JOURNAL OF THE FACULTY OF FORESTRY ISTANBUL UNIVERSITY
İSTANBUL ÜNİVERSİTESİ ORMAN FAKÜLTESİ DERGİSİ
ISSN: 0535-8418 e-ISSN: 1309-6257
Available at http://dergipark.ulakbim.gov.tr/jffiu Research Article

Soil respiration and carbon dynamics under different densities of *Shorea peltata* Sym. in Tenggaroh Forest Reserve, Malaysia

Musalam Mohammed Abdalmoula [1*], Mohamad Azani Alias [2], Mohamad Zaki Hamzah [2], Ahmad Ainuddin Nuruddin [3]

[1] Istanbul University, Faculty of Forestry, Department of Soil Science and Ecology, Sarıyer, Istanbul, Turkey
[2] University of Putra Malaysia, Faculty of Forestry, Department of Forest Production, Kuala Lumpur, Malaysia
[3] University of Putra Malaysia, Faculty of Forestry, Department of Forest Management, Kuala Lumpur, Malaysia

[*] **Corresponding author e-mail:** abdalmoulam@gmail.com

Received: 13 November 2014 - **Revised:** 25 November 2014 - **Accepted:** 26 November 2014

Abstract: A field experiment was conducted in Tenggaroh Forest to compare soil respiration and carbon dynamic under different densities of *Shorea peltata*. The objectives of this study were: to investigate soil respiration under different site characteristics of *Shorea peltata* and to determine the relationship between soil respiration and soil physical properties. Twenty observational plots 50x50 m namely, rare (E1), low (E2), moderate (E3) and high (E4) were established. Each plot was divided into 25 subplots. Five subplots were selected randomly. Soil respiration characteristics were recorded used LCpro+ instrument at 0 to 6 cm depth. The results of soil respiration and carbon dynamics showed significant differences at $P<0.05$ among the groups. Analysis for the relationship between soil respiration and site variables (correlation) showed that the soil temperature, total of carbon, total of nitrogen and available of sulphur were the important factors in the distribution of vegetation in study sites.

Keywords: Soil respiration, carbon dynamics, *Shorea peltata* sym., soil temperature, nitrogen, available sulphur

Tenggaroh-Malezya ormanındaki farklı sıklıkta *Shorea peltata* Sym. altında toprak solunumu ve karbon dinamiği

Özet: Bu çalışma, Malezya Tenggaroh Ormanı'nda gerçekleştirilmiştir. Çalışmanın amaçları, farklı sıklıktaki *Shorea peltata* sym. altında toprak solunumunun araştırılması, toprak solunumu ve toprağın fiziksel ve kimyasal özellikleri arasındaki ilişkinin belirlenmesidir. Yirmi adet 50x50 m boyutunda (E1) nadir, (E2) düşük, (E3) orta ve (E4) yüksek sıklıkta deneme alanları oluşturulmuştur. Her deneme alanında 25 alt parsel ayrılmıştır. Toprak solunumu LCpro+ cihazı ile 0-6 cm derinlikte ölçülmüştür. Toprak solunum ve karbon dinamiklerinin sonuçları gruplar arasında $P<0,05$ önem düzeyinde anlamlı farklılık göstermektedir. Toprak solunumu ve çevresel değişkenleri (korelasyon) arasındaki ilişki için analiz edilen toplam karbon, azot ve kükürt dinamiği dağılımında önemli faktörler olduğunu göstermektedir.

Anahtar Kelimeler: Toprak solunumu, karbon dinamiği, *Shorea peltata* sym., toprak sıcaklığı, azot, mevcut kükürt

1. INTRODUCTION

Tropical rainforests play an important role in the global ecosystem functioning and human existence is paramount. Unparalleled in terms of their biological diversity, tropical rainforests are a natural reservoir of genetic diversity which offers a rich source of medicinal plants, high-yield foods, and a myriad of other useful forest products. They are an important habitat for migratory animals and sustain as much as 50 percent of the species on earth as well as a number of diverse and unique indigenous cultures. Tropical rainforests play an important role in regulating global weather in addition to maintaining regular rainfall, while buffering against floods, droughts, and erosion. They store vast quantities of carbon while producing a significant amount of the world's oxygen (Butler and Laurance, 2008). Despite their

To cite this article: Abdalmoula, M.M., Alias, M.A., Hamzah, M.Z., Nuriddin, A.A., 2015. Soil respiration and carbon dynamics under different densities of *Shorea peltata* Sym. in Tenggaroh Forest Reserve, Malaysia. *Journal of the Faculty of Forestry Istanbul University* 65(2): 17-30. DOI: 10.17099/jffiu.36524

monumental role, tropical forests are restricted to the small land area between the latitudes 22.5° North and 22.5° South of the Equator, or in other words between the tropic of Capricorn and the tropic of cancer. Since the majority of Earth's land is located north of the tropics, rainforests are naturally limited to a relatively small area. Tropical rainforest has been estimated to be about 8.2 million km^2 (Whitmore, 1998).

Soil of Malaysia is extremely rich and unique. Tropical soil respiration is an ecosystem process that releases carbon dioxide from soil via root respiration, microbial decomposition of litter and soil organic matter and fauna respiration. As one key process of ecosystems, soil respiration is related to ecosystem productivity, soil fertility, regional and global carbon cycles. Since the global carbon cycle regulates climate change, soil respiration also becomes relevant to climate change, carbon trading, and environmental policy. It is a crucial piece of the puzzle that is the earth’s system. To understand how the earth’s system functions, we need to figure out the role that soil respiration plays in regulating atmospheric concentration and climate dynamics. Soil respiration rates can be largely affected by human activity. This is due to the fact that humans have the ability to change the various controlling factors of soil respiration for numerous years. Global climate change is composed of numerous changing factors including rising atmospheric, increasing temperature and shifting precipitation patterns. All of these factors can affect the rate of global soil respiration. Soil respiration and its rate across ecosystems are extremely important to understand. This is because soil respiration plays a large role in global carbon cycling as well as other nutrient cycles. The respiration of plant structures releases not only CO_2 but also other nutrients in those structures such as nitrogen. Soil respiration is also associated with positive feedbacks with global climate change. Positive feedbacks are when a change in a system produces response in the same direction of the change. Therefore, soil respiration rates can be affected by climate change and then respond by enhancing climate change (Mikan et al., 2002).

In tropical rainforests, soil temperature is the main determinant of soil respiration and soil water has little effect (Schlentner and Van Cleve, 1984). Soil respiration stops during freezing winter. In temperate forests, both soil temperature and soil water control soil respiration. Soil respiration changes seasonally with soil temperature and often reduces with decreasing of soil water during the summer (Dong et al., 1998). Soil respiration is relatively high during the rainy season and low during the dry season, although inter annual fluctuations are large. Soil moisture is widely different between the dry and wet seasons, while soil temperature changed little throughout the year. The concentration of CO_2 in the atmosphere is rising due to human activity. Soil respiration is one of the largest elements of carbon cycling in forests, so the accurate measurement of soil respiration is essential for understanding the carbon cycle in forest ecosystems.

As mentioned above, there are many studies on soil respiration in tropical and temperate forests. However, despite the large C efflux from soil in tropical forests (Malhi and Grace, 2000) there are few reports on soil respiration in tropical forests compared with other climate regions (Keller et al., 1988), especially for Southeast Asia. Also, there are so many types of tropical forests; various structures, diversities of species and climate compared with boreal and temperate forests (Whitmore, 1990).

2. MATERIALS AND METHODS

2.1 Description of study area

The project was conducted at Tenggaroh Forest Reserve in Mersing, Johor. Johor is located at 59 m above sea level and at latitude 2º 14’0’ N and longitude 103º 55’0’ E. Tenggaroh its approximately 25 km from Kota Tinggi and 15 km from Jemaluang Forest Reserve (Trocki, 1979). Tenggaroh Forest Reserve has been regazetted from Jemaluang Forest Reserve under the protected area programme (IUCN) and some part of this area was logged over on for timber production and silvicultural treatments have been done (Figure / Şekil 1).

2.2 Climatic characteristics of study area

The meteorological data about the study area were taken from Tenggaroh Forest Reserve in Johor. Climatically, Johor has a tropical rainforest with monsoon rain from November until February blowing from the South China Sea. The average annual rainfall is 1778 mm with average temperatures ranging between 25.5°C to 27.8°C. Humidity is between 82 and 86% (Johor State Forestry Department). Monthly means of the air temperature, humidity, wind speed and rainfall are shown in (Table / Tablo 1).

Figure 1. Location of the study area at Johor (Google maps, 2014)
Şekil 1. Çalışma alanının konumu (Google maps, 2014)

Table 1. Climatic elements in Tenggaroh Forest Reserve, Johor (2000 – 2008) (Johor State Forestry Department)
Tablo 1. İklim verileri (2000 – 2008) (Johor State Forestry Department)

	Air temperature (°C)		Humidity (%)	Wind speed (m/s)	Rainfall (mm)	
Month	**Max**	**Min**	**Mean**	**Mean**	**Mean**	**Total**
January	29	23	26.0	87.20	2.10	393.22
February	30	23	26.1	86.10	1.20	215.30
March	31	23	27.0	85.20	1.10	151.10
April	31	24	27.1	85.10	0.82	130.40
May	32	24	28,0	85.38	1.57	88.72
June	31	24	27.1	84.80	0.78	91.41
July	31	24	27.0	84.55	0.82	95.20
August	31	24	27.0	84.20	0.75	74.10
September	30	24	27.0	85.25	0.66	130.09
October	31	25	28.0	86.20	0.70	185.10
November	31	23	27.0	85.48	0.92	430.20
December	30	23	26.0	88.50	1.20	650.00
Means	31	24	27.1	86.30	1.40	2614.75

2.3 Soils of the study area

Tenggaroh Forest Reserve is typically of lowland health forest with the vegetation cover of 30 m high as described by Wyatt-Smith (1961). The soil types in Tenggaroh Forest Reserve are classified as of range series, which belong to the histosols orders and brownish, yellow (Figure / Şekil 2), with and of moderate to highly fertile and acidic.

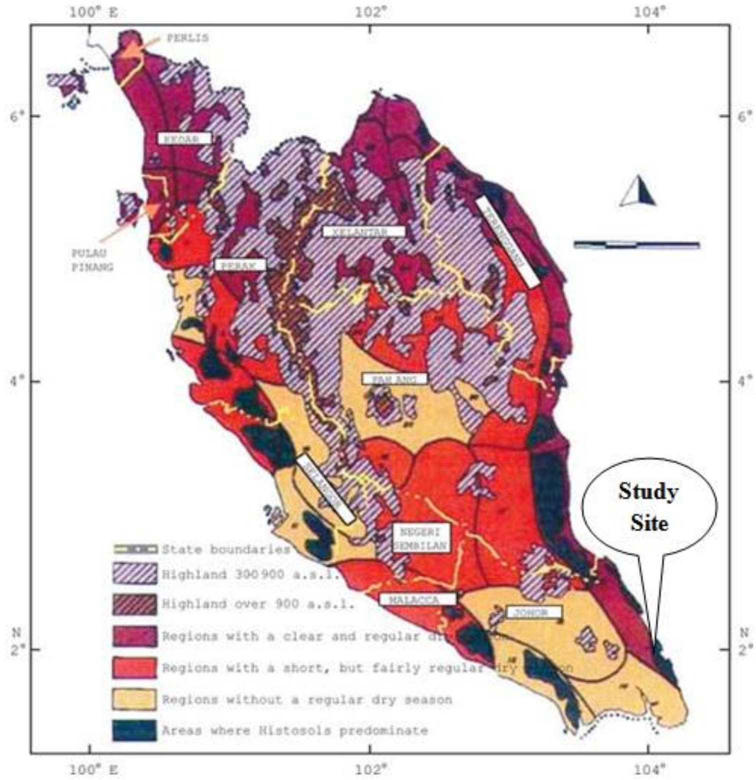


Figure 2. Soil series map of Tenggaroh District of Johor (Google maps, 2014)
Şekil 2. Johor-Tenggaroh bölgesi of toprak haritası (Google maps, 2014)

2.4 Vegetation of the study area

Tenggaroh Forest Reserve is typically of lowland forest ranging from 300 to 750 m of altitudes with the vegetation cover of less than 40 m high. The most common species in these altitudes forest are Dipterocarpus. Dipterocarpaceae is a family of 17 genera and approximately 500 species of mainly tropical lowland rainforest trees. The largest genera are Shorea (196 species), Hopea (104 species), Dipterocarpus (70 species) and Vatica (65 species). Many are large forest emergent species, typically reaching height of 40 to 70 m tall, some even over 80 m in the genera Dryobalanops, Hopea and Shorea with the tallest known living specimen (*Shorea faguetiana*) 88.3 m tall. The species of this family are of major importance in the timber trade (Ashton, 1998). Their distribution is pan tropical, from northern South America to Africa, the Seychelles, India, Indochina and Malaysia, with the greatest diversity and abundance in Borneo. North Borneo (Brunei, Sabah and Sarawak) is the richest area in the world for dipterocarp species (Dayanandan et al., 1999).

2.5 Methods

2.5.1 Experimental design

Twenty observational plots of vegetation samples (releves) with each size 50 m x 50 m about (5 ha) were laid out randomly in several points in different density of *Shorea peltata* in compartment 135 and 136 of Tenggaroh Forest Reserve, Johor (Figure / Şekil 3).

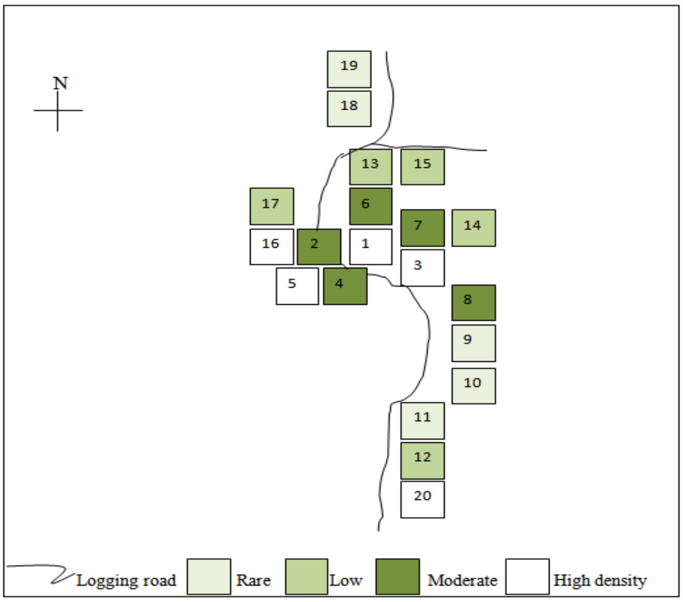


Figure 3. The layout of experiment plots
Şekil 3. Deney alanları düzeni

From these twenty plots, 100 samples were sellected for the analysis of soil respiration, soil properties and environmental factors. Preliminary survey of the study area (Observational plot), were established to measure the sample plots of the project. Plots were established in this area on 27 July 2008, data were collected from 23 July 2008 to 30 June 2009. The peculiar arrangement and placement of the plots were made base on the distribution of *Shorea peltat*a species in Tenggaroh Forest Reserve as an endemic species to provide the relationship between *Shorea peltata* species and soil respiration under tropical rain forest.

2.5.2 Plot design

Size of each plot was 50 m x 50 m, divided in to 25 subplots Q (Figure / Şekil 4). Five subplots were chosen in each plot. Due the size of plot and for easy analysis among plots and replications and to avoid missing of data and to minimize and maximize values observed in each plot, an observational study of plot was done to control the enumeration works and to get actual information for all parameters. An observational study of plot in statistics draws inferences about the possible effect of a treatment on subjects. Also it helps in observing more subjects that perform a task with the intention of describing and comparing particular aspects of their performance and information (Paul, 2002).

For the subplots, plots with size of 10 m x 10 m, consisting of different density of *Shorea peltata* species were constructed. Data were collected randomly (Figure / Şekil 5). Five replications of soil samples, environmental factors, and soil respiration data in each plot were collected. Hundred percent surveys were conducted in the subplot to identify soil community and soil respiration information under different density of *Shorea peltata* in the plot and the species occurs.

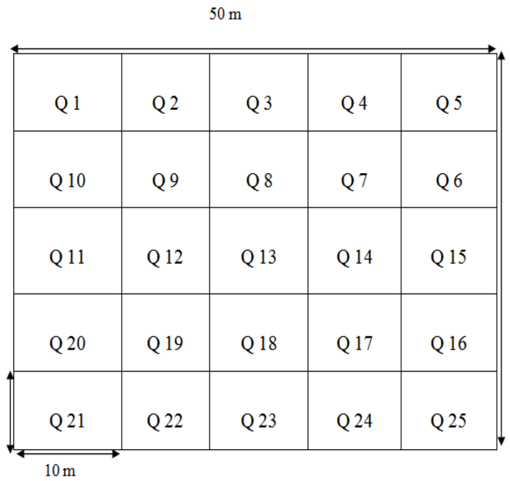


Figure 4. Details of experimental design for plot - Q = Quadrate (10 m x 10 m)
Şekil 4. Deney alanları tasarım detayları

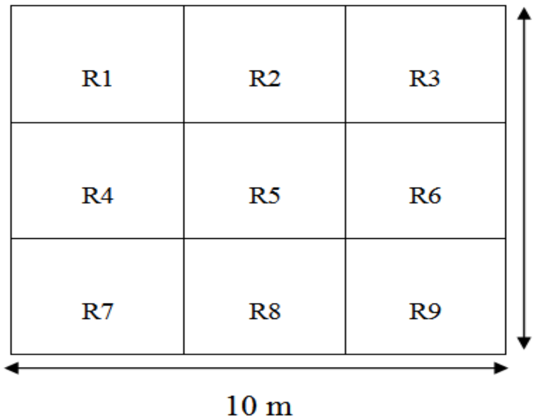
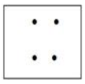
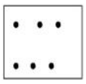
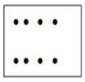
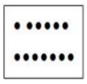


Figure 5. Detail layout experimental design for subplot - Were R is replicate
Şekil 5. Alt parsel deney alanları tasarım detayları

Preliminary investigation of the study area observed that the distribution of *Shorea peltata* was different in term of its abundance from site to site. It was also observed that in certain localities, the abundance of this species were not very high while it was rare to none in others. Because of this, the establishment of vegetation was based on the abundance of *Shorea peltata* as rare, low, moderate and high density followed by coverage degree – abundance using the community parameters: (Ter Braak and Verdonschot, 1995) of the species in each layer as shown in (Table / Tablo 2).

It is based on information theory and is a measure of the average degree of "uncertainty" in predicting to what species an individual chosen from a collection of *Shorea peltata* species. All the twenty (releve’s) were divided into four groups namely rare, low, moderate and higher density; each group consisted equal five plots. The size of each (releve’s) corresponded to the height of the forest stand and tree (Fujiwara, 1987).

Table 2. Distribution of *Shorea peltata* species among groups of density
Tablo 2. Sıklık grupları arasında *Shorea peltata* türlerinin dağıtımı

Plots	Density of *Shorea peltata*	Size of plots	Releve's
	Rare (E1) < 20 trees	50 x 50 m 2500 m^2	09, 10, 11, 18, 19
	Low (E2) 21-40 trees	50 x 50 m 2500 m^2	12, 13, 14, 15, 17
	Moderate (E3) 41-60 trees	50 x 50 m 2500 m^2	02, 04, 06, 07, 08
	High (E4) >61 trees	50 x 50 m 2500 m^2	01, 03, 05, 16, 20

2.5.3 Soil respiration

Closed Dynamic Chamber (CDC) Method was used to measure the soil respiration, net CO_2 and exchange of delta 14. It is used by covering an area of ground surface and meanwhile allows air to circulate in a loop between the chamber and a CO_2 detecting sensor (IRGA) infrared gas analyzer during the measurement. Once a closed chamber covers the soil surface, the CO_2 concentration in the chamber rises, due to release of CO_2 from beneath the soil surface. The rate of CO_2 increase is proportional to the soil CO_2 efflux. Soil respiration is measured using LCpro+ Infrared Gas IRGA instrument (Figure / Şekil 6). Soil respiration chamber is specifically designed for short term soil flux measurements. The chamber consists of a lower stainless steel collar and an upper measurement compartment (Davidson et al., 2002). Time of measurement in each plot was 9:00 am to 5:00 pm monthly. Soil was collected in rings depth of 6 cm soil (Tang et al., 2005) for duration of two hours; recording of information were done by replicating the records, meanwhile of measurement the data were stored.

Figure 6. Soil respiration measurement (SR2000 Intelligent Portable Soil Flux System)
Şekil 6. Toprak solunum ölçümü (SR2000 Taşınabilir toprak solunum ölçüm sistemi)

2.5.4 Soil samples

Soil samples were taken from the exciting field of study from two layers of each sample (releves) at depth of (0 – 10 cm) used core-ring for soil properties analysis such as C, N and S (Figure / Şekil 7).

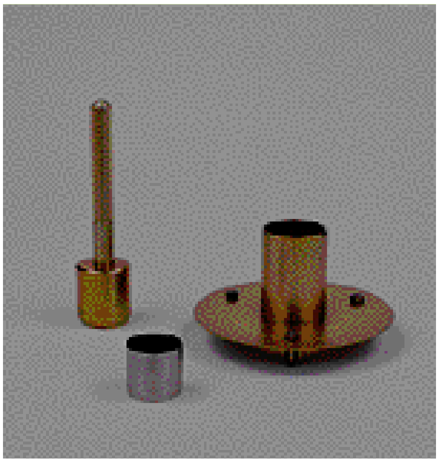


Figure 7. Core-ring used for soil samples
Şekil 7. Toprak örneklerinin alınmasında kullanılan silindir halkalar

2.2.5 Soil temperature

Soil temperature was recorded using Digital Soil Thermometer. This handy digital thermometer allows to quickly measure soil's temperature with turning it on and pushing the probe into the soil reading soil's temperature (Figure / Şekil 8).

Figure 8. Soil temperature measurement
Şekil 8. Toprak sıcaklığı ölçümü

2.2.6 Descriptive analysis

The data analysis is based on the data location for a period of eleven months. Descriptive analysis is employed to explore the data and to show the sample distribution. It is also employed to evaluate the data and to show the forms of samples distribution. Real distribution represents numbers of real values in classes of frequencies and percentage (Dennis et al., 2002). Descriptive statistics such as frequency means, standard error, maximum and minimum values were applied to present and summarize the data. Standard error was applied to calculate the error of any particular sampling distribution of the sample means. Also community parameter (Ter Braak and Verdonschot, 1995) was followed to cover and estimate the density of *Shorea peltata* species in the plots. Descriptive method was used to make general observation about the data.

2.2.7 Analysis of variance (Anova)

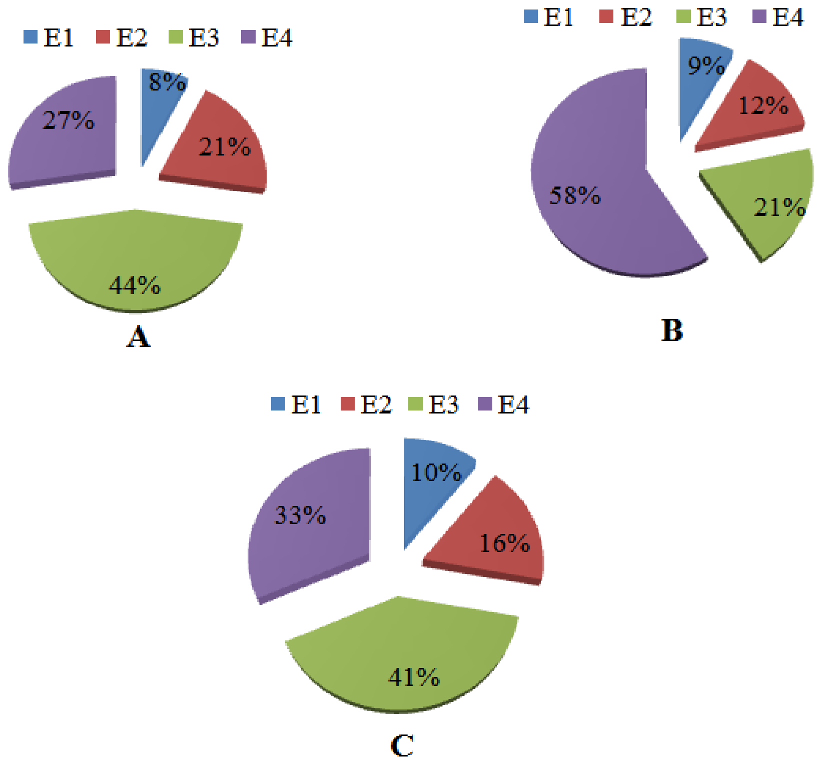
ANOVA is used in this case to test the hypothesis for differences between more than two independent sample descriptions (Bachman and Paternoster, 1997). Anova was used in this study to compare and determine the significant differences based on the quantitative data recorded between the density means in soil community under different density of *Shorea peltata* species. SAS programme for correlation (Proc Corr.) was also used to determine the strength of the association between the soil properties and soil respiration community for the study sites.

3. RESULTS AND DISCUSSIONS

Results were discussed by comparing each groups of releve’s, namely rare density / control (E1), low density (E2), moderate density (E3) and high density (E4) of *Shorea peltata* species.

3.1 *Shorea peltata* species

Result from the enumeration and identification of the types of *Shorea peltata* species, revealed that there are different stages of *Shorea peltata* in Tenggaroh Forest Reserve, namely (A) dominant trees, (B) understory trees and (C) shrub trees (Figure / Şekil 9). *Shorea peltata* species were classified as an endemic species. Endemic type or species are especially likely to develop on islands because of their geographical isolation.



Where E1 rare density, E2 low density, E3 moderate density, E4 high density

Figure 9. Percentage of *Shorea peltata* types by density groups, Tenggaroh Forest
Şekil 9. Tenggaroh ormanında *Shorea peltata* türlerinin sıklık gruplarına dağılımı

The most dominant trees were higher within group E3 moderate density 44%, followed by E4 high density 27%, while the percentage of understorey trees were observed to be higher within E4 than E3. However, the percentage of shrubs layer were higher within E3 41% than E4 33% (Figure / Şekil 9). The percentages are depended on the distribution of *Shorea peltata* species on each releves. The mean values of total number of individuals for *Shorea peltata* are showed in (Table / Tablo 3).

Table 3. F and P values of total individual numbers of (*Shorea peltata sym*)
Tablo 3. F ve P değerleri (*Shorea peltata sym*)

Groups	E1	E2	E3	E4	F value	P value
Total no of individuals	290a	308a	310a	322a	0.781	0.553
Total no of *Shorea peltata*	13.0	23.0	41.0	72.2	4.900	0.001
Percentage of *Shorea peltata*	4.00	7.82	14.53	22.67	3.120	0.003
Forest layers						
Dominant (T1)	72.00	70.20	67.40	65.40	0.011	0.950
Understory (T2)	106.30	110.00	109.20	108.20	0.131	0.622
Shrub (S)	106.10	103.30	108.90	101.20	0.900	0.660

3.2 Soil respiration and soil temparture

The description of mean values for soil respiration and soil temprature were summarized in (Table / Tablo 4). The high mean value of soil respiration observed at group E3 was 33.93 gcm^{-2}, followed by group E1 27.50 gcm^{-2} and group E2 25.68 gcm^{-2}, while observation in group E4 was 20.20 gcm^{-2}. Analysis shows a significant differences at $P<0.05$ (F. value 15.89 and P. value 0.000), this is because there was a much differences on environmental factors which are the most sources for soil respiration and effects almost all aspects of respiration processes. The differences between environmental factors such as air temperature, soil temperature and moisture content on soil can make differences in soil respiration through microorganism activities (Buchmann, 2000; Longdoz et al., 2001). Meanwhile, description of soil temperature it's observed that there is no significant difference at $P<0.05$ among groups except group E1. The high mean value observed in group E4 was (34.52ºC) followed by group E3 (34.12ºC) and group E2 (34.06ºC). Meanwhile, in group E1 it was observed that the mean value was (33.34ºC).

Table 4. Descriptive summary for soil respiration and soil temperature among density
Tablo 4. Gruplar arasında toprak solunumu ve toprak sıcaklığı değerleri

Group	Parameters	Plots for each density					Mean	SE
		TF09	**TF10**	**TF11**	**TF18**	**TF19**		
E1	Soil respiration (g cm^{-2})	33.16	10.80	24.18	48.18	21.20	27.50	5.201
	Soil temperature (C°)	33.10	33.90	33.30	33.31	33.10	33.34	2.345
		TF12	**TF13**	**TF14**	**TF15**	**TF17**		
E2	Soil respiration (g cm^{-2})	24.00	26.46	16.46	31.18	30.43	25.68	2.864
	Soil temperature (C°)	33.80	34.81	33.81	33.80	34.10	34.06	2.371
		TF2	**TF4**	**TF6**	**TF7**	**TF8**		
E3	Soil respiration (g cm^{-2})	16.41	25.50	38.28	54.66	34.18	33.93	5.321
	Soil temperature (C°)	34.71	34.62	33.70	34.63	32.90	34.12	2.383
		TF1	**TF3**	**TF5**	**TF16**	**TF20**		
E4	Soil respiration (g cm^{-2})	17.46	23.46	29.32	19.56	11.24	20.20	2.885
	Soil temperature (C°)	34.21	33.11	35.20	34.22	35.90	34.52	2.402

Where E1= Relev'e group for rare density of *Shorea peltata* species, E2= Relev'e group for low density of *Shorea peltata* species, E3= Relev'e Group for moderate density of *Shorea peltata* species, E4= Relev'e group for high density of *Shorea peltata* species, and SE = Standard error.

Comparison of mean values for soil respiration and soil temperature among groups which do not show any significant differences at $P<0.05$ (Table / Tablo 5). The result for soil temperature in this study sites were observed to be between 32.5 ºC to 36.0ºC and it is classified as best rates that can make microbiological activity which is the most important source of soil respiration (Soepadmo and Kira, 1977).

Table 5. Comparison of mean values for soil respiration and soil temperature among groups
Tablo 5. Gruplar arasında toprak solunumu ve toprak sıcaklığı ortalama değerlerinin karşılaştırılması

Parameters	Releves				F. value	P. value
	E1	E2	E3	E4		
Soil respiration (g cm^{-2})	27.50a	25.68a	33.93a	20.20a	15.89	0.000
Soil temperature (°C)	33.34a	34.06b	34.12b	34.52b	2.40NS	0.141

Soil temperature plays an important role in many processes, which take place in the soil such as chemical reactions and biological interactions. Soil temperature varies in response to exchange processes that take place primarily through the soil surface. These effects are propagated into the soil profile by transport processes and are influenced by such things as the specific heat capacity, thermal conductivity and thermal diffusivity (Zhang et al., 2002).

Every biological process needs an optimum temperature to get accomplished. A maize seed germinates only at a temperature range of 7 to 10 Cº (Mikan et al., 2002) and most of the soil microbes function best at 25 to 35 Cº (Fierer et al., 2003). Soil gets heated up mainly due to solar radiation and its temperature is highly influenced by the amount of solar radiation received by the soil which in turn depends on the climate of the region. The amount of sunlight reaching the soil again depends on the slope of the land. For example, if the land is in particular slope gradient, then the amount of solar radiation striking the unit volume of land decreases as the slope increases. This is not the case in the leveled land where each unit area of land receives equal proportion of solar radiation. Soil temperature also depends on the vegetation cover of the land. A barren land gets heated up faster and cools up at a rapid rate whereas in a land covered with vegetation which acts as an insulation barrier, soil temperature remains near optimum. Soil color also influences the temperature as seen in darker soils that absorb more solar radiation than a light colored soil (Noble, 2005).

3.3 Soil chemical properties

Soil chemical properties were such as total of soil carbon (C), total of nitrogen (N), and available sulphur (S) were summarized in (Table / Tablo 6).

Table 6.Total of soil carbon, nitrogen and availabe sulphur among density groups
Tablo 6. Yoğunluk grupları arasında toplam toprak karbonu, azot ve kükürt miktarları

Group	Parameters	Plots for each density					Mean	SE
E1		**TF09**	**TF10**	**TF11**	**TF18**	**TF19**		
	Total of soil carbon (%)	8.433	11.91	7.307	6.071	11.57	9.061	1.427
	Total of nitrogen (%)	0.049	0.046	0.045	0.045	0.048	0.046	0.001
	Available sulphur (%)	0.546	0.559	0.552	0.556	0.596	0.561	0.002
E2		**TF12**	**TF13**	**TF14**	**TF15**	**TF17**		
	Total of soil carbon (%)	5.809	7.263	11.96	11.58	10.05	9.336	1.706
	Total of nitrogen (%)	0.048	0.050	0.050	0.042	0.043	0.046	0.003
	Available sulphur (%)	0.461	0.670	0.569	0.583	0.535	0.563	0.021
E3		**TF2**	**TF4**	**TF6**	**TF7**	**TF8**		
	Total of soil carbon (%)	10.05	5.187	14.10	5.958	9.159	9.019	2.001
	Total of nitrogen (%)	0.053	0.044	0.059	0.059	0.049	0.052	0.000
	Available sulphur (%)	0.681	0.588	0.632	0.536	0.618	0.160	0.001
E4		**TF1**	**TF3**	**TF5**	**TF16**	**TF20**		
	Total of soil carbon (%)	0.248	8.838	7.061	5.178	9.728	6.210	1.786
	Total of nitrogen (%)	0.095	0.041	0.043	0.042	0.051	0.054	0.002
	Available sulphur (%)	0.838	0.546	0.541	0.583	0.599	0.530	0.000

The analysis of variance (Anova) for the data for the total of soil carbon shows no significant difference among group at $P<0.05$ (Table / Tablo 6). The mean value also shows that there is no significant difference among groups, the high value was observed in group E2 (9.336%), followed by group E3

(9.245 %) and group E1 (9.061%), while in group E4 was observed to be 6.210% with, F. value as 2.461 and P. value as 0.266 (Table / Tablo 7).

Meanwhile, results for the total of nitrogen in the soil at (0 – 15 cm) depth also suggest that concentration was not significantly different at ($P<0.05$) among the groups. Total of nitrogen was not significantly higher as compared within groups (Table / Tablo 6). The mean value shows that there is no significant difference at $P<0.05$. The highest mean value observed was in group E4 (0.054 %), followed by group E3 (0.052%), while in group E2 and E1 the values recorded was 0.046% (Table / Tablo 7).

Result from descriptive analysis for sulphur summarized in Table / Tablo 6 observed that there is no significant difference among density groups. Analysis of variance showed that there is no significant difference at $P<0.05$ among group. The high mean value observed was in group E2 (0.563%), followed by group E1 (0.561%) and group E4 (0.530%), while in group E3 was observed to be 0.160 % (Table / Tablo 7).

Table 7. Comparison of mean values for C, N and S among groups
Tablo 7. Gruplar arasında K, N ve S karşılaştırması

Parameter	**Releves**				**F. value**	**P. value**
	E1	**E2**	**E3**	**E4**		
Total of soil carbon (%)	9.061a	9.336a	9.245a	6.210b	2.46ns	0.266
Total of nitrogen (%)	0.046a	0.046a	0.052a	0.054a	0.97ns	0.452
Available sulphur (%)	0.561a	0.563a	0.160a	0.530a	2.88ns	0.381

3.5 Co-relationship between soil respiration and site characteristics

The correlation analysis results of 20 plots based on presence and absence of 100 samples is shown in (Table / Tablo 8). The groups of plots were defined by using different codes. A clear segregation was evident between soil respiration of plots in Group E1, E2, E3 and E4. There was some segregation on site variables and between the four groups of density. The different values of Pearson’s correlation for the first four variables (E1, E2, E3, and E4) were poorly related to respiratory characteristics, i.e. 26.40, 27.36, 32.20 and 21.10 respectively. The cumulative variance of soil respiration characteristics relation resulting from two groups is 58.60 % (Table / Tablo 8).

Table 8. Correlation coefficients between the density groups and variables of samples (r= 20)
Tablo 8. Yoğunluk grupları ve örneklerin değişkenler arasındaki korelasyon katsayıları

Variables	**E1**	**E2**	**E3**	**E4**
Soil respiration values	26.40	27.36	32.20	21.10
Site Variables	**R**			
Total of soil carbon	0.050	0.056	-0.076	0.036
Total of nitrogen	0.055	0.128	0.034	0.255
Available sulphur	0.124	0.281	0.105	-0.001
Soil temperature	0.801	0.856	0.407	0.751

Out of 20 environmental variables taken in this study, the result from SAS Correlation showed that only 2 factors were the most influential on the distribution of respiration in Tenggaroh Forest Reserves as shown in (Table / Tablo 8). First group was strongly correlated with soil temperature (r= 0.801) and available sulphur (r= 0.124). Second group correlated were soil temperature (r= 0.856), available sulphur (r= 0.281) and total of nitrogen (r= 0.128). In contrast, two variables had a negative correlation with group E3 via total of soil carbon (r= -0.076) and available sulphur in group E4 (r= -0.001).

Correlation showed that the soil temperature and available sulphur in the first group were contributed in separating the samples. However, based on the correlation coefficient values, it can be postulated that soil temperature and available sulphur makes the greatest contribution in determining the variation in the structural composition of the forest communities in the research area.

The relationship between soil respiration distribution with soil properties and environmental variables is important to consider the scale at which the variables are measured. However, conclusion obtained at one scale may not be valid at another scale suggesting that there exists a small-scale process for the large amount of unexplained variation in plot data sets. The effects of processes such as competition may not be detected by a broad-scale study, although it would be found at a finer scale.

Comparison of the correlation between groups shows that the most variables were found positive, however total of soil carbon was correlated negatively with group E3 (r= -0.076) and positively correlated with EI (r= 0.050). Other most important factor influencing the distribution of soil respiration was total of nitrogen. The SAS Correlation analysis also implies soil temperature and available sulphur were highly correlated with group EI (soil temperature r= 0.801, availble sulphur r= 0.124), showing that it is the most influencing factor in respiratory distribution in this study area.

4. CONCLUSION

As a natural forest, soil respiration was very high in the study area and it is known that soil respiration increases with temperature. Soil respiration is mostly affected by soil temperature. Soil temperature in this study site was observed to be between 32.5 ºC – 36.0ºC and it is classified as the best rates of the activity of soil microbes (Soepadmo and Kira, 1977).

The study suggested that the distribution of *Shorea peltata* in Tenggaroh Forest Reserve was mainly influenced by the soil characteristic and environmental factors. Soil temperature had a strong relationship with the distribution of *Shorea peltata*. The best performance of *Shorea peltata* in Tenggaroh Forest Reserve is probably accounted from the soil characteristics of the reserve area. This study contributes not only to soil respiration characteristics, but also for soil as basic unit of natural environment and various scientific studies. The study site was characterized as a lowland forest ranging from (300 – 750 m) of altitudes. The importance of altitudes however does not imply a clear predictor for the diversity within a small area as that used during in the present study.

ACKNOWLEDGEMENTS

I would like to gratefully and sincerely thank Prof. Dr. Mohamad Azani Alias for his guidance, understanding, patience, and most importantly his friendship during my graduate studies at UPM. I would like also to thank Prof. Dr. Mohmad Zaki and Prof. Dr. Ahmad Ainuddin Nuruddin and the rest of department of analytical services for their hard work, expertise and patience.

The research was funded by Tenggaroh Forest Reserve Department and University Putra Malaysia (UPM), Faculty of Forestry, Soil Science Department and was submitted to the Senate of University Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master science. Website for Master Thesis: http://psasir.upm.edu.my/19498/1/FH_2010_8_F.pdf

REFERENCES

Ashton, P.S., 1998. *Dipterocarpaceae*. In E. Soepadmo,L.G. Saw,and R.C.K. Chung (Eds.). *Tree Flora of Sabah and Sarawak*. Government of Malaysia, Kuala Lumpur, Malaysia.

Bachman, R., Paternoster, R., 1997. *Statistical Methods for Criminology and Criminal Justice* (2^{nd} ed.) New York: MCGraw-Hill Company.

Buchman, N., 2000. Biotic and abiotic factors controlling soil respiration rates in *Picea abies* stands. *Soil Biology and Biochemistry* 32: 1625-1635.

Butler, R., Laurance, W., 2008. New strategies for conserving tropical forest. *Trends in Ecology and Evolution* 23: 469-472.

Dayanandan, S., Ashton, P.S., Williams, S.M., Primack, R.B., 1999. Phylogeny of the tropical tree family *Dipterocarpaceae* based on nucleotide sequences of the chloroplast RBCL gene. *American Journal of Botany* 86: 11-82.

Dennis, E.H., William, W., Stephen, G.J., 2002. Applying statistical concepts. In P.R. Anant (Ed.). *Applied Statistical for the Behavioral Sciences* (pp. 5-10). USA: New York, Houghton Mifflin Harcourt.

Dong, Y., Scharffe, D., Lobert, J.M., Crutzen, P.J., Sanhueza, E., 1998. Fluxes of CO_2, CH_4 and N_2O from a temperate forest soil, the effects of leaves and humus layers. *Tellus* 50: 243-252.

Fierer, N., Allen, A.S., Schimel, J.P., Holden, P.A., 2003. Controls on microbial CO_2 production, a comparison of surface and subsurface soil horizons. *Global Change Biology* 9: 1322- 1332.

Fujiwara, K., 1987. Aims and methods of phytosociology of vegetation science. *Plant Ecology and Taxonomy* 5: 606-628.

Keller, M., Kaplan, W.A., Wofsy, S.C., Dacosta, J.M., 1988. Emissions of N_2O from tropical forest soilsand response to fertilization. *Journal of Geophysics Research* 93: 1600-1604.

Longdoz, B., Yernaux, M., Aubinet, M., 2001. Soil CO_2efflux measurements in a mixed forest: impact of chamber disturbances, spatial variability and seasonal evolution. *Global Change Biology* 6: 907-917.

Malhi, Y., Grace, J., 2000. Tropical forests and atmospheric carbon dioxide. *Plant Cell and Environment* 22: 715-740.

Mikan, C., Schimel, J., Doyle, A., 2002. Temperature controls of microbial respiration in arctic tundra soils above and below freezing. *Soil Biologyand Biochemistry* 1785-1795.

Noble, P.S., 2005. *Physiochemical and Environmental Plant Physiology* (3^{th} ed.). Amsterdam:Elsevier Academic Press.

Paul, R., 2002. Observational studies.In P. Cohn, P. Harris, W. Barry, R. Rosati, and C. Waternaux (Eds.). *Handbook of Engineering Statistics* New York: Springer-Verlag.

Schlentner, R.E., Van Cleve, K., 1984. Relationships between CO_2evolution from soil, substrate temperature and substrate moisture in four mature forest types in interior Alaska. *Canadian Journal of Forest Research* 15: 97-106.

Soepadmo, E., Kira, T., 1977. Contribution of the IBP-PT research project to the understanding of Malaysian forest ecology. In C.B. Sastry, P.B.L. Srivastava, and A. M. Ahmad (Eds.). *A New Era in Malaysian Forestry* (pp. 63-94) Kuala Lumpur, Serdang, UPM Press.

Tang, J., Xu, M., Misson, L., Goldstein, A.H., 2005. Forest thinning and soil respiration in a ponderosa pine plantation in the Sierra Nevada. *Tree Physiology* 25: 57- 66.

Ter Braak, C.J.F., Verdonschot, P.F.M., 1995. Canonical correspondence analysis and related multivariate methods in aquatic ecology. *Aquatic Science* 57: 255-289.

Trocki, A., 1979. *Prince of Pirates*: The temenggongs and the development of Johor and Singapore, 1784-1885 (pp. 125-128), Singapore: Singapore University Press.

Whitmore, T.C., 1990. An introduction to tropical rainforests. *Nordic Journal of Botany* 11: 548-560.

Whitmore, T.C., 1998. Potential impact of climatic change on tropical rainforest seedlings and forest regeneration. *Climate Change* 39: 429-438.

Wyatt-Smith, J., 1961. A note on the fresh-water swamp, lowland and hill forest types of Malaysia. *Malayan Forest* 24: 110-121.

Zhang, Y.P., Wang, J.X., Ma, Y.X., 2002. The temporal-spatial distribution of temperature on the surface roughness of the tropical secondary gap in Xishuangbanna, Yunnan Province. *Scientia Silvae Sinicae* 38: 1- 5.