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Diameter Growth Studies of Dipterocarp Hill Forest in Selangor Forest Reserves, Malaysia

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Abstract: A growth study is important in the management of hill dipterocarp forest in Malaysia. The future of role in management of hill dipterocarp forest was depending on how well the remaining available resource is managed today. In order to achieve sustainability of forest management and to better understanding of forest stand and behavior, accurate growth data were important to outline the management strategies. Specific information on the behavior of particular forest stands pertaining to growth performance, mortality, density, structure and species composition is urgently required to evaluate the management system. This study is aim to determine the diameter growth performance in hill dipterocarp forest after harvesting. The study was conducted in a logged-over hill dipterocarp forest at Sungai Lalang Forest Reserve, Selangor. Results show, the overall Diameter Mean Annual Increment of 0.4518 cm yr^{-1} for all trees 10cm to 30cm DBH and Diameter Mean Annual Increment of 0.5638 cm yr^{-1} for all trees 30cm DBH is considerably lower than the rate of 0.8 to 1.0cm yr^{-1} assumed under Selective Management Systems. Although Diameter Mean Annual Increment of dipterocarp (Dipterocarp Meranti= 0.6248 cm yr^{-1}, Dipterocarp Non Meranti = 0.3314 cm yr^{-1}) were higher than that of non dipterocarp, their overall contribution to forest growth was small due to their lower stocking in the residual stand. The results from this study have provided some understanding of growth in hill dipterocarp forest after harvesting. This should be useful for planning future research on growth and for guidelines for current management system of tropical forests, particularly in Peninsular Malaysia.

Keywords: Diameter Growth, Hill Dipterocarp Forest

Introduction

Dipterocarp forests are vital economic and ecological assets of Peninsular Malaysia. In Malaysia, the Dipterocarp forests are now being managed with the Selective Management System (SMS). Following the Selective Management System (SMS), as practiced in Peninsular Malaysia, advanced growth of 30-45cm diameter at breast height (dbh) is expected to produce the next harvest. In view of many difficulties encountered in regenerating hill forests, it was felt that the option of relying on advanced growth to produce the next crop warranted further investigation are important. One prerequisite for sustainable forest management is reliable information on growth and yield for different management regimes and silvicultural options. This information is needed for predicting future stand growth in a tropical rain forest and one of the paramount factors to be considered in forest management planning. Therefore it is very important to understanding of the trends of growth stands, distribution, regeneration status and growth potential of logged-over forests in ensuring the sustainable production of timber. This paper reviews about the growth response in Hill Dipterocarp Forest in Selangor Malaysia after harvesting. The results presented in this paper are related to growth response of the residual stands in term of treatment applied in the study site.

Methods

The forests areas selected for the study were at Compartments 50, Sungai Lalang Forest Reserved, Selangor. Compartment 50, Sungai Lalang Forest Reserve is located in the north-eastern part of Ulu Langat District bordering the state of Negeri Sembilan. The compartment covers a total area of 603ha. However, only 420 ha of the compartment are utilized. The general topography of compartment is undulating to hilly with elevation ranging from 150m to 1000m. Pre-felling inventory was carried out in December 1988 and logging completed in 1991 due to difficult terrain and the necessity to call for a tender to cut the remaining trees which were not felled during the first harvesting operation. Data was collected from the growth and yield study plots in year 1992, 1996, 2000, 2006 and 2011. The size of each plot was 100m x 100m (1ha). Figures 1 show the layout design of the studies plot.

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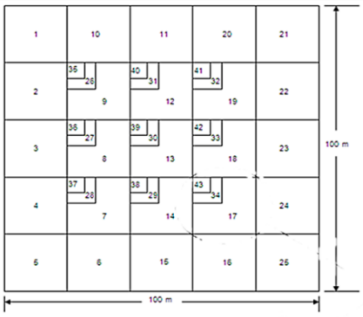

Figure 1 Layout Design of the Studies Plot at Sungai Lalang Forest Reserve, Selangor

Growth information including species names, health status of trees, diameter at breast height (DBH) and commercial bole height were recorded during the measurement. Data collected from the study plots were entered into a computer using Microsoft EXCEL software. Growth data of all measurements and data entry error were checked. Data were divided by class diameter 10cm-30cm DBH and 30cm DBH and above. Data were analysis in term of growth rate for diameter. The formulae of growth rate are as follow:

1) MAI= Total Increment, Number of Years

   Where
   MAI- Mean Annual Increment

2) $MAI = \sum MCAI \div t$
   $MCAI = \sum CAI \div n$

   Where
   MAI – Mean Annual Increment
   MCAI– Mean Current Annual Increment by stand age after harvesting
   CAI- Current Annual Increment of individual tree after harvesting
   t– Number of intervals (Stand ages)
   n – Number of trees

For these studies, 7 treatments in different logging intensity or cutting limits were used. The selected cutting limits are based on the cutting limits prescribed that are reflecting with existing forest management system in the country. Under the Selective Management System (SMS) which is currently being practised in Peninsular Malaysia, a split cut for the dipterocarp (dipt) and non-dipterocarp (non-dipt) trees has been advocated with dipterocarp trees being prescribed a higher cutting limit and The possibility of utilising smaller diameter logs in the future as well as the prospects of establishing indigenous forest plantation (Anon, 1994). They are as follows in Table 1.

Table 1 Treatment in Different Logging Intensity or Cutting Limit

TREATMENT	CUTTING LIMIT
A	• Cut all ≥30 cm dbh
B	• Cut all ≥45 cm dbh
C	• Cut dipt. spp. ≥35 cm dbh and cut non-dipt. spp. ≥30 cm dbh
D	•
E	•
F	• Cut dipt. spp. ≥50 cm dbh and cut non-dipt. spp. ≥45 cm dbh
H	• Cut dipt. spp. ≥65 cm dbh and cut non-dipt. ≥60 cm dbh

Results

Average Diameter by Treatment and Diameter Class

Generally, the average DBH of trees 10 cm – 30 cm DBH class is within 18.1793 cm ha^{-1} in first year measurement (1992) to 19.2438 cm ha^{-1} in year of measurement 2011. The diameter of trees 10cm – 30cm DBH has shown a gradually upward trend as in Table5.3. Treatment D recorded lowest average diameter for first measurement with average 17.9669 cm ha^{-1} and DMAI = 0.4729 cm yr^{-1}. The average diameter of trees of 30cm DBH and above (all treatments combined) showed the uptrend with

DMAI= 0.5638 cm yr^{-1}. (Table 5.5). The average of DBH of trees 30cm DBH and above is between 37.6814 cm ha^{-1} to 41.8748 cm ha^{-1}. Result show, Treatment A recorded lowest average diameter with average 24.3167 cm ha^{-1} for the 1992 and grew up to 37.8299 cm ha^{-1} for year 2011 with DMAI=0.6725 cm yr^{-1}. Compare with other treatments, Treatment H recorded highest average between 49.9315 cm ha^{-1} in year 1992 to 51.7149 cm ha^{-1} in year 2011 with DMAI= 0.4352 cm yr^{-1}.

Table 1: Average Diameter of Trees 10cm -30cm DBH

TREATMENT	AVERAGE DIAMETER (cm ha^{-1})				
	1992	1996	2000	2006	2011
A	18.0390	18.2446	18.7226	19.4670	19.7162
B	18.5550	18.1883	18.5750	19.2423	19.2546
C	18.2843	17.7046	17.7510	18.6150	19.1113
D	17.9669	18.4927	18.5297	19.0437	19.3047
E	18.0677	18.3912	17.8527	19.0491	19.4773
F	18.0456	18.0485	17.9931	18.4872	18.8363
H	18.2969	18.2867	18.5520	18.7683	19.0059
MEAN	**18.1793**	**18.1938**	**18.2823**	**18.9532**	**19.2438**

Table 2: Average Diameter of Trees 30cm DBH and Above

TREATMENT	AVERAGE DIAMETER (cm ha^{-1})				
	1992	1996	2000	2006	2011
A	24.3167	33.4247	34.8652	37.2351	37.8299
B	35.9030	37.5828	38.4556	39.6221	40.2641
C	36.5893	33.5537	35.3454	38.3342	39.0470
D	36.8341	37.2972	38.4020	39.6416	40.4841
E	39.3501	39.6792	40.4925	40.6333	40.9275
F	40.8453	40.7495	41.6907	42.3216	42.8560
H	49.9315	51.7568	51.8031	51.5345	51.7149
MEAN	**37.6814**	**39.0063**	**40.1506**	**41.3318**	**41.8748**

Diameter Increment by Treatment and Diameter Class

The Diameter Mean Annual Increment (DMAI) of all treatments was 0.4518 cm yr^{-1}. The most obvious growth however can be seen in the Treatment A. In this treatment, trees grew rapidly from about 0.8256 cm yr^{-1} to 0.2493 cm yr^{-1} (DMAI=0.5676 cm yr^{-1}) during the year 1992-1996 and 2006-2011. Compared with Treatment H, the trees grew produced slow with the DMAI= 0.2303 cm yr^{-1}. From this situation, in terms of diameter increment, the lowers cutting limits seems to result in a reasonably good overall. This implies the higher intensities of logging created large enough crown openings to allow a fast, growth of the residual trees. The overall trend of diameter increment shown in Table 5.4. During the first diameter increment (1992-1996), all the treatments in this size class responded very well to the opening brought about by the logging operations. However, at diameter increment in year 1996-2000, the trees began to settle down and grow differently at their own paces. Hetherington (1985, pers.comm.) stated, experience in the temperate forests showed that diameter growth slows down unless the stands are constantly thinned to release the tree crowns whereas basal area increment does not slow down or is less affected. Generally, the trees of 30cm DBH and above have greater DMAI than the trees of 10cm -30cm DBH. In year 1992-1996, the diameter increment for all treatment recorded 0.6860 cm yr^{-1}. After the initial increase during the year 1996-2000(0.6539 cm yr^{-1}), the diameter increments of the trees fell consistently down to levels 0.5717 cm yr^{-1} (year 2000- 2006) and 0.3434 cm yr^{-1} (2006 – 2011). Treatment C recorded the highest DMAI value (DMAI= 0.7207 cm yr^{-1}) followed by Treatment A (DMAI= 0.6725 cm yr^{-1}). While Treatment H recorded lowest DMAI (DMAI= 0.4352cm yr^{-1})

Table 3: Diameter Increment of Tree 10cm – 30cm DBH (cm yr^{-1}) by Treatment

TREATMENT	DIAMETER INCREMENT (cm yr-^{1}) BY TREATMENT				DMAI
	1992-1996	1996-2000	2000-2006	2006-2011	(1992-2011)
A	0.8256	0.6753	0.5204	0.2493	0.5676
B	0.6390	0.4954	0.3478	0.2880	0.4425
C	0.7101	0.5722	0.4776	0.2527	0.5031
D	0.7104	0.5180	0.4373	0.2258	0.4729
E	0.7338	0.5328	0.4879	0.2909	0.5114
F	0.6483	0.4517	0.3832	0.2558	0.4347
H	0.3298	0.2402	0.2412	0.1101	0.2303
MEAN	**0.6567**	**0.4979**	**0.4136**	**0.2389**	**0.4518**

Table 4: Diameter Increment of Trees 30cm DBH and Above (cm ha^{-1}) by Treatment

TREATMENT	DIAMETER INCREMENT (cm yr^{-1}) BY TREATMENT				DMAI (1992-2011)
	1992-1996	1996-2000	2000-2006	2006-2011	
A	0.6357	0.9386	0.7828	0.3329	0.6725
B	0.6261	0.5537	0.4766	0.3713	0.5069
C	0.8321	0.8278	0.7349	0.4879	0.7207
D	0.5320	0.6351	0.6014	0.3551	0.5309
E	0.7887	0.5592	0.5205	0.3738	0.5605
F	0.7183	0.5573	0.4553	0.3483	0.5198
H	0.6692	0.5060	0.4308	0.1349	0.4352
MEAN	**0.6860**	**0.6539**	**0.5717**	**0.3434**	**0.5638**

Diameter by Group Species

In terms of species, the DMAI of trees 10 cm – 30cm DBH showed some interesting and consistent trends. In all treatments, the growth of the DM is consistently higher than the DNM. Figure 5.8 shows the trends of the diameter increment of trees 10cm – 30cm DBH in different treatment for the major species groups. Combining all the treatments, the DMAI of DM was 0.7127 cm yr^{-1}. While DNM, 0.4523 cm yr^{-1} . Among the non-dipterocarp species, the LHW (DMAI= 0.4613 cm yr^{-1}) came out with the higher followed by MHW (DMAI=0.4043 cm yr^{-1}), HHW (DMAI= 0.3548 cm yr^{-1}) and MISC (DMAI= 0.1821 cm yr^{-1}) respectively. LHW in the Treatments A, grew higher than other treatment as much as 0.5885 cm yr^{-1} . In Figure 5.9 clearly shows the trends of the dipterocarp species had a generally high DMAI (DMAI=0.6248 cm yr^{-1}) than the non meranti (DMAI= 0.3314 cm yr^{-1}). Whereas among the non dipterocarp species, the LHW (0.5231 cm yr^{-1}) grew faster than the MHW (0.4561cm yr^{-1}) which turn grew faster than HHW (0.3945 cm yr^{-1}) and MISC (0.0009 cm yr^{-1}). These trends of growing of trees of 30cm DBH and above are similar like trees of 10cm – 30cm DBH. In the latter cases, the DMAI trees of 30cm DBH and Above were 0.4 cm yr^{-1} to 0.7 cm yr^{-1} which can considered low and below the standard set by the SMS. Followed by the SMS standard, all the trees in residual stand must have a sustained diameter increment rate about 0.8 cm yr^{-1} to 1.0 cm yr^{-1}.

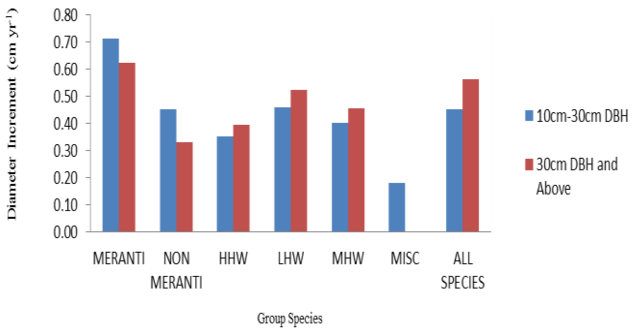

Figure 1: Diameter Increment by Group Speices

Diameter Growth Projection

Despite the significant of the retating diameter and year (t), simple linear regression analyses revered that the diameter and year (t), positively related with level of significant was P=0.025 and P=0.00. The effect of time on the diameter growth shows that the time (year after felling) is one of the major factors in influencing the diameter growth of trees. Time (years), can have both positive and negative effects as one of the factors affecting growth processes. This is related to the changes in the availability of nutrients and energy and other factors affecting process of life in the forest environment. The result of the linear regression was summarized in Table 5.16 and 5.17. It is clearly indicated that the data calculation can easily estimate by using established equation. i) $DBH_1 = 17.704 + 0.289\ (t)$ and ii) $DBH_2 = 36.897 + 1.047\ (t)$. The coefficients of determination for equation i and ii were found R^2=0.853 and R^2=0.984

Table 5: Linear regression Coefficient of Average Diameter for trees 10-30cm DBH

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Year (t)	0.289	0.069	0.924	4.176	0.025
(Constant)	17.704	0.229		77.179	0.000

$DBH_1 = 17.704 + 0.289\ (t)$ …………………….. *equation (i)*; DBH = Diameter (R^2= 0.853)

Table 6: Linear regression Coefficient of Average Diameter for trees 30cm DBH

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Year (t)	1.047	0.077		145.097	0.000
(Constant)	36.897	0.254	0.992	13.659	0.001

$DBH_2 = 36.897 + 1.047\ (t)$ …………………….. *equation (ii)* ; DBH = Diameter (R^2= 0.984)

Conclusion

Forest management today is more challenging. Nowadays, forests are expected not only to produce wood. It is also to consider non-wood products, to conserve biodiversity, also to maintain the environment and to provide for social and recreational needs. Wan Razali (1990) stated, some policy related actions are important that require silvicultural inputs include increase awareness, support, commitment to early out initiatives that have been formulated, such as forests policies and strategies; to ensure that the permanent forest estate remains forest after harvesting by using environmentally sound silvicultural systems and consolidating existing knowledge of natural forest management. Thru the forest management system, under a selective management regime, the big timber sized individuals are felled and taken out leaving behind the pole-sized and smaller trees to grow into the next crop over a specified length of cutting cycle. This growth is, theoretically enhanced by the growing space created by the felling and removal of the larger trees. The amount of space created which is directly proportional to the number of trees felled would ideally have to be properly estimated so as to be optimally distributed over the entire area in order that the remaining trees and seedlings can make the best use of the space and light thus made available. The result show, the diameter mean annual increment of trees was better in the plots subjected to cutting limits than the control plots, indicating the forest openings or liberation is needed to enhance diameter growth. Forest growth studies of this nature are invariably complex as they involve the monitoring of growth response of trees subjected to different cutting intensities and stocking classes over large forest areas. Results of growth studies are very important in refining and adjusting the current management system to ensure that the management of productive forest is realistic. It is important that more of such plots be established and if possible in all forest types in Peninsular Malaysia and more research on growth and development of hill dipterocarp forests is necessary to update, improve and expand our existing knowledge, it also necessary to carry out research in the others aspects like economics.

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