B I O D I V E R S I T A S
Volume 10, Number 4, October 2009
Pages: 187-194

ISSN: 1412-033X (printed edition)
ISSN: 2085-4722 (electronic)
DOI: 10.13057/biodiv/d100405

Forest Dynamics of Peat Swamp Forest in Sebangau, Central Kalimantan

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Received: 18th March 2009. Accepted: 5th June 2009.

ABSTRACT

Forest dynamics were studied from 1999 to 2001 for individuals ≥ 15 cm in girth of 24 most common species in six 0.25-ha plots. The plots were set up in natural peat swamp forest in the upper catchments of Sebangau, Central Kalimantan. Aim of the study is to understand the dynamics and vegetation changes of forest studied during period of study. The peat swamp forest in the study site might be categorized as moderately forest dynamic in term of rate of growth, mortality and recruitment. Annual relative growth rate and mortality rate was comparable to previous study but recruitment rate relatively higher. There was significant effect of diameter class on annual growth rate, but not to mortality rate. Even not too strong two environment factors (peat depth and distance to river) were significant correlated with rate of mortality and recruitment. During two-year period study there was no significant changes in vegetation structure.

Key words: Central Kalimantan, dynamic, growth, mortality, peat swamp forest, recruitment, Sebangau.

INTRODUCTION

It was often assumed that a tropical rain forest characteristics is diversity in term of plant species and vertical and horizontal dynamics complexity. Although the coexistence among individuals of tree species whom living together have been observed (Kohyama, 1992; 1993). The dynamics of forest naturally was steady state (Kohyama et al., 2001), but impact of human activities and disturbance events might change the pattern and process of forest dynamics. Studies on forest dynamics approach have been widely used to compare the undisturbed and disturbed forests in order to evaluate the effect of disturbances.

Forest dynamics in term of rate of diameter growth, mortality and recruitment have been studied in many temperate and tropical forests with various aims and aspects. Studies on forest dynamics following impact of logging, silviculture treatment and natural disturbance (Silva et al., 1995; Pelissier et al., 1998; Graff et al. 1999; Nebel et al., 2001; Vandermeer et al., 2001; Coates, 2002; Sist et al., 2002; Olano and Palmer, 2003; Wolf et al., 2004), and based on long-term observation (Takahashi et al., 2003; Laurance et al., 2004) have been studied. In addition some studies have been also conducted on the level of population (Primack et al., 1985; Roger, 1999; Fuhr et al., 2001; Guedje et al., 2002; Sanford et al., 2003), and have been used to estimate age of forest (Martínez-Ramos and Alvarez-Buylla, 1998). Almost of those previous forest dynamics studies have been conducted in dry forest, whereas in wet forest has been reported by Visser and Sasser (1995), and also Nebel et al. (2001). Study on forest dynamics of peat swamp forest, on the other hand so far is undocumented.

Aim of the present paper is to provide information on forest dynamics and vegetation changes of natural peat swamp forest in Sebangau, Central Kalimantan, Indonesia. The forest is one of remain relatively undisturbed peat swamp forest in this area and has been declare as *Natural Laboratory of Peat Swamp Forest*. So far there have little report on forest ecological study based on some permanent plots (Rieley et al., 1996; 1997; Shepherd et al., 1997; Page et al., 1999; and Mirmanto et al., 2003). Forest dynamics were studied for individual ≥ 15 cm in girth breast height of 24 most common species in six 0.25-ha plots. The rate of growth, mortality and recruitment were calculated and compare to others studies, and the effects of related factor were described.

MATERIALS AND METHODS

Study site

The study has been done in the upper catchments of Sebangau river, which is situated at 2°18' 24" S

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and 113^{o} 55' 4.1" E, at about 10 m above sea level. This area is a small part of peat-covered landscape between Katingan river to the west and Kahayan river to the east. The study area belongs to Kereng Bangkirai village about 20-km southwest of Palangkaraya the capital city of Central Kalimantan, Indonesia. The vegetation here is characteristic of peat-swamp forest, with condition in general was flooded, especially during rainy season and with the peat layer depth varied from 2 to 10 m up. In general the condition of vegetation is a primary forest, although in some sites have been disturbed due to the selective logging.

According to Schmidt and Ferguson (1957), the climates in those three study areas are belonging to type of A, with mean annual rainfall generally exceeds 2.500 mm (Page et al., 1999) The mean daily temperature varied from 25^{o} up to 33^{o} C, with high in humidity (up to 90%).

Methods

Six permanent plot of 50-m x 50-m was established in a relatively undisturbed forest with distance at least 500 m up to 1 km each other and then each plot was divided into 25 sub-plots of 10m x 10m. First enumeration of all six plots was made in 1999. All trees with girth breast high (gbh) over 15 cm were tagged with aluminium tag on 1.4 m above ground. Trunk girth measurement was conducted on 10 cm below tagged or above buttress and the position of measurement was recorded. The density and dominance (expressed with basal area) and their relative value for each species were calculated follows Mueller-Dombois and Ellenberg (1972). In second enumeration on 2001, tree recruitment (new individual that grow up to 15-16 cm gbh) and tree death within each plot were recorded. The similar trunk measurement was also conducted for all survive and recruited trees. All species recorded were col-ected as voucher specimen for scientific identification.

Data analysis

The growth was analyzed based on girth increment of survive trees. Growth rate was calculated as relative growth rate (RGR) follow formula of Kohyama and Hotta (1986):

$$\mathbf{RGR = (ln\ G00 - ln\ G99)/t}$$

where G99 and G00 are girth breast high in first and second measurement respectively, and t is period of study.

Mortality rate (M) was calculated based on individuals with dbh 6 cm up, and calculated following formula of Condit et al. (1995) and Sheil et al. (1995).

$$\mathbf{M = (ln\ N0 - ln\ N1)/t}$$

where N0 is number of individuals at beginning measurement and N1 is survive individual at the second measurement, and t is period of study.

Recruitment rate per unit area is defined as the number of recruit's trees, which reaches up to minimum size (16 cm) in gbh during two-years (1999-2001) period. Recruitment rate (R) calculated as formula of Nebel et al. (2001).

$$\mathbf{R = Nr/(N0 - Nm)}$$

Nr is number of recruited trees, N0 is number of trees at beginning measurement and Nm is number of mortal trees.

Growth rate and mortality rate were calculated for each plot and each diameter class per plot. Relationships between the above parameter were analyzed in Spearman correlation analysis and multiple regression analysis, in which diameter class, total density and total basal area per plot, relative density and dominance per species, diversity, peat-depth and distance to river were chosen as independent variables. The values of total density, total basal area, diversity, peat depth and distance to river followed Mirmanto et al. (2003).

RESULTS AND DISCUSSION

Vegetation features

The total number of species among 4.656 trees (dbh > 4.8) recorded within 6 plots was 126 trees. The most abundant 24 species were analyzed (Table 1), and these accounted for 66.41% of number of tree, 74.13% of basal area but only 18.25% of number of species. Almost all of those 24 species were occurs in 6 plots, except *Combretocarpus rotundatus* and *Calophyllum biflorum* in 5 plots, and *Palaquium* sp.1 *and Shorea* cf. *parvifolia* in 4 plots. However the contributions in density and basal area of those 4 species were relatively high. Figure 1 shows the similar pattern in distribution of diameter of those 24 species, except for *Combretocarpus rotundatus*.

Growth-rates

Growth rate, mortality rate, recruitment rate of 24 most common species recorded within 6 plots of 0.25 ha were shown in Table 2. Growth-rate was significantly positive correlated with relative density but was negatively correlated with diameter class and relative dominance (r =-0.884, p = 0.000; r = 0.567, p = 0.000; r =-0.229, p = 0.000 (Table 3). That mean growth rate to increase with increasing in population density, but to decrease with increasing in size of trees. In other words that growth rate of the dense young population is high, which indicated by a lot of small size individuals, tended higher. In addition according to multiple regression analysis, growth rate also affected by diameter class and relative density of each species but there is no significant effect of relative dominance (Table 4). Analysis of one-way ANOVA seems to fit these results. Although there is any variation among species in growth-rate within each class diameter (Figure 2), but in general the growth rate of small trees were significantly higher than the big trees (ANOVA; Tukey test, p < 0.001).

Mortality

Total number of tree death recorded over one year period was 70 individuals within 6 plots, with total basal area of 0.66 m^2/ha. They belong for about 25% of tree species, which occur in at least 4 plots with number of individual relatively higher. On the other hand, there is no mortality for about 75% of tree species, and most of them may be able to be categorized as uncommon species, which only occur on 1 or 2 plots with relatively lower in number of individual.

The mean annual mortality rates of 24 species analyzed varied from 0.0 to 6.6% yr^{-1} with mean 1.1% yr^{-1} (Table 2). This variation in mortality rate among 24 species was not significant (ANOVA; P = 0.207). However, even not significant *Lithocarpus elegans* tended the highest in mortality rate, followed by

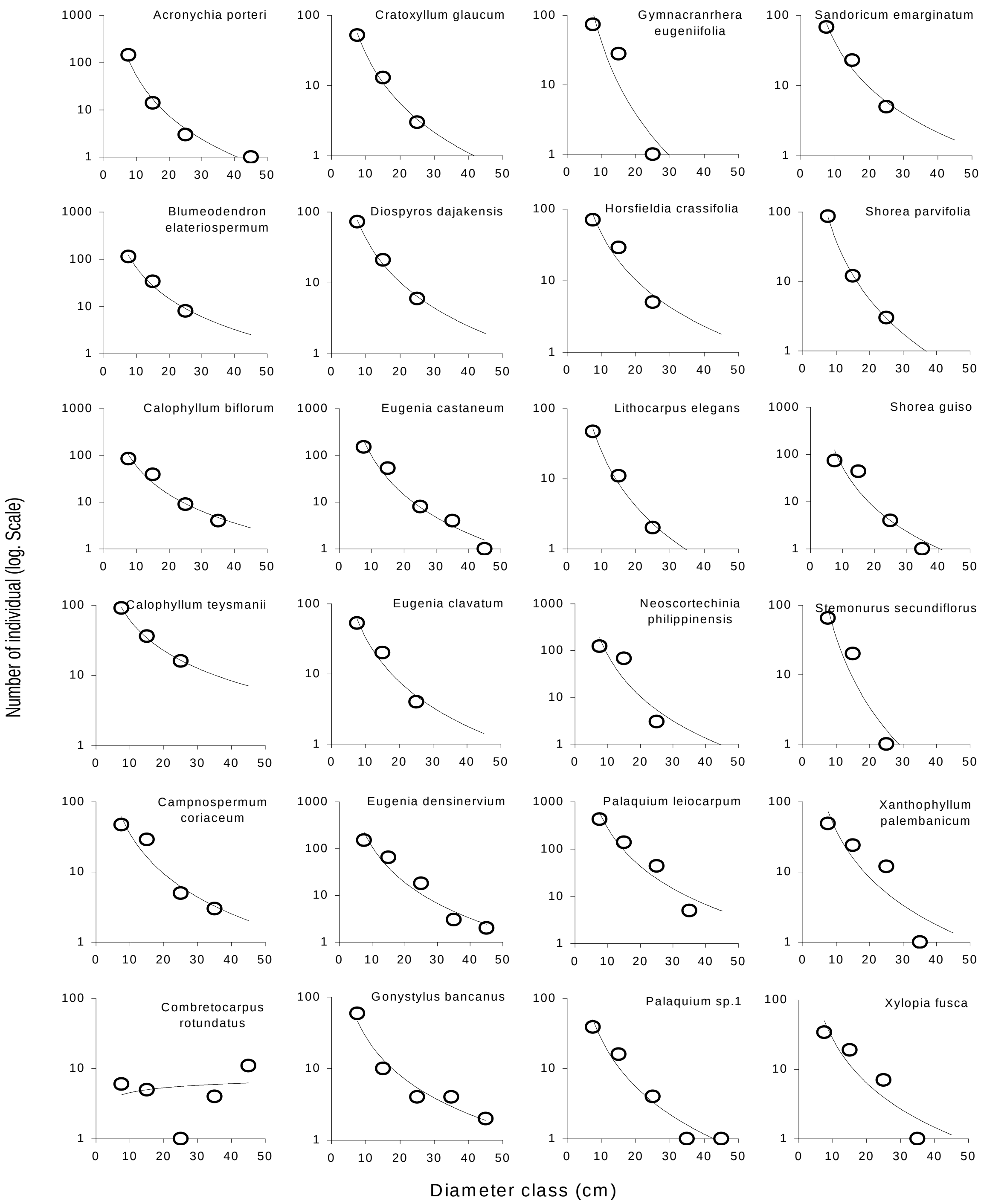

Figure 1. Number of individual of 24 most common species according to diameter class.

Table 1. Frequency (F= number of plot where a species occur), diameter minimum (D-min= cm), diameter maximum (D-max= cm), total basal area (BA= m^2/ha), total density (trees /1.5 ha), relative dominance (RDo=%) and relative density (RD=%) of 24 most common species recorded within 6 plots of 0.25 ha.

Species	F	D-min	D-maks	BA	D	RDo	RD
Acronychia porteri	6	4.8	62.7	0.92	197	2.90	4.23
Blumeodendron elateriospermum	6	4.8	29.5	0.77	155	2.43	3.33
Calophyllum biflorum	5	4.8	56.0	1.25	136	3.96	2.92
Calophyllum teysmannii	6	4.8	29.1	1.03	144	3.27	3.09
Campnosperma coriaceum	6	4.8	45.6	0.83	84	2.63	1.80
Combretocarpus rotundatus	5	4.8	74.5	2.26	27	7.15	0.58
Cratoxylum glaucum	6	4.8	22.5	0.30	67	0.96	1.44
Diospyros dajakensis	6	4.8	29.1	0.53	97	1.69	2.08
Eugenia castaneum	6	4.7	42.9	1.39	217	4.39	4.66
Eugenia clavatum	6	4.8	31.1	0.46	79	1.47	1.70
Eugenia densinervium	6	4.8	44.3	2.07	238	6.54	5.11
Gonystylus bancanus	6	4.8	62.8	1.00	80	3.18	1.72
Gymnacranthera eugeniifolia	6	4.8	19.2	0.42	100	1.34	2.15
Horsfieldia crassifolia	6	4.8	28.2	0.68	107	2.14	2.30
Lithocarpus elegans	6	4.8	26.5	0.30	59	0.94	1.27
Neoscortechinia philippinensis	6	4.8	33.2	1.09	196	3.46	4.21
Palaquium leiocarpum	6	4.8	39.4	4.34	624	13.76	13.40
Palaquium sp.1	4	4.8	44.0	0.59	45	1.87	0.97
Sandoricum emarginatum	6	4.8	24.6	0.53	96	1.69	2.06
Shorea guiso	6	4.8	38.2	0.84	124	2.66	2.66
Shorea parvifolia	4	4.8	30.8	0.38	72	1.22	1.55
Stemonurus secundiflorus	6	4.8	29.1	0.41	86	1.30	1.85
Xanthophyllum palembanicum	6	4.8	41.8	0.83	86	2.64	1.85
Xylopia fusca	6	5.1	33.7	0.57	62	1.81	1.33

Table 2. Growth rate, mortality rate, recruitment rate of 24 most common species recorded within 6 plots of 0.25 ha.

Species	Growth rate yr-1					Mortality rate yr-1					Rect-rate
	< 10	< 20	< 30	< 40	> 40	< 10	< 20	< 30	< 40	> 40	yr^{-1}
Acronychia porteri	0.03	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.07
Blumeodendron elateriospermum	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Calophyllum biflorum	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.12	0.00	0.00	0.01
Calophyllum teysmannii	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Campnosperma coriaceum	0.03	0.02	0.01	0.01	0.01	0.00	0.07	0.00	0.00	0.00	0.03
Combretocarpus rotundatus	0.03	0.02	0.02	0.01	0.01	0.69	0.00	0.00	0.00	0.00	0.00
Cratoxylum glaucum	0.03	0.02	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.02
Diospyros dajakensis	0.03	0.02	0.01	0.00	0.00	0.05	0.00	0.18	0.00	0.00	0.02
Eugenia castaneum	0.03	0.02	0.01	0.01	0.01	0.03	0.00	0.00	0.00	0.00	0.01
Eugenia clavatum	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Eugenia densinervium	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.06	0.00	0.00	0.03
Gonystylus bancanus	0.03	0.02	0.01	0.01	0.01	0.03	0.00	0.00	0.00	0.00	0.03
Gymnacranthera eugeniifolia	0.03	0.02	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
Horsfieldia crassifolia	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Lithocarpus elegans	0.02	0.02	0.01	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.07
Neoscortechinia philippinensis	0.03	0.02	0.01	0.01	0.00	0.02	0.01	0.00	0.00	0.00	0.01
Palaquium leiocarpum	0.03	0.02	0.01	0.01	0.00	0.02	0.01	0.02	0.00	0.00	0.01
Palaquium sp.1	0.03	0.02	0.01	0.01	0.01	0.00	0.00	0.18	0.00	0.00	0.04
Sandoricum emarginatum	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Shorea cf. *parvifolia*	0.03	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Shorea guiso	0.03	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Stemonurus scorpioides	0.03	0.02	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.04
Xanthophyllum palembanicum	0.03	0.02	0.01	0.01	0.01	0.03	0.09	0.00	0.00	0.00	0.01
Xylopia fusca	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.18	0.00	0.00	0.02
All species	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.03	0.00	0.00	0.02

Combretocarpus rotundatus, Diospyros dajakensis and *Xanthophyllum palembanicum*. Mortality rate was significantly correlated with relative density and relative dominance of each species and distance to river even not strong (Table 3). However according to multiple regression analysis, the effect of both those parameters above were not significant (Table 4).

Recruitment

During one-year period, there are 48 individual of trees were reach up to 15-17 cm in girth breast high, or about 41 trees ha^{-1} yr^{-1}. Out of 24 species, 22 of them were recruited and 2 others (*Combretocarpus rotundatus* and *Gymnacranthera eugeniifolia*) were not recruited. Recruitment rate among those 24 species varied from 0.0 to 7.41% yr^{-1} with mean value was 1.65% yr^{-1}. There is no significant difference in recruitment rate among 22 species (ANOVA; $p = 0.132$). However the *Acronychia porteri* and *Lithocarpus elegans* were tended the highest in recruitment rate.

Recruitment rate was positive correlation with diversity but negative correlation with total density per plot (Table 3). Even not strong, recruitment rate was also negative correlated with peat depth and distance to river. This may be explaining that within community with condition low in density but high in diversity recruitment rate tends to be higher. According to multiple regressions analysis, recruitment even not strong was affected by total basal area, relative dominance and distance to river (Table 4). However based on Gf (recruitment estimation) as expected the recruitment rate was strong affected by relative density and relative dominance (Table 4).

Table 3. Correlation coefficients between various measurements (growth rate, mortality rate,) and some parameter factors (diameter class, total density, total basal area, relative density, relative dominance, diversity, distance to river and peat depth).

	Dependent variable		
Independent variable	Grw-rate	Mor-rate	Rec-rate
Diameter class (cm)	-0.884 ***	-0.068	
Total density (ind./ha)	-0.045	-0.066	-0.265 **
Total basal area (m2/ha)	-0.023	-0.070	-0.135
Diversity	0.045	0.066	0.265 **
Distance to river (km)	-0.012	-0.102 *	-0.182 *
Peat depth (m)	-0.030	-0.072	-0.205 *
Relative density (%)	0.564 ***	0.152 **	0.138
Relative dominance (%)	-0.229 ***	0.130 **	0.029

* p < 0.05; ** p < 0.01; *** p< 0.001

Table 4. Results of multiple regression analysis between various measurements (growth rate, mortality rate, recruitment rate and Gf) and some parameter factors (diameter class, total density, total basal area, relative density, relative dominance, diversity, distance to river and peat depth).

	Dependent variable		
Independent variable	Grw-rate	Mor-rate	Rec-rate
Diameter class (cm)	-0.799 ***	0.017	
Total density (ind./ha)	0.068	0.286	-0.243
Total basal area (m^2/ha)	0.180	0.832	2.074 *
Diversity	0.194	0.848	1.201
Distance to river (km)	-0.077	-0.902	-1.786 *
Peat depth (m)	0.007	0.413	0.722
Relative density (%)	0.111 **	-0.039	0.165
Relatif dominance (%)	-0.012	-0.028	-0.252 *
F	123.23 ***	1.65 ns	2.860 ***

* p < 0.05; ** p < 0.01; *** p< 0.001

Change in tree density and basal area

During one-year period there are any changed both in density and basal area of 24 tree species within 6 plot (Table 5). Overall the basal area increase from 20.91 m^2 ha^{-1} to 21.44 m^2 ha^{-1} and density increase from 1895 to 1905 individuals' ha^{-1}. The tree density increase because the increase of tree density from recruitment was greater than lost of tree by death. The increase of tree density also followed by increase of basal area, because the increase of basal area of survived trees and from recruited trees were greater than the lost by death. However this differences both in density and basal area were not significant (ANOVA; $p > 0.9$).

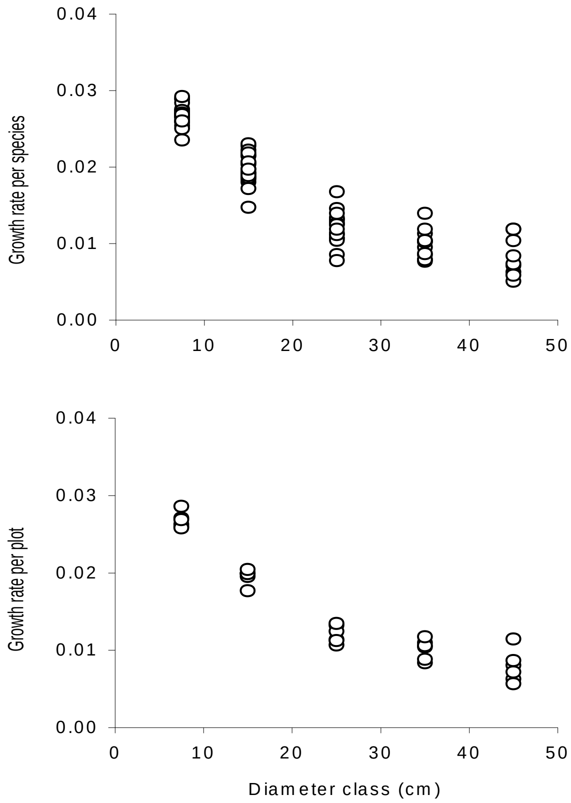

Figure 2. The value of growth rate among 24 most common species according to diameter class

Overall the mean diameter increment of 24 species was 2.11 mm yr^{-1} with range from 0.32 to 5.73 mm yr^{-1}. This range value is comparable those reported in some tropical rain forest of southeast Asia (Nicholson, 1965; Manokaran and Kochummen, 1993; and Sist et al., 2002), but little bit lower than Amazonian rain forest (Condit et al., 1995; Clark and Clark, 1999; Nebel et al., 2001; Silva et al., 2002; and Laurance et al., 2004). Some of those previous studies (Silva et al., 2002; Clark and Clark, 1999 and Sist et al., 2002) reported that growth pattern was highly dependent on tree size. Based on absolute growth rate was found that big trees tended faster with assumption because larger trees occupy the canopy, and have more energy supply and higher photosynthetic rates. In this study we use relative growth rate and detect there is negative significant effect of diameter class to relative growth rate (Table 4). As have been observed in some previous studies, the relative growth rate of 24 species analyzed tended decrease with increasing in diameter class (Kohyama and Hotta, 1986; Yoneda et al., 1994; Simbolon et al., 2000). In addition Kohyama et al. (2003) stated that growth rate is exponential function of size of tree trunk. This support our finding that growth rate was significantly affected by diameter class.

This study found that means annual mortality in total was 1.1% with slightly varied among 24 species (0.0-6.6% yr^1). This is comparable to those reported in some previous studies both tropical and temperate forest (Sist et al., 2002; Silva et al., 2002; Guedje et al., 2002; Olano and Palmer, 2003; and Takahashi et al., 2003). However, Finegan and Camacho (1999) found that the annual mortality rates was 2.0-2.3% and stated similar to those the most dynamics forest at La Selva. The differences in mortality rate might be associated with differences in environmental and climate conditions, for example higher mortality rate in La Selva was impact of unfamiliar climate and environment (Lieberman and Lieberman, 1987). Some previous studies reported that there are higher mortality rates of small trees (Guedje et al., 2002; Pelissier et al., 1998; Olano and Palmer 2003). In contrast this study detect that there is no significant effect of diameter class in mortality rate similar to those reported in mixed dipterocarp forest (Wyatt-Smith, 1966; Primack et al., 1989; Sist et al., 2002) and others studies in tropical forest (Philips and Gentry, 1994; Lieberman et al., 1985; Swaine et al., 1987; Manokaran and Kochumen, 1987; Sheil et al., 1996). According to Pelissier et al. (1998) higher mortality of small trees was common in temperate forest but rarely documented for tropical forests. Competition, for light, water or other nutrients, among trees of the smaller size classes is the major factor determining tree death or survival (Wolf et al., 2004). Martinez-Ramos and Alvarez-Buylla (1998) on the other hand, assumed that mortality rate might be higher in older individuals because they lose vigor and become more liable to predation by natural enemies and physical damage. Unfortunately trees with same size may have different in age. In addition, the fact that most tropical rain forest species do not lose vigor with age, except in short-lived species (Sarukhán, 1980). In this study there is no significant different in mortality rate among size class, even each species was calculated separately.

This study found that means annual recruitment rate of 24 species was 1.94% yr^{-1} with slightly varied among species (0-7.41% yr^{-1}). The value is relatively higher compared to those reported in some previous studies (Takahashi et al., 2003; Pelissier et al., 1998). The differential in recruitment rate might be associated with seed availability and suitable habitat condition. Coates (2002) observed that difference in abundance of parent tree species might influence difference in its recruitment density. In this study however, there is no significant correlation between recruitment and relative density of each species.

Table 5. Density and basal area change of 24 most common species during period of study.

Species	Density (trees /1.5 ha)								Basal area (m^2 ha^{-1})									
	1999	%	M	%	R	%	2000	%	1999	%	GR	%	M	%	R	%	2000	%
Acronychia porteri	131	100	-1	-0.8	7	5.3	137	104.6	0.70	100	0.02	3.3	-0.02	-2.6	0.009	1.3	0.72	102.0
Blumeodendron elateriospermum	145	100	0	0.0	1	0.7	146	100.7	0.64	100	0.03	3.9	0.00	0.0	0.001	0.2	0.67	104.1
Calophyllum biflorum	117	100	-1	-0.9	0	0.0	116	99.1	1.10	100	0.04	3.3	-0.04	-3.4	0.000	0.0	1.10	99.9
Calophyllum teysmannii	132	100	-2	-1.5	3	2.3	133	100.8	0.93	100	0.03	3.4	0.00	-0.3	0.004	0.5	0.97	103.6
Campnosperma coriaceum	69	100	-4	-5.8	0	0.0	65	94.2	0.75	100	0.02	3.0	-0.03	-3.6	0.000	0.0	0.74	99.3
Combretocarpus rotundatus	23	100	-1	-4.3	0	0.0	22	95.7	1.62	100	0.03	1.9	0.00	-0.1	0.000	0.0	1.65	101.7
Cratoxylum glaucum	58	100	-1	-1.7	1	1.7	58	100.0	0.31	100	0.01	4.2	0.00	-0.7	0.001	0.4	0.32	104.0
Diospyros dajakensis	80	100	-3	-3.8	2	2.5	79	98.8	0.40	100	0.02	3.8	-0.01	-1.8	0.003	0.6	0.41	102.6
Eugenia castaneum	195	100	0	0.0	3	1.5	198	101.5	1.19	100	0.04	3.8	0.00	0.0	0.004	0.4	1.24	104.1
Eugenia clavatum	43	100	0	0.0	3	7.0	46	107.0	0.35	100	0.01	3.2	0.00	0.0	0.004	1.1	0.36	104.3
Eugenia densinervium	201	100	-1	-0.5	6	3.0	206	102.5	1.79	100	0.06	3.4	0.00	-0.2	0.008	0.5	1.86	103.6
Gonystylus bancanus	72	100	-3	-4.2	2	2.8	71	98.6	0.67	100	0.02	2.8	-0.01	-0.9	0.003	0.4	0.69	102.3
Gymnacranthera eugeniifolia	94	100	0	0.0	1	1.1	95	101.1	0.40	100	0.02	4.4	0.00	0.0	0.002	0.4	0.42	104.8
Horsfieldia crassifolia	87	100	-1	-1.1	3	3.4	89	102.3	0.50	100	0.02	3.9	0.00	-0.4	0.004	0.7	0.52	104.3
Lithocarpus elegans	62	100	-3	-4.8	0	0.0	59	95.2	0.39	100	0.01	3.5	-0.02	-5.1	0.000	0.0	0.38	98.4
Neoscortechinia philippinensis	155	100	-1	-0.6	2	1.3	156	100.6	0.88	100	0.03	3.9	-0.02	-1.8	0.003	0.3	0.90	102.4
Palaquium leiocarpum	622	100	-5	-0.8	5	0.8	622	100.0	4.42	100	0.16	3.7	-0.05	-1.1	0.012	0.3	4.55	102.9
Palaquium sp.1	58	100	-1	-1.7	3	5.2	60	103.4	0.53	100	0.02	3.5	-0.02	-4.7	0.004	0.7	0.52	99.5
Sandoricum emarginatum	89	100	-2	-2.2	1	1.1	88	98.9	0.46	100	0.02	4.0	0.00	-0.9	0.001	0.3	0.48	103.3
Shorea cf. parvifolia	91	100	-1	-1.1	1	1.1	91	100.0	0.45	100	0.02	3.9	0.00	-0.6	0.001	0.3	0.47	103.6
Shorea guiso	117	100	0	0.0	1	0.9	118	100.9	0.84	100	0.03	3.5	0.00	0.0	0.001	0.1	0.87	103.6
Stemonurus scorpioides	73	100	0	0.0	1	1.4	74	101.4	0.34	100	0.01	3.9	0.00	0.0	0.001	0.4	0.35	104.2
Xanthophyllum palembanicum	74	100	-2	-2.7	2	2.7	74	100.0	0.69	100	0.02	3.1	-0.01	-1.6	0.009	1.3	0.71	102.8
Xylopia fusca	55	100	-1	-1.8	0	0.0	54	98.2	0.55	100	0.02	2.9	-0.02	-4.3	0.000	0.0	0.55	98.6

In addition there is negative correlated with total density. This may suggests that there is presence competition among individuals of seedling during early growth rather than among species.

In all the forest studied in term of growth, mortality and recruitment may be able to categorize as moderately dynamics forest. Relatively higher in growth rate may suggest that poor nutrient habitat condition was not as major limited factor. This indicated by increasing in basal area about 4% yr^{-1} (0.71-m2 ha^{-1} yr^{-1}) of 24 most abundance species. Annual recruitment rate was relatively higher, with contribution in basal area about 0.4%. Lower mortality rate compare to some Amazonian forest may suggest that there is no any significant disturbance during study period. The higher mortality rate was only found for uncommon species (not include in this analysis) such as *Macaranga* sp., which its mortality rate was 26.2%. There is indication that mortality rate of uncommon species was relatively higher but lower in recruitment rate, which may influence diversity of tree species.

CONCLUSION

There is significant effect of diameter class on annual growth rate, but not to mortality rate. Even not too strong two environment factors (peat depth and distance to river) were significant correlated with rate of mortality and recruitment. In addition, annual relative growth rate and mortality rate was comparable to previous study but recruitment rate relatively higher. During two-year period study there is no significant changing in vegetation structure

AKNOWLEDGEMENT

This work was financed by counterpart budget of Research Center for Biology under LIPI-JSPS Core University Program on Environmental Management of Wetland Ecosystems in Southeast Asia. We wish to thank Messer Suwido H. Limin, Patih, Agung and Adi of Palangkaraya University, Dirman, Wardi Yosman and Aden Muhidin of Herbarium Bogoriense and anonymous reviewer for much help.

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