SMALLER TREES CAN FRUIT IN LOGGED DIPTEROCARP FORESTS

S. Appanah & Mohd. Rasol Abd. Manaf

Forest Research Institute Malaysia, Kepong, 52109 Kuala Lumpur, Malaysia

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APPANAH, S. & MOHD. RASOL ABD. MANAF. 1990. Smaller trees can fruit in logged dipterocarp forests. Currently, the hill dipterocarp forests in Peninsular Malaysia are selectively felled for marketable timber trees >45 (or >50) *cm* dbh. The advanced residuals >15 to <45 (or <50) *cm* dbh are left to form the next crop, as well as provide the seedling regeneration for future crops. However, it is not known if these smaller trees can fruit, early and effectively enough, to regenerate the forests. In this study, the fruiting potential of dipterocarps forming the advanced residuals in a recently logged forest is compared with that in an undisturbed and old regrowth forest. In the recently logged forest, the small dipterocarp residuals (>25 *cm* dbh) could fruit. By comparison, equivalent sized individuals in the old regrowth and undisturbed forests did not; here, the fruiting individuals were generally >35 and >50 *cm* dbh, respectively. The results suggest that dipterocarp forests are potentially capable of regenerating their young crops within a few years after logging, on condition sufficient advanced residuals are present.

Key words: Dipterocarp forests - logging - residuals - fruiting - seedling regeneration

Introduction

The nub of all sustained yield natural forest management practices lies in the regeneration process: future cuts ultimately depend on fruiting and seedling establishment. The only alternative is artificial planting. Therefore, different forest management practices directly or indirectly attempt to maximise the seedling regeneration of desired species.

An example of management where seedling regeneration is directly manipulated is the Malayan Uniform System (MUS) designed for lowland dipterocarp forests in Peninsular Malaysia (Wyatt-Smith 1963). An adequate stocking of seedlings of economic species is a prerequisite before exploitation. If the stocking is inadequate, then tending procedures for seedling regeneration improvement are prescribed.

On the other hand, the Selective Management System (SMS), currently used for managing the hill dipterocarp forests of Peninsular Malaysia (Thang 1987), only indirectly attends to seedling regeneration. Timber trees >45 or >50 *cm* dbh are felled if an economic cut is met, while advanced regeneration from >15 to <45 *cm* (or <50) dbh is left behind to form the next cut in about 25to 30 years. Stocking of seedlings prior to felling is not considered. It is assumed that the seedlings that have escaped logging damage, and those from future fruitings would constitute the third and subsequent cuts.

Since it is not an axiom in the SMS for hill forests to be adequately stocked of desired seedlings before logging, then logged forests would be dependent on the advanced residuals for seedling regeneration. But most of the advanced residuals are small diameter trees - would these fruit early, and effectively regenerate the logged forest is not known? The size of residuals to be retained is based on growth forecasts and cutting cycles; their readiness to set fruit is not considered. This is a matter of concern since observations in undisturbed forests suggest only the bigger individuals of timber species flower and fruit (S. Appanah personal observations). If the advanced residuals in logged forests delay the onset of fruiting, say by a decade or more, such forests would remain understocked of seedling regeneration, and consequently affect future timber yield.

It may also come as a surprise that although hill dipterocarp forests have been exploited for nearly two decades in Peninsular Malaysia, we know little about the fruiting behaviour of the principal timber species in them. The work of Burgess (1972) on *Shorea curtisii* stands out alone. While a reasonable amount of knowledge exists on the fruiting behaviour of dipterocarps in lowland forests (Foxworthy 1932, Woods 1956, Ashton 1969, Fox 1972, Chan & Appanah 1980, Appanah 1985, and several others), there is no information from logged forests.

The gregarious fruiting of dipterocarps in 1989 in several forests in Peninsular Malaysia presented the opportunity to study some of the seedling regeneration issues in logged and undisturbed forests. Here we present a comparison of the sizes of dipterocarp trees that fruited in a logged hill forest, and undisturbed and old regrowth populations from a lowland dipterocarp forest.

Site

The undisturbed and old regrowth populations are located in the Pasoh nature reserve (Lat.2°58.4'N, Longtd.102°16.9'E), in the southwest of Peninsular Malaysia. This is a lowland dipterocarp forest, with an altitudinal range of 80 to 120 *m* above sea level, and is dominated by *Shorea* and *Dipterocarpus* species in the upper storey. The observation sites were Plot 1 (see Ashton 1971, mimeograph), and the Pasoh Arboretum. Plot 1 is a 2-*ha* undisturbed site. The arboretum, a 2-*ha* site too, constitutes an old regrowth forest logged of commercial trees >30 *cm* dbh in about 1955. In 1985, the site was converted to an arboretum. As a result all seedlings and saplings <10 *cm* dbh were removed, and so the ground is very open compared to the undisturbed forest site. Although the crowns of residual trees have fully developed, the canopy is still partially open when compared to the undisturbed site.

The logged forest site is located in the Berkelah Forest Reserve (Lat.4° 15'N, Longtd. 102° 37' E), east of the main range and in the centre of the peninsula.

The forest is a hill dipterocarp forest, with an altitudinal range of 80 to 325 *m* above sea level. The terrain is undulating. The composition of vegetation, before logging approximated that of the lowland dipterocarp forests, with *Shorea* and *Dipterocarpus* species predominating the upper storey. The observation site was selectively logged of all commercial timber trees about three years before the present observations were made. Dipterocarps >50 *cm* dbh and non-dipterocarps >45 *cm* dbh were felled. Adjacent to the site was a logging road. The vegetation cover was quite broken, and most of the residual trees in the sample were fully exposed.

Methods

The diameters at breast height of samples of dipterocarps were measured in the two forests, and the flowering status of each tree noted. In Pasoh, all dipterocarp trees >10 *cm* dbh in Plot 1 and the arboretum were measured. In Berkelah, all dipterocarps >10 *cm* dbh within an area of approximately 1000 × 50 *m*, adjacent to the logging road, were measured.

Results and discussion

The distribution of the diameters differed between the populations in the two localities, and three forest conditions (Tables 1 to 3). The undisturbed plot in Pasoh had the full complement of diameter ranges, including small and big trees. The upper diameter classes were absent in the arboretum and logged forest, the maximum sizes being 87.1 and 56.2 *cm* dbh, respectively (Tables 2 & 3). The big trees were removed from the latter two populations during logging. The mean, median, and range of the diameters of the three populations are given in Table 4.

The sizes of the fruiting trees differed in the three sites too (Tables 1 to 3). The mean dbh of fruiting trees was greatest in the virgin forest (70.2 *cm*), and declined progressively for the arboretum (53.2 *cm*) and the logged forest (40.3 *cm*) (Table 4). The sizes of the fruiting trees in Berkelah were significantly smaller than the virgin plot ($t=3.572$, $P<0.05$) and the arboretum ($t=2.454$, $P<0.05$). That of the virgin plot and the arboretum were not significantly different ($t=1.7165$, $P>0.10$), although the fruiting trees in the arboretum were relatively smaller (Table 2). While small trees (>25.5 *cm* dbh, Table 3) were fruiting in the logged forest, they were less so in the Arboretum (>33.9 *cm* dbh, Table 2), and least in the virgin forest (>53.8 *cm* dbh, Table 1). However, the smallest fruiting tree, only 21.9 *cm* dbh came from the virgin plot (Table 1). This was exceptional as the rest of the fruiting individuals in the population were >53.8 *cm* dbh (Table 1).

Why should smaller trees flower in the recently logged forests while similar sized individuals remain quiescent in undisturbed or old regrowth forests? A reasonable explanation could be based on the climatic conditions experienced by the trees under different forest canopy conditions. It has been shown

Table 1. The dbhs of all dipterocarps >10 *cm* found in Pasoh Plot 1 (fruiting individuals are indicated in **bold**; the observations were made on 30 May 1989)

Dbh class	dbh (*cm*)	Number		
		Fruit	Nil	Total
10.0-19.9	12.5, 13.1, 13.4, 14.5, 14.7, 15.0, 17.1, 17.4, 17.6, 18.7, 19.5	-	11	11
20.0-29.9	20.0, 21.0, 21.5, 21.5, **21.9**, 22.0, 22.1, 22.3, 22.7, 23.3, 23.5, 23.5, 23.8, 25.0, 25.5, 26.0, 26.6, 27.4, 28.3, 28.5, 28.5, 29.9	1	21	22
30.0-39.9	30.4, 31.5, 31.5, 31.7, 31.8, 31.9, 32.0, 32.2,33.4, 33.5, 34.2, 34.3, 35.5, 35.8, 36.6, 36.9, 37.1, 37.5, 39.0	-	19	19
40.0-49.9	40.2, 41.2, 41.3, 42.1, 42.9, 43.4, 46.0, 49.5	-	8	8
50.0-59.9	50.0, 50.4, 52.0, 52.6, 53.0, 53.8, **53.8**, 54.3, **54.7**, 56.3, 56.8, 57.0, 57.0, 58.0, 58.0, **58.5**	3	13	16
60.0-69.9	**60.5**, **60.6**, 60.8, 62.8, 63.0, 63.0, 64.8, **65.8**, **66.8**, 68.9, 68.9	4	7	11
70.0-79.9	**71.2**, 72.0, 78.3, 78.5	1	3	4
80.0-89.9	-	-	-	-
90.0-99.9	**93.0**	1	-	1
100.0-109.9	101.2, 107.5	-	2	2
110.0-119.9	**110.0**	1	-	1
120.0-129.9	120.5, **125.0**	1	1	2
Number of individuals		12	85	97
Fruiting intensity			12.4%	

Table 2. The dbhs of all dipterocarps >10 *cm* found in Pasoh arboretum (fruiting individuals are indicated in **bold**; the observations were made on 31 May 1989)

Dbh class	dbh (*cm*)	Number		
		Fruit	Nil	Total
10.0-19.9	10.5, 12.2, 17.5, 18.0, 18.3, 18.6, 18.6, 18.9	-	8	8
20.0-29.9	20.0, 21.4, 21.8, 22.0, 22.0, 22.0, 22.3, 22.3,22.5, 22.5, 24.9, 25.2, 25.8, 26.0, 26.9, 27.0, 27.1, 27.1, 27.4, 27.4,27.6, 27.7, 29.0, 29.2, 29.5, 29.5	-	26	26
30.0-39.9	30.6, 30.7, 30.7, 30.8, 31.0, 31.4, 31.4, 31.5, 31.7, 32.3, 33.3, 33.5, 33.8, **33.9**, **35.5**, 35.5, 35.9, 36.5, 36.8, 37.3, 37.4, 39.4	2	20	22
40.0-49.9	40.6, **45.2**, **45.2**, **48.7**, **49.4**, **49.4**	5	1	6
50.0-59.9	51.6, 55.6, 59.2, **59.5**	1	3	4
60.0-69.9	**60.4**	1	-	1
70.0-79.9	**71.1**, 71.8, 74.1	1	2	3
80.0-89.9	**87.1**	1	-	1
Number of individuals		11	60	71
Fruiting intensity			15.5%	

that there is a strong correlation between narrow declines in nighttime temperature minima (about 2°*C* below average minimum) for a series of nights (>3 nights) and population or region-wide flowering of dipterocarps (Ashton *et al.* 1988). In pristine forests where the canopy is mostly intact and closed, such nighttime temperature declines are buffered compared to the more open conditions of newly logged forests. This would explain why dipterocarps in logged forests tend to flower more frequently, than those in undisturbed sites the samples were *Shorea* species of Section *Muticae*. These are commonly represented throughout the dipterocarp forests of Peninsular Malaysia. Therefore difference resulting from dissimilarity of species does not bear in this instance.

A certain demurring point of this study is the sample size, only one, a logged plot *versus* a virgin one. It is unlikely, but possible, that trees fruit at a smaller size at Berkelah, irrespective of logging. Furthermore, when comparing fruiting of dipterocarps from two forests which differ in altitude, somewhat in vegetation composition and climate, and are geographically isolated, a difficulty arises. Even between neighbouring forests, concurrent dipterocarp flowerings may differ greatly in intensity. Many factors influence this. Nevertheless, heavy fruiting in undisturbed forests do not include smaller trees. For example, in the exceptionally strong 1976 flowering in Pasoh, some small dipterocarps were observed flowering, but they were mainly in the forest fringes and disturbed sites (S. Appanah personal observations).

So, it is reasonable to conclude that relatively small dipterocarp trees can fruit in some logged forests, while such trees remain non-reproductive in virgin forests. If this is generally true for the forests throughout the region, which is likely, it will have important implications for forest management. The practice in the SMS of leaving behind residuals that are not >50 *cm* dbh need not have adverse implications. Residual trees between 25 and 50 *cm* dbh are capable of becoming reproductive following logging disturbances, and so the potential for regeneration of logged forests is kept.

Other considerations would of course have to be taken into account on the gain purporting from the fruiting of smaller trees in newly logged forests. Questions like do these small trees set sufficient fruits to escape predator pressure? still remain. This will be discussed elsewhere. Moreover, if the advanced residuals are not adequate and well spread out in the forest, then the regeneration would be localised, and patches of forest may remain unproductive. Death of the advanced residuals following heavy logging damage may depress their numbers too.

Conclusion

In the logged forest at Berkelah many of the residuals were capable of fruiting even though small. More surveys are needed to determine the generality of this phenomenon but at this stage it does suggest that forest managers should aim at leaving behind an adequate number of healthy advanced residuals, uniformly distributed in the productive site, to achieve sufficient seedling regeneration stocking. In this respect, similar attention should also be paid to older residuals and cull trees which could act as mother trees.

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