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Carbon stock of *Macaranga gigentia* and *Adinandra dumosa* in Universiti Teknologi Malaysia (UTM) Green Area

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The purpose of this study is to identify contribution of pioneer species in retaining carbon stock at university campus. It focuses on two pioneer species, *Macaranga gigentia* and *Adinandra dumosa,* that emerge naturally in Universiti Teknologi Malaysia (UTM) green area. A total of 15 plots sized 10 meter x 10 meter were established randomly at UTM green area. Coordinate for each plot has been recorded using Trumble GPS. Trees with diameter more than 5 cm were tagged. Diameter at Breast Height (DBH) and height for these two species has been recorded. DBH has been measured by diameter tape while tree height by Leica Disto D2. A total of 28 of *Macaranga gigentia* and 17 of *Adinandra dumosa* have been recorded. Carbon stock estimation of the species is analyzed by Brown's (1997) equation. It is found that *Macaranga gigentia* is the most dominant pioneer species that stored 91 kg C per tree whereas *Adinandra dumosa* stored three times less, 23 kg C per tree. It means that *Macaranga gigentia* contribute more carbon stock compare to *Adinandra dumosa*. Therefore, conservation for pioneer species should be taken to reduce carbon in the atmosphere.

Keywords: *Pioneer Species, Macaranga gigentia, Adinandra dumosa, green area, carbon stock*

1. Introduction

Worldwide, deforestation[1] and forest degradation[2] contributes to land use and land cover change where most of green area were disturbed. Until now, nearly 70 percent total of forest loss was recorded (Paula, Patrícia, & Costa, 2011). This green area was changed to infrastructure such as factory, houses and agriculture to fulfill human demand for food and shelter. However, main concern is regarding to the accumulation of carbon in the atmosphere which emitted by this activities. About 6 to 17 percent of global carbon dioxide from anthropogenic activities comes from deforestation (Baccini et al., 2012). From tropical deforestation has contribute nearly to 25 percent of carbon dioxide to the atmosphere (Skutsch et al., 2007). This number keeps increasing every year and gives bad impact to human and environment although each country developed an act in conserving forest.

About 60 percent of the world's total forest carbon stored inside living biomass from tropical forest (Paula et al., 2011). After, more trees have been cleared more carbon stock were disturbed and destroyed. All carbon stored in above such as in plant leaves and bark, and below ground released to the atmosphere. This situation becomes worst when all the natural biodiversity at that particular area was disappeared. Although replanting program was done, the area still different as previous.

As people knows, trees and green plants play important role in reducing carbon. Plants used carbon during photosynthesis and at the same time declined number of carbon in the atmosphere. If more trees alive, more carbon will absorb by trees and at the same time helping to avoid climate change and global warming occurred. Climate change is a different long term of weather at a particular areas (VijayaVenkataRaman, Iniyan, & Goic, 2012).

Since many primary forest and green area were disturbed, more green area was turned to secondary areas which dominated by pioneer species. Pioneer species is a species where their seed can germinate in gaps of canopy forest with a little sun light received (Swaine & Whitmore, 1988). For example of pioneer species that emerged in tropical region are *Macaranga gigentia*, *Mallotus paniculatus*, *Trema orientalis*, *Ficus* sp. and *Vitex pinnata* (Davies & Semui, 2005; Ipor, Jusoh, Wasli, & Abu Seman, 2013; Shono, Davies, & Kheng, 2006).

This pioneer species recognize as fast growing trees and can live until 30 years old (Bischoff et al., 2005). This pioneer species not only contribute for carbon stock but also valuable habitat for animal and medicinal value. For example, *Macaranga* sp. gives shelter for ant and at the same time the ants will protect the tree from herbivores (Fiala, Maschwitz, Yow, & Helbig, 1989). Meanwhile, *Dillenia suffruticosa* which also known as a pioneer species and indicator for disturbance area had been use as traditional medicine in Perak. Perak is one of district in Malaysia. This species beneficial for antibacterial and antifungal activities specifically as an astringent[3] (Wiart et al., 2004)

After a few reviews have been done, less study concern about carbon stock that contributed from pioneer species. Most study has been done specifically trees from Dipterocarpaceae family such as from genus *Shorea* (Noor & I Faridah-hanum, 2008) and trees from mangrove ecosystem. This is because it contributed in economy and coastal protection (Kridiborworn, Chidthaisong, Yuttitham, & Tripetchkul, 2012). Therefore this study was implemented to identify how much contribution of carbon stock by these two pioneer species.

1.1 Trends in Carbon Stock Studies from 2004 until 2014

Carbon stock studies started from early 19th after people realized carbon gives bad impact to human and environment. Researchers started from conventional until high technology methods in order to measure and solve carbon problem. A few programmed have been done to educate people in reducing carbon emission to develop a carbon balance. Below are summarizations of trends in carbon stock studies (Table 1).

Table 1 Summarizations of Trends in Carbon Stock Studied since 2004 until 2014

Years	Author	Research Concern
2004 - 2008	Kim Phat, Knorr, & Kim, (2004)	Identify implication of carbon stock in alternative forest and land management options
	Chave et al. (2005)	Develop new model in estimating biomass from by destructive methods. They found the most important parameters in estimating biomass were trunk diameter, wood specific gravity, total height, and forest type. Also test the regression in different tropical forest type.
	Jepsen (2006)	Used different established equation to estimate biomass in cultivation areas
	Lasco & Cardinoza (2006)	Recognized carbon stock baseline from reforestation and fast growing species
	Terakunpisut, Gajaseni, & Ruankawe (2007)	Investigate carbon stock potential in Thong Pha Phum National Forest, Thailand
	Takimoto, Nair, & Nair (2008)	Discovered the important of assessing carbon stock in soil which did not emphasized in Kyoto Protocol
2009 - 2014	Saatchi et al. (2011)	Provide a benchmark map in monitoring status of carbon stock either poor or incomplete
	van Breugel, Ransijn, Craven, Bongers, & Hall (2011)	Estimate Above-ground biomass at young secondary forest and by using selected regression models
	Eckert,	Carbon stock at Low

	Ratsimba, Rakotondraso a, Rajoelison, & Ehrensperger (2011)	Degraded forest and degraded forest
	Thangata & Hildebrand (2012)	Found simpler method in quantifying carbon stock at fallows
	Ren et al. (2012)	Discovered the effect of urban sprawl on carbon stock balance by using satellite image and forest inventory in Xiamen, China
	Petsri, Chidthaisong, Pumijumnong , & Wachrinrat (2013)	Estimating carbon stock in rubber tree plantation. Identify carbon emission that comes from fertilizer and herbicide application.
	O'Donoghue & Shackleton (2013)	Role of green area (urban trees) at parking lot in absorbing carbon
	Ngo et al. (2013)	Carbon stock at Primary and Secondary Tropical forest in Singapore
	L & Karthick (2013)	Carbon stock potential by two different tree plantations at Bharathiar University campus
	Rathore & Jasrai (2013)	Carbon stock at green patches in Gujarat University Campus
	Yang, Xu, Cai, Bi, & Wang (2014)	Assessed impact of socioeconomic factors due to total of carbon stock

2. Methods

2.1 Study site

The study area was conducted at Universiti Teknologi Malaysia (UTM) Skudai Campus green area (Fig. 1). UTM is located at Skudai district in Johor Bharu, Malaysia.

This university comprises 1177 hectares of land covers. Most of the area occupied of buildings for teaching and learning such as lecture halls and classes, administration, students hostel, staff resident and green area which remain as lungs of the campus area.

Fig. 1 Location of the study site at Universiti Teknologi Malaysia Campus Skudai

2.2 Plot setting

Each plot directed to North and standardizes the plot shape by using SUUNTO Compass. Fifteen plots of 10 m x 10 m each were established randomly at green area around UTM.

2.3 Data collection

Coordinate for each plot have been recorded using Trumble GPS. In Table 2 showed latitude and longitude for each plot. *Macaranga gigentia* and *Adinandra dumosa* with diameter ≥ 5 cm were tagged and identified at field.

Species identification was done by referring taxonomist from Universiti Kebangsaan Malaysia (UKM), Bangi and a book title *Tree Flora of Malaya*. Species height and Diameter at Breast Height (DBH) were recorded using Leica Disto D2 and DBH tape. DBH for each species was measured 1.3 meter from soil surface. Both species coordinate for each plot also recorded in x and y using meter tape.

Fig. 3 Location of fifteen plots at UTM

Table 2 Longitude and latitude for each plot

Plot	Latitude	Longitude
1	01° 34' 08. 724"	103° 38' 09. 084"
2	01° 34' 10. 908"	103° 38' 11. 885"
3	01° 34' 31. 169"	103° 37' 12. 777"
4	01° 34' 30. 325"	103° 37' 13. 000"
5	01° 34' 29. 617"	103° 37' 12. 893"
6	01° 34' 27. 654"	103° 37' 13. 466"
7	01° 34' 26. 753"	103° 37' 02. 626"
8	01° 34' 25. 464"	103° 37' 01.356"
9	01° 34' 24. 497"	103° 37' 01. 313"
10	01° 34' 24. 685"	103° 37' 00. 090"
11	01° 33' 10. 006"	103° 38' 18. 392"
12	01° 33' 51. 305"	103° 38' 59. 247"
13	01° 33' 51. 051"	103° 38' 59. 821"
14	01° 33' 44. 061"	103° 39' 12. 571"
15	01° 33' 43. 219"	103° 39' 12. 477"

2.4 Data Analysis

Data entry and statistical analysis was carried out using SPSS, version 20.0. Independent *t-test* was applied to determine which species stored more carbon based on tree height and DBH. In estimating carbon stock, non-destructive method was choosing which only implement equation. Some previous studies the researchers preferred to harvest the trees to estimate carbon stock. However, to conserve these species and sustain carbon stock, Brown equation in 1997 was utilized.

3. Characteristic for *Macaranga gigentia* and *Adinandra dumosa*

3.1 Macaranga gigentia

Macaranga gigentia was included in Euphorbiaceae family. Euphorbiaceae family consist 57 genera and 198 species (Kiew, Chung, Saw, Soepadmo, & Boyce, 2010). This family contains numerous types of trees from herbs, shrubs, small and until medium trees and can easily found throughout the world.

Most of trees in this family can achieve 30 meter tall and 180 cm girth. Family Euphorbiaceae is the commonest family and usually emerged at lowland, hill primary and secondary forest. This species easily recognized and differentiate with the other species since size of the leaves is bigger compare to the others (Whitmore, 1972).

3.2 Adinandra dumosa

Adinandra dumosa was classified under Theaceae family but previously located under Ternstroemiaceae family or tea family. Types of plants in this family are shrub or trees. Theaceae family only consist three genera and fifteen species. This species is a common species in Malaysia and can produced leaves and flowers throughout the year. It can achieve until 20 meter tall (Whitmore, 1978).

4. Results and Discussion

4.1 Species Composition

The study recorded 28 individuals of *Macaranga gigentia* and 17 individuals of *Adinandra dumosa* (Table 3). Total 45 individuals of trees were collected within fifteen plots at UTM green area. Within fifteen plots that have been established, only eleven plots comprised with these two species. However, other pioneer species such as *Mallotus* and *Dillenia* live in plot 6, 11, 13 and 14 (Fig. 4).

Some of plot study lack of number pioneer species because most of the area was covered by large tree crown. Therefore, most of pioneer species cannot survive due to less of sunlight received. Only four plots consists both species which in plot 1, 2, 4 and 7. Plot fifteen shows the highest number of

Macaranga gigentia trees. Most of plot area that consist only one pioneer species was new disturbed area without any barriers such as canopy cover.

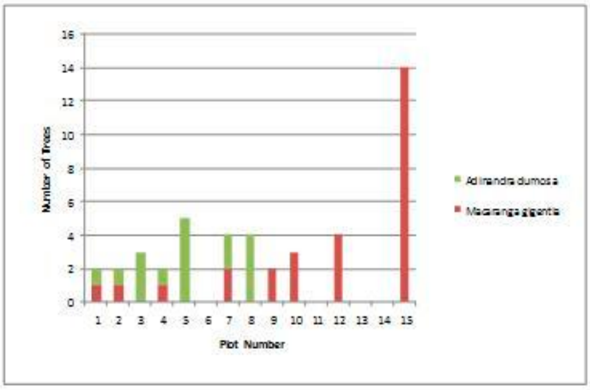

Fig. 4 Graph species composition for each fifteen plot

Table 3 Species number based on plot study

Plot	*Macaranga gigentia*	*Adinandra dumosa*
1	1	1
2	1	1
3	0	3
4	1	1
5	0	5
6	0	0
7	2	2
8	0	4
9	2	0
10	3	0
11	0	0
12	4	0
13	0	0
14	0	0
15	14	0
Total	28	17

4.2 Carbon Stock

In Table 4 showed total number individuals and carbon stock for each species. *Macaranga gigentia* stored more carbon compare to *Adinandra dumosa*. Total of carbon store influenced by growth rate for each species. Growth rate usually measured based on tree height and DBH. Large trees with higher DBH stored more carbon compare to small DBH. This shown by the total amount of carbon that stored in *Macaranga gigentia* much greater than *Adinandra dumosa* since the highest DBH recorded by *Macaranga gigentia* was 20.3 meter and height 11.1 meter.

This situation had been reported when primary forest sustained 50 percent carbon compared to secondary forest because primary forest has higher of DBH compare to secondary forest (Ngo et al., 2013). Therefore, DBH considered as an important factors in determining carbon stock since most of carbon stock equation use DBH as one of the parameter.

However, total number of trees indicate the amount of carbon stored because total number of *Macaranga gigentia* more than *Adinandra dumosa*. Therefore, more trees should be conserving to sustained carbon balance in the atmosphere. Carbon balance means total carbon output equal to carbon stored.

Table 4 Total of carbon stock for each species

Species	Family	Frequency	Carbon (kg)
Macaranga gigentia	Euphorbiaceae	28	2560.498
Adinandra dumosa	Theaceae	17	391.587
Total		45	4125.518

There is significant different of mean carbon stock between these two species (Table 5). It found that *Macaranga gigentia* standard deviation is higher compared to *Adinandra dumosa* species. Therefore, this study revealed *Macaranga gigentia* stored more carbon from *Adinandra dumosa*.

Table 5 Comparison of carbon stock between *Macaranga gigentia* and *Adinandra dumosa* using T-Test analysis by SPSS

Species	N	Carbon stock Mean (SD)	Statistic (df)	p-value
Macaranga gigentia	28	91.45 (68.79)	3.822 (43)	< 0.001
Adinandra dumosa	17	23.03 (33.52)	4.462 (41)	< 0.001

5. Conclusion and Suggestion

There are a lot of pioneer species emerged after one area was disturbed. *Macaranga gigentia* and *Adinandra dumosa* only two pioneer species that were selected for this study in order to identify contribution of these two species in absorbing carbon and stored as biomass. Trees with large DBH stored more carbon compare to small DBH. It showed by *Macaranga gigentia* that stored 2560 kg C however *Adinandra dumosa* only 391 kg C.

Conversely, total carbon stock from these two species still low compare to carbon stock from primary forest where contain climax trees. However, since land use and land cover change occurred in Malaysia, most of the urban area consist of these two species which fast growing and can retain carbon very rapid. Therefore, conservation of these two species in an urban area very important to reduce global warming, later reduce amount of carbon in the atmosphere.

Further studies regarding carbon stock should consider about soil and not only specific to trees. Because most of carbon was stored in soil after one area disturbed. Therefore in measuring carbon stock in trees, data from carbon stock in soil also important and will reveal carbon balance in one of an ecosystems.

Note

1. Deforestation is a situation where forest or any green area had been cleared and change to non-forest use such as agriculture.
2. Forest degradation where forest area reduced impact from deforestation.
3. Astringent is a chemical that has been found in *Dillenia suffruticosa* which help in shrinking body tissues.

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