Technical Report No. 1/2007

ANALYSIS OF GROWTH PLOTS DATA FOR THE STATE OF JOHOR

INTRODUCTION

In the species-rich tropical forests, the most appropriate form of management is to rely on natural regeneration to provide the future crop through selective felling of the mature crop. Following the Selective Management System (SMS), as practiced in Peninsular Malaysia, advanced growth of 30-45 cm diameter at breast height (dbh) is expected to produce the next harvest. Therefore it is important to note that residual stands must be adequate in quantity and of a specific quality to ensure a future yield that is both economical and sustainable in the long term.

An understanding of the distribution, regeneration status and growth potential of logged-over forests is important in ensuring the sustainable production of timber. An assessment of the residual stocking and development status of logged-over forests was carried out by examining the data obtained from growth plots that have been established in the State of Johor since 1992. Based on the enumeration of data obtained from these plots, the results of the analysis are discussed with particular reference to their implications on future production.

METHODOLOGY

Site description

The growth plots in the State of Johor were randomly distributed in four (4) forest districts namely Northern Johor (Segamat) Forest District, Southern Johor (Johor Bahru) Forest District, Eastern Johor (Mersing) and Central Johor (Keluang) Forest District. A total of eleven (11) Growth Plots of were established. These plots were established based on the following characteristic, namely; (i) located in the Permanent Reserve Forest, (ii) number of years after logging to sufficiently represent the different stages of forest development after logging and (iii) available information on Pre-Felling Inventory and Post-Felling Inventory for the purpose of stocking and species comparison. The size of each plot is one (1) hectare with 25 sub-plots of 20m x 20m and 9 sub-plots of 10m x 10m. In the 20m x 20m sub-plots all trees 10cm dbh and above were measured while in the 10m x 10m sub-plots all trees 5cm-10cm dbh were measured. (Forestry Department Peninsular Malaysia 1992). The background information of the Growth Plots in the State of Johor is shown in Table 1.

The first enumerations were made in 1992 and here since being re-measured seven times. The years 2004 was used as the reference year in relation to the year that the compartment was logged. The definitions of original forest in terms of good, moderate and poor were based on the Second National Forest Inventory 1981-1982. (Forestry Department Peninsular Malaysia 1987).

Table 1. Information on growth plots

Location of Forest Reserve	Status of Original Forest	Year After Logging	Logging Strata
Compt. 16 Panti	Good	56	Above - 51
Compt. 11 Labis	Moderate	46	41-50
Compt. 58 Ulu Sedili	Good	44	41-50
Compt. 3A G. Arong	Moderate	40	31-40
Compt. 579 Labis	Good	33	31-40
Compt. 148 Maokil	Poor	25	21-30
Compt. 847 Labis	Poor	23	21-30
Compt. 37 Labis	Good	16	11-20
Compt. 120 Ulu Sedili	Good	11	11-20
Compt. 25 Mersing	Poor	14	11-20
Compt 101 Lenggor	Good	19	11-20

RESULTS AND DISCUSSION

Only trees that were alive, of good physical standing, and with complete stem and crown were considered. Trees that had fallen, or with broken tops and stumps, were not taken into consideration as they might not be able to contribute to the next harvest. All plots have been enumerated since 1992. Only the results of the last enumeration and only trees greater than 10 cm dbh and 30 cm dbh are shown (Setje-Eilers 2001).

Number of Stems Per Hectare

The results on number of stems per hectare for dipterocarps and commercial non-dipterocarps are shown in Tables 2 and 3, respectively. The dipterocarps show the highest number of stems of 67 stem/ha in the 10<20 cm diameter class and then a gradual decrease to 4 stem/ha after that. As for the commercial non-dipterocarps it showed a drastic decrease with the number of years after logging from 704 stem/ha in the 10<20 cm diameter class to 3 stems/ha in the >60 cm diameter class.

Table 2. Mean no. of stems (ha^{-1}) for dipterocarps

Location of Forest Reserve	Diameter Class (cm) 10<20	20<30	30<40	40<50	50<60	>60	Total
Compt. 16 Panti	1	15	19	14	2	2	53
Compt. 11 Labis	103	67	52	21	9	6	258
Compt. 58 Ulu Sedili	31	16	3	4	0	1	55
Compt. 3A G. Arong	64	27	8	2	1	0	102
Compt. 579 Labis	97	67	34	1	1	1	201
Compt. 148 Maokil	25	10	5	3	8	6	57
Compt. 847 Labis	66	36	22	3	2	0	129
Compt. 37 Labis	15	25	14	6	10	6	76
Compt. 120 Ulu Sedili	149	14	4	2	1	0	170
Compt 101 Lenggor	136	43	17	13	4	3	216
Compt. 25 Mersing	53	8	5	1	0	0	67
Average	67	30	17	6	4	4	128

The results indicate that the bulk of stems in logged-over forests are in the diameter class of 10 to 40 cm dbh. This was due to the fact that trees >45 cm dbh would have been logged and the trees that appear in these diameter classes are ingrowth from the years after logging. It is also observed that on average all the compartments recorded a residual stand containing commercial species having size 30cm dbh and larger exceeding 32 trees/ha which is the threshold set under the Selective Management System.

Table 3. Mean no. of stems (ha^{-1}) for commercial non-dipterocarps

Location of Forest Reserve	Diameter Class (cm)						
	10<20	20<30	30<40	40<50	50<60	>60	Total
Compt. 16 Panti	284	134	28	18	4	3	471
Compt. 11 Labis	592	167	28	10	1	0	798
Compt. 58 Ulu Sedili	1033	268	87	20	2	1	1411
Compt. 3A G. Arong	892	307	64	11	0	0	1274
Compt. 579 Labis	682	185	47	16	3	2	935
Compt. 148 Maokil	523	173	50	28	10	7	791
Compt. 847 Labis	929	246	50	15	1	0	1241
Compt. 37 Labis	431	160	28	16	7	4	646
Compt. 120 Ulu Sedili	389	199	50	16	1	2	657
Compt 101 Lenggor	1045	199	44	14	1	0	1303
Compt. 25 Mersing	944	242	40	13	1	0	1240
Average	704	207	47	16	3	3	980

Basal Area (m^2/ha)

The results of basal area per hectare for dipterocarps, and commercial non-dipterocarps, are shown in Tables 4 and 5, respectively**.**

The results on basal area for dipterocarps showed a gradual increase in basal area with the number of years after logging from 0.45 m^2/ha in the 10<20 cm diameter class to 1.88 m^2/ha in the 50<60 cm diameter class. As for the commercial non-dipterocarps, it showed highest basal area of 6.96 m^2/ha in the 20<30 cm diameter class and then a gradual decrease to 0.94 m^2/ha in the >60 cm diameter class. This may due to greater competition for dipterocarps which occupy most of the upper storey.

Table 4. Basal area (m^2/ha) for dipterocarps

Location of Forest Reserve	Diameter Class (cm) 10<20	20<30	30<40	40<50	50<60	>60	Total
Compt. 16 Panti	0.01	0.57	2.18	3.04	1.02	0.68	7.5
Compt. 11 Labis	0.88	2.68	5.61	4.31	3.74	2.50	19.72
Compt. 58 Ulu Sedili	0.26	0.59	0.27	0.83	0.25	0.16	2.36
Compt. 3A G. Arong	0.52	0.95	0.78	0.42	0.32	0.22	3.21
Compt. 579 Labis	0.63	2.36	3.74	0.20	0.52	0.35	7.8
Compt. 148 Maokil	0.10	0.37	0.56	0.54	4.70	3.13	9.4
Compt. 847 Labis	0.42	1.33	2.30	0.64	0.36	0.24	5.29
Compt. 37 Labis	0.21	0.89	1.57	1.19	5.91	3.94	13.71
Compt. 120 Ulu Sedili	0.87	0.46	0.42	0.34	0.50	0.33	2.92
Compt 101 Lenggor	0.75	1.45	1.81	2.74	1.43	0.95	9.13
Compt. 25 Mersing	0.30	0.22	0.58	0.19	0.00	0.00	1.29
Average	0.45	1.08	1.80	1.31	1.88	1.25	7.77

Table 5. Basal area (m^2/ha) for commercial non-dipterocarps

Location of Forest Reserve	Diameter Class (cm) 10<20	20<30	30<40	40<50	50<60	>60	Total
Compt. 16 Panti	2.12	4.83	2.80	3.57	2.06	1.38	16.76
Compt. 11 Labis	3.71	5.74	2.80	2.08	0.18	0.12	14.63
Compt. 58 Ulu Sedili	6.01	9.21	9.13	4.14	0.85	0.56	29.9
Compt. 3A G. Arong	6.29	10.42	6.18	2.12	0.00	0.00	25.01
Compt. 579 Labis	4.34	6.55	4.81	3.06	1.07	0.71	20.54
Compt. 148 Maokil	3.52	5.71	5.45	5.90	5.39	3.60	29.57
Compt. 847 Labis	5.86	7.80	5.33	3.19	0.17	0.12	22.47
Compt. 37 Labis	3.07	5.21	3.04	3.42	3.29	2.19	20.22
Compt. 120 Ulu Sedili	2.80	6.65	5.23	3.24	0.64	0.42	18.98
Compt 101 Lenggor	5.99	6.64	4.74	2.81	0.18	0.12	20.48
Compt. 25 Mersing	5.12	7.77	4.06	2.51	0.20	0.14	19.80
Average	4.44	6.96	4.87	3.28	1.40	0.94	21.88

Volume (m^3/ha)

The results of the volume per hectare for dipterocarps and commercial non-dipterocarps are shown in Tables 6 and 7, respectively**.** The results on volume for dipterocarps showed that the volume increases from the lower 10<20 cm diameter class at 2.0 m^3/ha to the highest at 27.9 m^3/ha in the 50<60 cm diameter class and decreases to 18.6 m^3/ha in the >60 cm diameter class. As for the commercial non-dipterocarps, the trend is exactly the opposite i.e the highest at 69.8 m^3/ha in the 20<30 cm diameter class and decreases to 12.8 m^3/ha in the >60 cm diameter class. This may due to greater competition from dipterocarps which have grown taller and bigger in size and dominated the upper storey.

Table 6. Volume (m^3/ha) for dipterocarps

Location of Forest Reserve	Diameter Class (cm)						
	10<20	20<30	30<40	40<50	50<60	>60	Total
Compt. 16 Panti	0.1	6.0	25.3	38.3	14.9	9.9	94.5
Compt. 11 Labis	4.2	28.0	63.9	54.7	53.9	35.9	240.6
Compt. 58 Ulu Sedili	1.1	6.1	3.1	10.8	3.9	2.6	27.6
Compt. 3A G. Arong	2.6	9.7	8.9	5.4	4.8	3.2	34.6
Compt. 579 Labis	3.0	24.1	43.4	2.4	7.6	5.1	85.6
Compt. 148 Maokil	0.5	3.9	6.6	6.7	70.7	47.2	135.6
Compt. 847 Labis	1.5	13.7	26.6	8.2	5.2	3.4	58.6
Compt. 37 Labis	1.5	9.0	18.4	14.9	90.5	60.4	194.7
Compt. 120 Ulu Sedili	3.0	4.6	4.8	4.1	7.7	5.1	29.3
Compt 101 Lenggor	3.2	14.6	21.1	35.0	20.0	13.4	107.3
Compt. 25 Mersing	1.3	2.0	6.8	2.2	0.00	0.00	12.3
Average	2.0	11.1	20.8	16.6	27.9	18.6	97.0

Diameter Increment

Table 8 shows the summary of mean annual diameter increment for both dipterocarp and commercial non-dipterocarp while Table 9 and 10 show mean annual diameter increment by locations.

The mean annual diameter increment of dipterocarps ranges from 0.32 cm/year in the 10<20 cm diameter class to 0.83 cm/year in the 60<70 cm diameter class (Table 9). This indicates that the diameter of dipterocarps increases with higher diameter class which is in accordance with the fact that dipterocarps are more dominant in terms of basal area and volume in the higher diameter class. The results of growth and yield

study in Gunung Tebu Forest Reserve, Terengganu for the period 1974 – 1988 showed that the mean annual diameter increment for dipterocarps at 30cm dbh and above is 0.56 cm/year and for non-dipterocarps at 0.37 cm/year (Yong 1998). The results of growth and yield study in Angsi Forest Reserve in Negeri Sembilan for the period 2001-2005 showed that the mean annual diameter increment for dipterocarps at 30cm dbh and above is 0.72 cm/year and for non-dipterocarps at 0.52 cm/year (Frisco *et al.* 2006).

Table 7. Volume (m^3/ha) for commercial non-dipterocarps

Location of Forest Reserve	Diameter Class (cm)						
	10<20	20<30	30<40	40<50	50<60	>60	Total
Compt. 16 Panti	10.7	49.3	28.8	41.2	28.0	18.6	176.6
Compt. 11 Labis	16.4	57.9	28.5	24.2	2.3	1.6	130.9
Compt. 58 Ulu Sedili	25.5	93.0	94.6	48.0	10.9	7.3	279.3
Compt. 3A G. Arong	29.4	104.9	62.9	24.2	0.0	0.0	221.4
Compt. 579 Labis	18.7	66.7	49.6	34.5	13.6	9.0	192.1
Compt. 148 Maokil	15.3	57.1	57.1	68.4	75.8	50.5	324.2
Compt. 847 Labis	24.0	76.8	55.3	37.1	2.3	1.6	197.1
Compt. 37 Labis	15.2	51.8	31.5	39.2	46.0	30.6	214.3
Compt. 120 Ulu Sedili	13.2	66.7	54.1	36.5	8.0	5.3	183.8
Compt 101 Lenggor	23.7	66.4	49.2	31.9	2.2	1.5	174.9
Compt. 25 Mersing	19.8	76.8	41.7	28.6	2.5	1.6	171.0
Average	19.3	69.8	50.3	37.6	19.2	12.8	208.9

Table 8. Mean annual diameter increment of dipterocarps and commercial non-dipterocarps by diameter class

Species Group	Diameter Class (cm)					
	10<20	20<30	30<40	40<50	50<60	60<70
Dipterocarps	0.32	0.44	0.64	0.65	0.67	0.83
Commercial Non-Dipterocarps	0.25	0.32	0.44	0.45	0.42	0.41
Mean	0.29	0.38	0.54	0.55	0.55	0.62

The mean diameter increment of non-dipterocarps ranges from 0.25 cm/year in the 10<20 cm diameter class to the highest of 0.45 cm/year in the 50<60 cm diameter class (Table 10) . This suggests that diameter increment of non-dipterocarps increases at a lower rate when compared to dipterocarps. As the number of years after logging increases dipterocarps will slowly dominate over the non-dipterocarps in terms of basal area and volume in the higher diameter classes.

The present cutting limits for both dipterocarps and non-dipterocarps commercial is capped at 65 cm dbh for dipterocarps and 55 cm dbh for commercial non-dipterocarps.

Table 9. Mean annual diameter increment (cm) for dipterocarps

Location	Diameter Class (cm) and No. of Tree (n)											
	10<20	(n)	20<30	(n)	30<40	(n)	40<50	(n)	50<60	(n)	60<70	(n)
Compt. 16 Panti	0.28	10	0.46	12	0.56	15	0.8	12	0.59	5	0.07	1
Compt. 11 Labis	0.09	77	0.27	56	0.45	40	0.58	17	0.63	9	0.94	7
Compt. 58 Ulu Sedili	0.14	20	0.31	10	0.68	1	0.54	2	0.43	2	0	0
Compt. 3A G. Arong	0.29	51	0.35	14	0.39	3	0.79	1	0.32	1	0	0
Compt. 579 Labis	0.25	85	0.56	32	0.91	23	0.35	1	0	0	0.84	2
Compt. 148 Maokil	0.47	8	0.34	5	0.7	4	0.49	3	0.38	4	0.17	3
Compt. 847 Labis	0.33	38	0.42	20	0.64	13	0.2	4	0.84	3	0	0
Compt. 37 Labis	0.23	38	0.23	14	0.47	10	0.51	7	0.56	6	0	0
Compt. 120 Ulu Sedili	0.71	24	0.7	6	0.88	4	0.8	1	0	0	0	0
Compt. 25 Mersing	0.38	12	0.54	3	0.53	3	0.4	2	0	0	0	0
Compt 101 Lenggor	0.32	62	0.63	16	0.85	9	1.03	13	1.36	6	0	0
Average	0.32	38.64	0.44	17.09	0.64	11.3	0.65	5.73	0.67	4.50	0.83	3.25

Table 10. Mean annual diameter increment (cm) for commercial non-dipterocarps

Location	Diameter Class (cm) and No. of Tree (n)											
	10<20	(n)	20<30	(n)	30<40	(n)	40<50	(n)	50<60	(n)	60<70	(n)
Compt. 16 Panti	0.29	208	0.33	65	0.49	26	0.46	20	0.39	6	0.34	2
Compt. 11 Labis	0.11	308	0.28	77	0.56	16	0.5	9	0.54	3	0	0
Compt. 58 Ulu Sedili	0.14	380	0.29	143	0.42	56	0.37	29	0.25	8	0	0
Compt. 3A G. Arong	0.2	605	0.34	128	0.36	46	0.36	8	0.19	3	0.2	1
Compt. 579 Labis	0.16	322	0.27	95	0.38	41	0.36	17	0.44	6	0.31	3
Compt. 148 Maokil	0.16	249	0.18	67	0.24	37	0.36	29	0.2	15	0.53	6

Table 10. Continued

Location	Diameter Class (cm) and No. of Tree (n)											
	10<20	(n)	20<30	(n)	30<40	(n)	40<50	(n)	50<60	(n)	60<70	(n)
Compt. 847 Labis	0.29	411	0.3	61	0.33	40	0.37	16	0.01	6	0	0
Compt. 37 Labis	0.15	283	0.21	69	0.33	24	0.38	14	0.48	10	0.68	4
Compt. 120 Ulu Sedili	0.48	257	0.54	76	0.72	38	0.65	11	0.54	8	0	0
Compt. 25 Mersing	0.43	287	0.43	73	0.6	28	0.65	15	1.22	2	0.42	1
Compt 101 Lenggor	0.34	348	0.34	64	0.42	34	0.47	15	0.36	5	0	0
Average	0.25	332.6	0.32	83.45	0.44	35.09	0.45	16.64	0.42	6.55	0.41	2.83

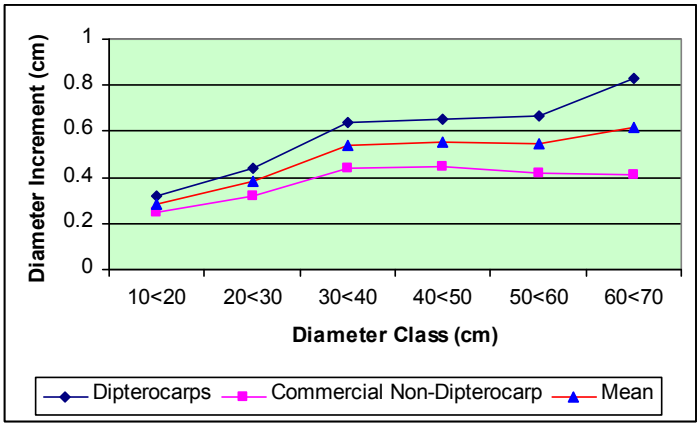

Figure 1. Mean annual diameter increment of dipterocarps and commercial non-dipterocarps by diameter class

Species Composition

Species composition of the eleven (11) growth plots in the State of Johor for the 10 most common species is shown in Table 11.

In term of species composition, Kelat topped the list with 32.62%, followed by Kedondong at 12.07%, Meranti are ranked 5th at 6.32%. However, in term of stocking, basal area and volume, dipterocarps contributed 31 trees/ha or 2.79 % of trees >30cm dbh; 6.24 m2/ha or 21.04% and 83.9 m3/ha or 27.4%, respectively. This trend is very similar in all our natural or logged-over forests where dipterocarps have formed dominant residual stands over time.

Table 11. Species composition of the growth plots

No.	Group of Species	Percentage (%
1	Kelat *(Syzygium* spp.*)*	32.62
2	Kedondong *(Canarium* spp.*)*	12.07
3	Penarahan (*Myristicaceae* spp.)	7.84
4	Medang *(Cinnamomum* spp.*)*	7.14
5	**Meranti *(Shorea* spp.*)***	**6.32**
6	Mempisang *(Annonaceae* spp.*)*	5.85
7	Nyatoh *(Sapotaceae* spp.*)*	2.83
8	Sesendok (*Endospermum malaccense*)	2.39
9	Rengas (*Anacardiaceae* spp.)	2.04
10	Bintangor (*Calophyllum* spp.)	1.38
11	Others	19.52

Mortality

The mortality rates are shown in Table 12. The overall mortality rate of the growth plots study areas in the State of Johor ranges from 0.14 % to 2.36% with the mean of 0.78% (>11 years after logging). In comparison, results of mortality rates from studies conducted by the Malaysia-ITTO Project at Lesong and Sungai Lalang Forest Reserves from 1988-2002 showed that the mortality rate was between 0.5 – 3.2% (5 to 8 years after logging) and 0.4- 2.1% (unlogged areas). It was observed that mortality rates are usually high immediately after logging but with time the mortality will decreases to the normal level. The results from the growth plots in Johor showed that the forest is getting towards the equilibrium state.

Table 12. Mortality rates (%)

Location	Mortality Rate (%)				
	10<30 (cm)	30<50 (cm)	50<70 (cm)	>=70 (cm)	Total
Compt. 16 Panti F.R.	2.26	0.10	0.00	0.00	2.36
Compt. 11 Labis F.R.	0.47	0.00	0.00	0.00	0.70
Compt. 58 Ulu Sedili F.R.	0.63	0.05	0.00	0.00	0.68
Compt. 3A G. Arong F.R.	1.56	0.02	0.00	0.00	1.58
Compt. 579 Labis F.R.	1.56	0.03	0.00	0.00	1.59
Compt. 148 Maokil F.R.	0.52	0.08	0.00	0.00	0.61

Table 12. Continued

Location	Mortality Rates (%)				
	10<30 (cm)	30<50 (cm)	50<70 (cm)	>=70 (cm)	Total
Compt. 847 Labis F.R.	0.23	0.01	0.00	0.00	0.24
Compt. 37 Labis F.R.	0.16	0.00	0.00	0.00	0.16
Compt. 120 Ulu Sedili F.R.	0.37	0.01	0.00	0.00	0.38
Compt. 25 Mersing F.R.	0.14	0.00	0.00	0.00	0.14
Compt 101 Lenggor F.R.	0.36	0.01	0.00	0.00	0.37
Mean	0.75	0.03	0.00	0.00	0.78

CONCLUSION

Much more work needs to be undertaken so as to better understand the structure and regeneration status, as well as the growth and development of logged-over forests. Based on the above data analyses, the following conclusions were drawn. The stocking and basal area of all the eleven growth plots in the State of Johor showed gradual increment over time after logging, with the dipterocarp group gaining increasing dominance with the number of years after logging.The results also showed a general trend towards the original stand composition in most of the logged-over forests. The most important factor in ensuring sustainable timber production in the future is the retention of sufficient numbers of trees of the desired species groups after logging, particularly for size classes between 30 to 45 cm dbh. In this regard, all the compartments recorded a residual stand containing commercial species of more than 32 trees/ha having diameter size of 30 cm dbh and higher. The dipterocarp group was found to be growing faster at the higher diameter classes and thus becoming more dominant in terms of size, basal area and volume contribution towards the stand. It is suggested that the Dipterocarp Forest Growth Simulation Model (DIPSIM) be used to assist the Forestry Department in predicting the next harvest for different forest conditions and harvesting regimes by using the growth data obtained from the 96 growth plots established in Peninsular Malaysia. Basically it is an individual tree based model which allows for the simulation of annual growth in terms of stems, basal area and volume and the effect of different harvesting prescriptions to provide support for decisions in yield prediction. Finally, the monitoring of growth and development in logged-over forests is an important activity in ensuring sustainable management of forest resources. Further analysis of the growth data over longer terms is needed to indicate threshold levels for composition, removal and retention for different forest types. This will assist in fine-tuning the currently employed management practices to achieve sustainable forest management.

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