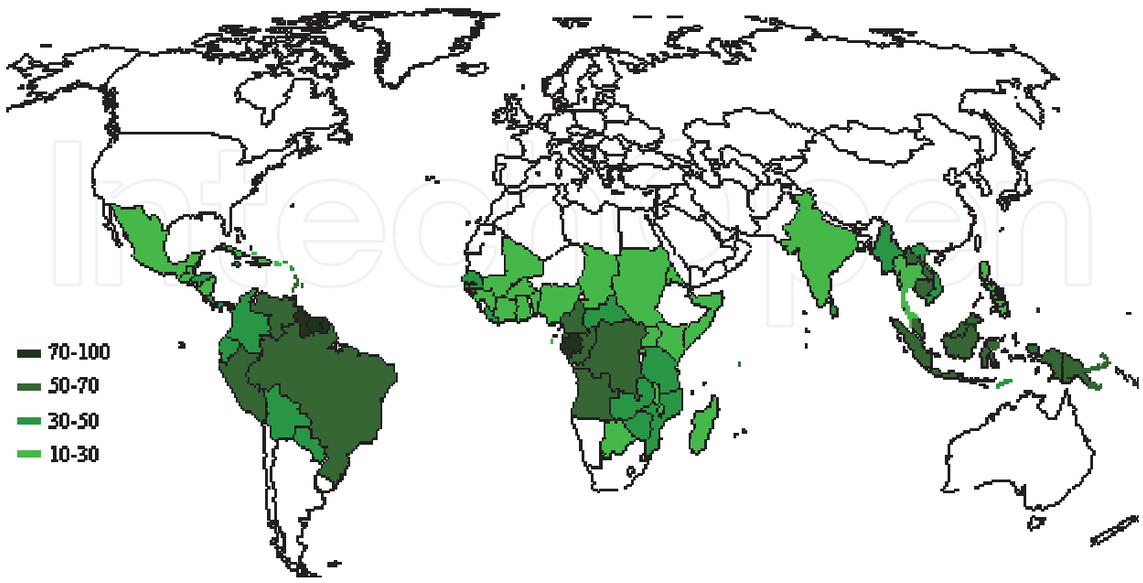


Fig. 1. The distribution of the world's tropical forest area in 2000 from UNCTAD Secretariat (n.d.)

Park is also part of the Dong Phaya Yen . The Dong Phayayen-Khao Yai Forest Complex is an important pool of biodiversity and complex terresstrial habitats not only in region, but also at global level. It was granted as a UNESCO Natural World Heritage Site on 14 July 2005 (Kekule, 2009). The climatological data was recieved from Khao Yai station, Department of Meteorology provied 25 years from 1982 – 2006. The annual temperature in the area varied from 30 - 33^{o} C and the area recieved the annual mean precipitation of 1,123.48 ± 165.08 mm. The selected study areas were carried out in Nakhon Ratchasima Province as shown in Figure 2. The sites were selected based on anthropogenic disturbance. The primary forest was classified as non or least disturbed forested area and the main area characteristic was classified as the tropical rain forest. On the other hand, the secondary forest was disturbed from anthropogenic activities in the past and described as dry evergreen and mixed deciduous forest types. All sampling plots were in the permanent plot of Professor Emeritus Warren Y. Brockelman under the project : foraging and ranging behavior of gibbons in Khao Yai National Park.



(a) The sampling plot in the primary forest (b) The sampling plot in the secondary forest

Fig. 2. The study sites in Khao Yai National Park

2.2 Data collection and analysis

A randomly 1 ha sampling plot (100 m x 100 m) in each forest type was established. To reveal the tree composition and biomass, all live trees with a diameter ≥ 4.5 cm were recorded. The diameter was measured at breast height (DBH, 1.3 m height from the ground) to estimate biomass and the size class distribution of trees as well as species diversity in a sampling plot. All supported botanical data were represented by the species in terms of taxonomic classification identifie into Genera or Species, providing both local and scientific names by Aunttara Na-Thalang, a researcher at BIOTEC central research unit and a co-researcher of this project. In case of irregularities of trunk tree, the measurement was taken at the nearest lower point where the stem was cylindrical, or above the buttresses on large trunks. DBH was measured by used of diameter tape. Trees with multiple stems connected near the ground were counted as single individuals and bole circumference was measured separately. Tree height was recored by using a measuring pole. Figure 3 displayed primary data record and field measurement.



(a) Trees ≥ 4.5 cmwere measured

(b) DBH was measured above the buttress root

(c) Tree height was recorded

Fig. 3. Field measurement

3. Data analysis

3.1 Species diversity and Important Value Index (IVI)

It was widely believe that species diversty related to the level of disturbance (Mackey and Currie, 2001). Thus, species diversity was evaluated by using the Shannon – Wiener index method (see Equation 1) in this study to compare between primary forest and secondary forest. It was assumed that all species represented in the sampling plot were randomly sampled. In this method, the proportion of number of individuals of a species to the overall number of individuals in the sample plots was used to express the diversity of species in the studied ecosystem (Krebs, 1999).

$$H' = -\sum_{i=1}^{s} (p_i)(\log_2 p_i) \tag{1}$$

Where:

H' = Index of species diversity

s = Species number in the sample

p_i = Proportional abundance of the ith species = (n_i / N)

To investigate the structural role of tree in the sampling plots, the importance value index (IVI) of each species was calculated using the percentage of relative abundance (R.A.), relative dominance (R.D.) and relative frequency (RF) (see Equation 2)

$$\text{I.V.} = \text{R.A.} + \text{R.D.} + \text{R.F} \ldots\ldots \text{Whittaker (1970)} \tag{2}$$

Where:

I.V. = Important value index of each species

$$\text{R.A.} = \text{Relative abundance} = \frac{\text{total number of each species x 100}}{\text{total nuber of all species}}$$

$$\text{R.D.} = \text{Relative dominance} = \frac{\text{basal area of each species x 100}}{\text{basal area of all species}}$$

$$\text{R.F.} = \text{Relative frequency} = \frac{\text{chance to find each species x 100}}{\text{chance to find all of species}}$$

To test the significance of the difference between categories, one way analysis of variance (ANOVA) was carried out using the SPSS Statistics 17.0 software. Data on species distribution in two forest types were analyzed by correspondence analysis using the same software. We used correspondence analysis (CA) as the ordination method to examine the differences in the distribution of tree species using the same software.

3.2 Aboveground biomass and carbon sequestration

To estimate aboveground biomass in the study areas by non – destructive methods, we had to collect data such as diameter at breast height (DBH) and height of all trees. SILVIC Program was used to predict the mean total tree height in the sampling plots. It was developed from the relationship between DBH and tree height (Ht) by hyperbolic equation (see Equation 3) or D – H curve (Ogawa, Yoda and Kira, 1961). Forty trees in different sizes in the sampling plots were observed to analyse their height and DBH relationships. Ogawa (1969) showed that H was approximately equal to one for most mature forests. Assuming that h equaled one, the other coefficients, A and H* for each stand were calculated by using the non – linear least square method. These constant values were used to predict tree height in this study.

$$1/H_t = 1/A\,(DBH)^h + 1/H^* \quad (3)$$

Where
Ht = height of tree (m)
DBH = diameter at breast height (cm)
A, h, H* = constant

The next step was the aboveground biomass evaluation by non-destructive assessments. The biomass regression equations on the basis of DBH and Ht which derived from in tropical forests were applied for calculating the aboveground biomass and the size class analysis will evaluate the status of forest ecosystem. The primary forest used the equation developed by Tsutsumi *et al*. (1983) (see Equation 4) and the equation developed by Ogawa *et al*. (1965) was used for the secondary forest (see Equation 5).

$$\text{Stem (WS)} = 0.0509*(D^2H)^{0.919} \quad (4)$$

$$\text{Branch (WB)} = 0.00893*(D^2H)^{0.977}$$

$$\text{Leaf (WL)} = 0.0140*(D^2H)^{0.669}$$

and

$$\text{Stem (WS)} = 0.0396*(D^2H)^{0.9326} \quad (5)$$

$$\text{Branch (WB)} = 0.003487*(D^2H)^{1.027}$$

$$\text{Leaf (WL)} = ((28.0/\text{WS} + \text{WB}) + 0.025)^{-1}$$

Where
Ws = stem mass(kg/ individual tree)
Wb = branches mass (kg/ individual tree)
Wl = leaf mass (kg/ individual tree)
Ht = height of tree (m)
DBH = diameter at breast height (cm)
Total carbon content was estimated from aboveground biomass by converted from biomass to carbon stock. From the reports (Atjay et al., 1979; Brown & Lugo, 1982; Iverson et al., 1994; Dixon et al., 1994; Cannell & Milne, 1995 and Terakunpisut et al., 2007), carbon content would be about fifty percent of the amount of aboveground biomass. To compare the potential of carbon sequestration between primary forest and secondary forest, frequency distribution of total aboveground biomass in a range of DBH size classes were considered to assess the potential of the forests across their size classes and age.

4. Results and discussion

4.1 Species diversity

Across sampling sites, tree species varried with forest types. Primary forest had greater species richness (75 species/ ha) than secondary forest (47 species/ ha). It probably implied that the study site in primary forest was more complexity in a community and species interaction. Since number of species compositions indicated the degrees of energy transfer through foodweb. In this case, the level of energy transfer in primary forest was stronger than secondary forest in order to support the higher total number of individuals of all species. This meant that the productivity in primary forest was also higher than another. In addition, the greater number of species compositions were most in ecosystems that have long time evolution, because organisms may develop mechanisms to conserve or more efficiently acquire any of the other limiting resources by certain physical or abiotic factors of the environment such as temperature, precipitation, light and soil.
From the species diversity (H') measurement, The results showed that the overall plant species diversity of primary forest was higher than secondary forest, with the Shannon-Wiener indexes being 3.46 and 2.03 respectively. In practical, species diversity has been used to indicate the stability of the ecosystem. It meant that the high species diversity can exist in the spatially heterogeneous environment where the disturbances influence to the species in different degree. The species diversity index values measured and calculated from different forest ecosystems in Thailand had been listed and compared with this study as shown in Table 1. The species diversity values in primary forest and secondary forest were not much different from others study. The main conclusion was clearly demonstrated that the highest species diversity was from primary forest (tropical rain forest) because there were rich in

resource such as diverse of habitat types and a large extent on food available in the tropical rain forest more than in other forest types.

Forest ecosystem	Shannon – Wiener diversity index	References
The primary forest The secondary forest	3.46 2.03	This study
Tropical rain forest	3.48 - 3.52	Terakunpisut et al., 2007
Dry evergreen forest	3.62 3.5 – 4.9	Terakunpisut et al., 2007 Sahunalu et al., 1979
Mixed deciduous forest	3.09 3.5 – 3.9	Terakunpisut et al., 2007 Sahunalu et al., 1979

Table 1. A comparison of species diversity index under different forest ecosystems in Thailand among this study and the others.

This study also identified the dominant species according to the important value index (IVI). The result represented in Figure 4, which ranked from the highest value to lower value. The result indicated that common species in the primary forest were *Ardisia nervosa* (127 tree/ ha, IVI = 56.08) followed by *Mastixia pentandra*, *Gonocaryum lobbianum*, *Dipterocarpus gracilis*, *Cinnamomum subavenium* and *Aglaia elaeagnoidea*. The contribution of the dominant species in the secondary forest was *Schima wallichii* (505 trees/ ha, IVI = 71.94) and 2 co-dominant species were *Machilus odoratissima* and *Eurya nitida*.

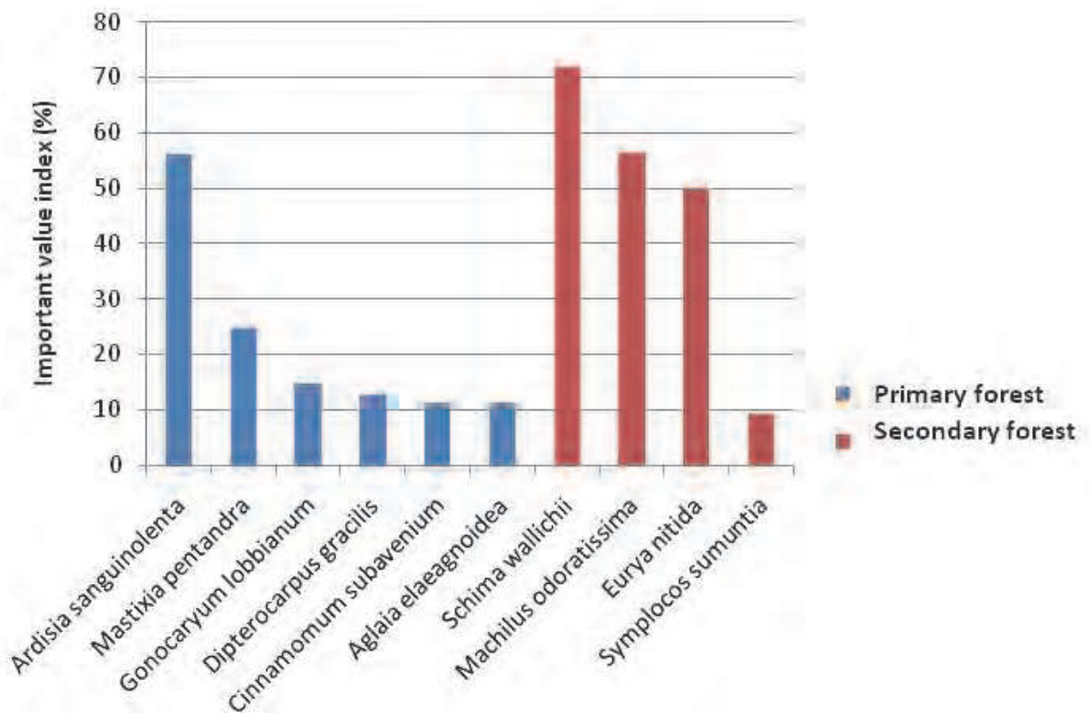


Fig. 4. Important value index of tree species (DBH ≥ 4.5 cm) in the primary forest and the secondary forest

The correspondence analysis revealed the pattern of the species distribution tree distribution in the study areas (see Figure 5). A correspondence map displayed two of the dimensions to relate the distribution of tree species with forest types. It showed that some plant species had high potential distribution. Thus, there were overlapped in their distribution between the different forest types. For example, *Aquilaria crassna*, *Bridelia insulana*, *C. subavenium*, *Cleistocalyx operculatus*, *D. gracilis*, *Eurya nitida*, *Garcinia benthamii*, *G. lobbianum*, *Helicia formosana*, *Ilex chevalieri*, *Litsea umbellata*, *M. pantandra*, *Phoebe lanceolata*, *Syzygium grande*, *S. siamensis* and *S. Syzygiodes* occurred in both forest types and the pattern indicated links to both forests. Because of the similarity of climate such as annual precipitation and annual temperature, the species compositions of each forest type had features in common and only a few rare species were specific to a single forest type. The analysis of variance showed that tree species did not significantly differ across the two forest types in terms of species richness, F (1, 120) = 2.328, p = 0.130. This was due to several species were found in both forests.

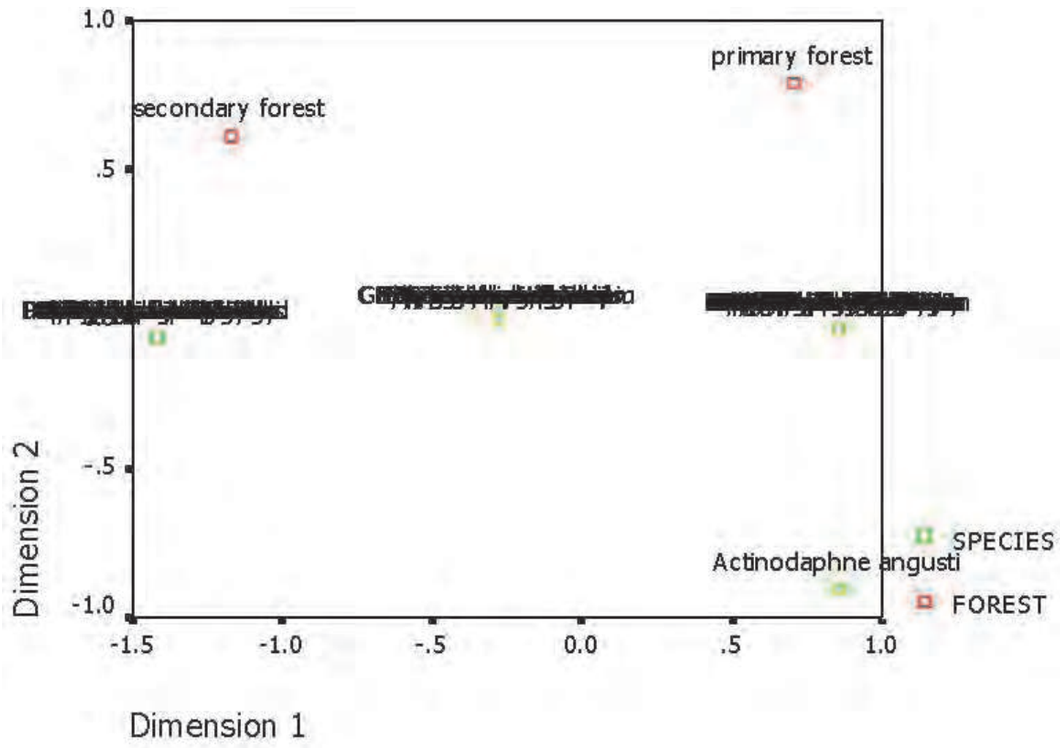


Fig. 5. Species distribution and forest types. Tree compositions in both forests were not significantly different across groups, F (1, 120) = 2.328, p = 0.130

Figure 6 showed the DBH size class distribution on two sampling plots. The density of plants with DBH ≥ 4.5 cm in secondary forest was 1,249 trees/ ha due to lots of small tree sizes. While tree density in primary forest was only 919 trees/ ha since the main tree size class in this area was medium to large tree sizes at DBH > 40 – 60 cm and 60 – 80 cm. It was cler that the frequency distribution curves of DBH were all L- shaped in both forests. The density of trees was the highest at the left end of the graph and decreased afterward. Up to > 20 – 40 cm, the distribution curves of primary forest and secondary forest were similar,

although the amount of trees in secondary forest were much higher, especially in DBH size class ≥ 4.5 – 20 cm. The main differences between primary forest and secondary forest were in the number of trees in medium size class at DBH > 40 – 60 cm and > 60 – 80 cm which were greater amount in primary forest. The analysis of variance showed that there was significant difference of tree density between primary forest and secondary forest, F (1, 120) = 4.393, p = 0.038.

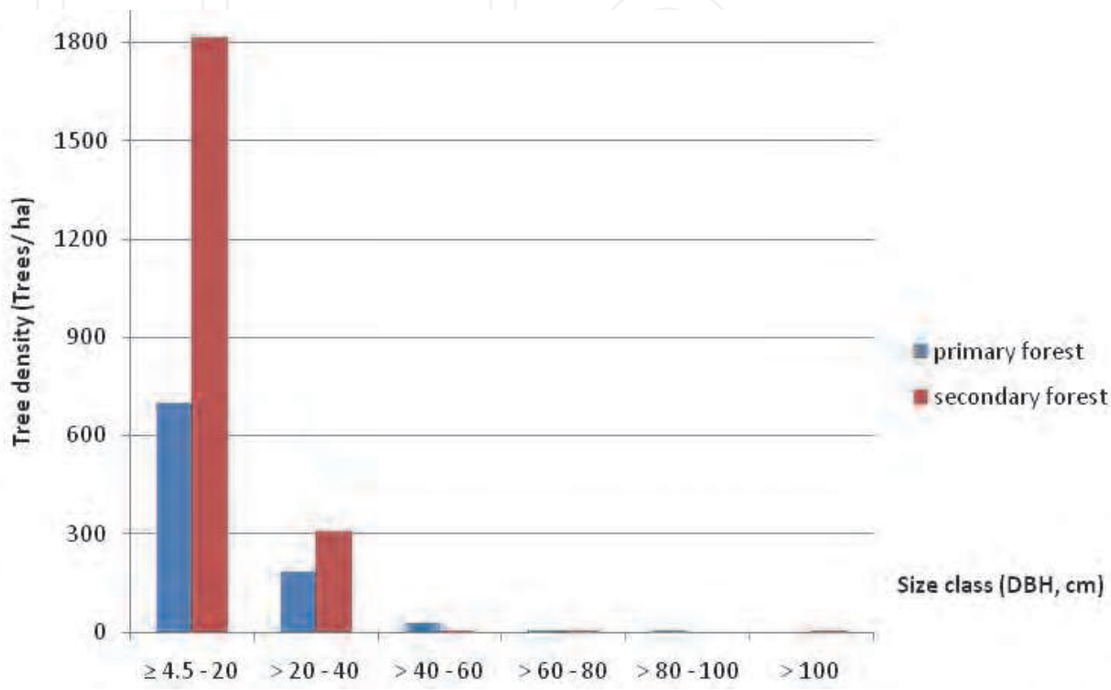


Fig. 6. A trend of tree density distribution in different DBH size classes

4.2 Aboveground biomass and carbon sequestration

Aboveground biomass distribution and carbon storage in different DBH size classes were compared between primary forest and secondaryforest in Khao Yai National Park (see Figure 7). It was remarkable that total aboveground biomass accumulation in primary forest (684.76 tonne/ ha) was higher than seconday forest (198.20 tonne/ ha). Although the number of trees were significantly greater in secondary forest, but the highest tree density were in the group of small tree size classes at DBH ≥ 4.5 – 20 and 20 – 40 cm which had lowest individual volume and biomass. On the other hand, the most aboveground biomass accumulation was found in big trees of size class at > 60 – 80, > 80 –100 and > 100 cm that were dominant tree groups in primary forest. Because these trees were highest stem volume and large diameter, although they were the smallest group of tree densities. The analysis of variance revealed a significant difference in terms of median total aboveground biomass between primary forest and secondaryforest, F (1, 3046) = 29.189, p = 0.000.

In comparison with other tropical forests, the range of aboveground biomass in this study both areas were similar (see Table 2). The result in Primary forest was compared to tropical rain forest, while data in secondary forest was compared with the biomass in dry evergreen forest and mixed deciduous forest.

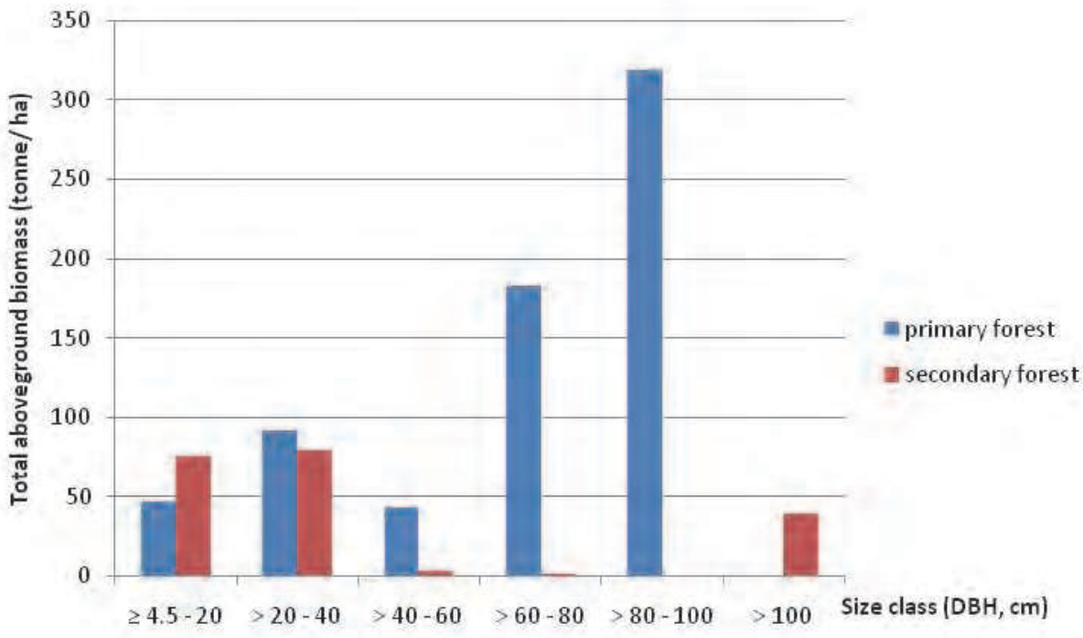


Fig. 7. Frequency distribution of total aboveground biomass in a range of DBH size classes between the primary forest and the secondary forest

Forest ecosystem	Aboveground biomass (tonne/ ha)	References
The primary forest Tropical rain forest	684.76 509.00	This study Yamakura et al., 1986
The secondary forest Dry evergreen forest Dry evergreen forest Mixed deciduous forest	198.20 73.06 - 173.10 140.58 96.28	This study Mani and Parthasarathy, 2007 Terakunpisut et al., 2007 Terakunpisut et al., 2007

Table 2. A comparison of total aboveground biomass in this study and the others.

The percentage data of tree density and carbon sequestration were presented in Table 3. The total carbon sequestration in primary forest and secondary forest were equal to 342 and 99.10 tonne C/ ha, respectively. The results showed that the distribution of DBH size classes and the total carbon storage in each size class varied between the forest types. About 80 per cent of the carbon stock was presented in DBH size class at ≥ 4.5 – 20 cm and > 20 – 40 cm in secondary forest but contributed only 20 per cent of total carbon stock in primary forest. The carbon storage was highest in DBH size class at > 60 – 80 cm and > 80 – 100 cm in primary forest.

However, the highest potential size class to sequester CO_2 from the atmosphere in primary forest and secondary forest were DBH size class at > 60 – 80 cm and > 20 – 40 cm, respectively. Since number of trees in these size classes were lower than other, but the

amount of carbon storage were greater than other groups which had higher tree density. For example, in secondary forest; trees in the size class at ≥ 4.5 – 20 cm were five times more tree density than trees in the size class at > 20 – 40 cm, but the amount of carbon storage were similar. Likewise primary forest, trees in the size class at > 60 – 80 cm were found only 0.44 per cent, but the amount of carbon storage was nearly four times of trees in the size class at ≥ 4.5 – 20 cm.

size class (DBH, cm)	The primary forest		The secondary forest	
	Tree density (%)	Carbon stock (%)	Tree density (%)	Carbon stock (%)
≥ 4.5 - 20	76.20	6.93	85.30	38.18
> 20 - 40	20.00	13.43	**14.37**	**39.96**
> 40 - 60	3.04	6.37	0.19	1.48
> 60 - 80	**0.44**	**26.73**	0.05	0.62
> 80 - 100	0.33	46.53	-	-
> 100	-	-	0.09	19.75

Table 3. A comparison of the percentage of tree density and carbon sequestration potential between the primary forest and the secondary forest

In summary, the distribution pattern of aboveground biomass had been related to past disturbance history the forests. Total aboveground biomass in the primary forest was about triple that of the secondary forest. However, both study areas had high carbon sequestration potential in the future due to presence of large number of trees belonging to small DBH size classes. These trees in size class at ≥ 4.5 – 20 cm were in the youth phase and their growth rate was accelerating to reach maturity. It meant that at the present these smaller trees are not the highest carbon sequestration potential, but in the near future they can sequester CO_2 from the atmosphere through photosynthesis to form their structure till senescent phase. Broadmeadow and Matthews (2003) suggested the option to reserve carbon in the forests by minimal intervention, with a gradual long – term increase in carbon stocks.

5. Conclusions

The number of tree species occurring on the sample area in the primary forest and the secondary forest were 75 and 47 species, respectively. To conclude the correspondence analysis and ANOVA, it was found that there were many species in common between primary forest and secondary forest. So each forest type had not a distinctive of species distribution. From the results, it was found that the tree density was counted in the secondary forest as 2,129 trees/ ha due to lots of saplings and small trees, while the tree density in the primary forest was found only 919 trees/ ha since the main tree size class in this area was medium to large tree size at > 60 – 80 cm.

The primary forest and secondary forest of Khao Yai National Park had carbon stocks 342.29 and 99.10 tonne C/ ha, respectively. The total aboveground carbonstorage in the primary forest was significantly greater than the secondary forest. Although the young trees belonging to the size class at DBH ≥ 4.5 - 20 cm dominated both forests in terms of tree density, the carbon sequestration potential was greater in the size class at DBH > 20 - 40 cm in secondary forest and in the size class at DBH > 60 - 80 cm in primary forest. Both forests were very important for carbon sequestration because there were typically high carbon

stocks. Moreover, the result also implied that the potential was considerably high to sequester carbon in both forest areas in the near future due to lots of small trees in the areas. We hope that the results of this study on aboveground biomass and carbon sequestration will be useful to conserve these forest areas under sustainable management.

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7. References

Alexandrove, G.A. (2007). Carbon Stock Growth in a Forest Stand: the Power of Age, *Carbon Balance and Management*, Vol. 2 (4), pp. 1 – 5.

Alley, R., Berntsen, T., Bindoff, N.L., Chen, Z., Chidthaisong, A., Friedlingstein, P., Gregory, J., Hegerl, G., Heimann, M., Hewitson, B., Hoskins, B., Joos, F., Jouzel, J., Kattsov, V., Lohmann, U., Manning, M., Matsuno, T., Molina, M., Nicholis, N., Overpeck, J., Qin, D., Raga, G., Ramaswamy, V., Ren, J., Rusticucci, M., Solomon, S., Somerville, R., Stocker, T.F., Stott, P., Stouffer, R.J., Whetton, P., Wood, R.A. & Wratt, D. (2007). *The Fourth Assessment Report of the Intergovernmental Panel on Climate Change: Climate Change 2007: the Physical Science Basis,* Geneva, Switzerland, Intergovernmental Panel on Climate Change.

Atjay, G.L., Ketner, P. & Duvignead, P. (1979). Terrestrial Primary Production and Phytomass. In B. Bolin, E.T. Degens, & S. Kempe, (Eds.), *The Global Carbon Cycle*, Wiley and Sons, New York, pp. 129 – 182,

Broadmeadow, M. & Matthews, R. (2003). Forests, Carbon, and Climate Change: the UK Contribution, *Information Note*, June 2003. Available from http://www.forestry.gov.uk/pdf/fcin048.pdf/$FILE/fcin048.pdf

Brown, S. & Lugo, A.E. (1982). The Storage and Production of Organic Matter in Tropical Forests and Their Role in the Global Carbon Cycle, *Biotropica* Vol 14, pp. 161 – 187.

Cannell, M.G.R. & Milne, R. (1995). Carbon pools and sequestration in forest ecosystems in Britain, *Forestry* Vol 68, pp. 361 – 378.

Chakraborty, S., Tiedemann, A.V. & Teng, P.S. (2000). Climate Change: Potential Impact on Plant Diseases, *Environmental Pollution* Vol.108, pp. 317-326.

Dixon, R.K., Brown, S., Solomon, R.A., Trexler, M.C. & Wisniewski, J. (1994). Carbon Pools and Flux of Global Forest Ecosystems, *Science* Vol 263, pp. 185 – 190.

Forest Research. (2011). Kyoto Protocol and UK forests, *Climate Change Mitigation*, Available from http://www.forestry.gov.uk/website/forestresearch.nsf/ByUnique/INFD-62VEK3.

Gibbs, H.K., Brown, S., Niles, J.O., & Foley, J.A. (2007). Monitoring and Estimating Tropical Forest Carbon Stocks: Making REED a Reality, *Environ. Res. Lett.* Vol. 2, pp. 1 – 13.

Gorte, R.W. (2009). Carbon Sequestration in Forests. *CRS Report for Congress*, Congressional Research Service, August 6, 2009.

Iversion, L. R., Brown, S., Prasad, A., Mitasova, H., Gillespie, A.J.R. & Lugo, A.E. (1994). Use of GIS Estimating Potential and Actual Forest Biomass for Continental South and Southeast Asia. In W. Dale, (Ed.), *Effect of Land-Use Change on Atmospheric CO_2 Concen-tration*, Springer - Verlag, New York, pp 67 – 116.

Kekule, L.B. (2009). Khao Yai: Thailand's First and Most Famous National Park. In: *Bangkok Post*, August 31, 2009, Available from http://brucekekule.com/the_northeast/a-world-heritage-treasure-in-the-north-east/

Lasco, R.D. (2002). Forest Carbon Budgets in Southeast Asia following Harvesting and Land Cover Change, *Science inChina* Vol. 45, pp. 55–64.

Leith, H.F.H. (1975). Primary Productivity in Ecosystems: Comparative Analysis of Global Patterns. In W.H. Van Dobben & R. H. McConnell, (Eds.), *Unifying Concepts in Ecology*, The Huge, Wageningen, pp 67 – 87.

Mackey, R.L. & Currie, D. (2001). The Diversity – Disturbance Relationship: Is It Generally Strong and Peaked?, *Ecology* Vol 82(12), pp. 3479-3492.

Malhi, Y., Wood, D., Bakers, T.R., Wright, J., Phillips, O.L., Cochrane, T., Meir, P., Chave, J., Almeida, S., Arroyo, L., Higuchiss, N., Killeen, T.J., Laurance, S.G., Laurance, W.F., Lewiss, S.L., Monteagudo, A., Neill, D.A., Vargas, P.N., Pitman, N.C.A., Quesadas, C.A., Salomao, R., Silva, J.N.M., Lezama, A.T., Terborgh, J., Martinez, R.V. & Vinceti, B. (2006). The Regional Variation of Aboveground Live Biomass in Old-Growth Amazonian Forests, *Global Change Biology* Vol 12, pp. 1-32.

Mani, S. & Parthasarathy, N. (2007). Above-ground biomass estimation in ten tropical dry every forest sites of peninsular India, *Biomass and Bioenergy*, Vol 31, pp. 284-290.

Michaelowa, A. & Rolfe, C. (2001). Early Action to Reduce Greenhouse Gas Emissions before the Commitment Period of the Kyoto protocol: Advantages and Disadvantages, *Environmental Management* Vol 28, pp. 281–292.

Ogawa, H. 1969. An attempt at classifying forest types based on the relationship between tree height and DBH. In T. Kira (ed.), *Comparative study of primary productivity of forest ecosystem*, pp. 3 – 17.

Ogawa, H., Yoda, K. & Kira, T. (1961). A Preliminary Survey on the Vegetation of Thailand, *Natural and Life in Southeast Asia* Vol 1, pp. 21–157.

Ogawa, H., Yoda, K., Ogino, K. & Kira, T. (1965). Comparative Ecological Studies on Three Main Type of Forest Vegetation in Thailand II. Plant Biomass, *Nature and Life in Southeast Asia* Vol 4, pp. 49 - 80.

Mackey, R.L. & Currie, D.J. (2001). The Diversity – Disturbance Relationship: Is It Generally Strong and Peaked?, *Ecology* Vol. 82 (12), pp. 3479-3492.

Sahunalu, P., Chamreanpruk, M., Puriyakorn, B., Dhanmanonda, P., Suwannapin, W. & Prachaiyo, B. 1979. *Structure of three forest types in the Prom Basin, Chaiyaphum Province*. Faculty of Forestry: Kasetsart University.

Terakunpisut , J., Gajaseni, N. & Ruankawe, N. (2007). Carbon Sequestration Potential in Aboveground Biomass of Thong Pha Phum National Forest, Thailand, *Applied Ecology and Environmental Research* Vol.2, pp. 93-102, ISSN 1589-1623

Tsutsumi, T., Yoda, K., Sahunalu, P., Dhanmanonda, P. & Prachaiyo, B. (1983). Forest: Felling, Burning and Regeneration, In K. Kyuma & C. Pairintra, (Eds.), *Shifting cultivation*, Tokyo, pp. 13-62.

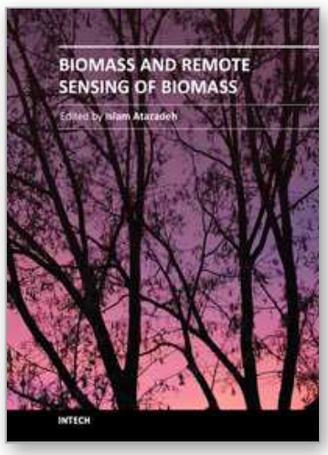
UNCTAD secretariat. (n.d.). Trends in Tropical Forest Area. *Tropical Timber* [Online], Available from http://www.unctad.org/infocomm/anglais/timbertrop/crop.htm

UNFCCC. 1997. *Kyoto Protocol to the United Nations Framework Convention on Climate Change* Available from:
http://www.unfccc.de/resource/ index.html

Whittaker, R.H. (1970). *Communities and Ecosystem*, Toranto, Macmillian.

Yamakura, T., Hagihara, A., Sukardjo, S. & Ogawa, H. (1986). Aboveground biomass of tropical rain forest stands in Indonesian Borneo, *Plant Ecology* Vol. 68 (2), pp. 71-82.

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Generally, the term biomass is used for all materials originating from photosynthesis. However, biomass can equally apply to animals. Conservation and management of biomass is very important. There are various ways and methods for biomass evaluation. One of these methods is remote sensing. Remote sensing provides information about biomass, but also about biodiversity and environmental factors estimation over a wide area. The great potential of remote sensing has received considerable attention over the last few decades in many different areas in biological sciences including nutrient status assessment, weed abundance, deforestation, glacial features in Arctic and Antarctic regions, depth sounding of coastal and ocean depths, and density mapping. The salient features of the book include:
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Use of remote sensing for evaluation of biomass
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