Pertanika1 (2), 126-135 (1978)

Progress of Natural Regeneration after Final Felling under the Current Silvicultural Practices in Matang Mangrove Reserve

P. B. L. SRIVASTAVA and DAUD KHAMIS[1]
Faculty of Forestry, Universiti Pertanian Malaysia

Key Words: Mangrove, Natural Regeneration

RINGKASAN

Kertas ini membincangkan keputusan penyelidikan ke atas kemajuan pemulihan hutan-hutan bakau selepas tebangan, khususnya susunan jenis, pola taburan dan kepadatan stok.

Penyelidikan tersebut telah dibuat di Matang Hutansimpanan Bakau dalam Renj Port Weld. Kawasan-kawasan yang dipilih adalah dari kelas-kelas 'inundation' III dan IV (Watson, 1928) dan mengandungi tumbuhan jenis Rhizophora *yang biasa. Pemulihan di dua kelas umur, iaitu 12 bulan dan 24 bulan selepas tebangan, telah dibanci secara Bancian Linear (LRS).*

Rhizophora *spp. dan* Bruquiere parviflora *adalah jenis-jenis yang penting terdapat di dirian-dirian baki. Bilangan anakbenih-anakbenih* Rhizophora *spp. di kawasan-kawasan 12 dan 24 bulan selepas tebangan adalah 3701 dan 3376 seekar. Bilangan anakbenih-anakbenih* B. parviflora *pula di kawasan-kawasan 24 bulan selepas tebangan merosot secara berkesan, kepada 62 seekar jika dibandingkan dengan 1282 anakbenih-anakbenih seekar di kawasan 12 bulan selepas tebangan. Anakbenih-anakbenih* Rhizophora *spp. tidak mati berluasan di dalam jangkamasa tersebut. Kawasan-kawasan di kedua-dua kelas umur mempunyai bilangan anakbenih-anakbenih yang mencukupi untuk mewujudkan dirian yang bercukupan stok pada hujung giliran sekiranya kematian yang berluasan tidak berlaku.*

SUMMARY

The paper presents the results of an investigation on the progress of regeneration of mangrove forests after logging with emphasis on species composition, distribution pattern and stocking.

The investigation was undertaken in the Port Weld Range of The Matang Mangrove Reserve. The areas chosen belong to inundation classes III and IV (Watson, 1928) representing a typical Rhizophora *type. Two age classes, i.e. 12 months and 24 months after felling, were sampled by means of Linear Regeneration Sampling (LRS 1) method.*

Rhizophora *spp. and* Bruguiere parviflora *were the most important species in the residual stands with 3701 and 3376 seedlings per acre of* Rhizophora *spp. respectively in the areas 12 and 24 month after final felling. There was a significant decrease in the number of* B. parviflora *seedlings in the areas 24 months after felling with only 62 seedlings per acre compared to 1282 seedlings per acre, 12 months after felling. There was no large scale mortality in the* Rhizophora *seedlings with time during this period. At both the age classes, the areas had enough number of seedlings to produce a fully stocked stand at the end of rotation if no large scale mortality occurred.*

INTRODUCTION

In a study conducted simultaneously, Sani (1977) discussed the effect of logging at the time of final felling on different aspects of natural regeneration in a typical *Rhizophora* type in Matang Mangrove Reserve. It was found that though there was heavy damage to the existing seedling crop during logging and transporting operations, there was still a sufficient number of seedlings in the residual stands to give an anticipated yield provided no mortality due to exposure or any other cause occurred.

[1]Amanah Saham Pahang Berhad, Kuantan

This study reports the progress of natural regeneration during the two years after felling in the same locality and type of forest. So far, there has been no quantitative information on the progress of natural regeneration of *Rhizophora* spp. In many areas, natural regeneration is deficient due to yet unknown causes and the State Forest Department has to resort to planting to obtain adequate stocking for sustained yield. Systematic studies are, therefore, needed to determine the progress of natural regeneration of *Rhizophora* species after the final felling in some typical localities.

REVIEW OF WORK

Watson (1928), writing at a time when the current techniques of treating a mangrove stand were only just beginning to be tried out, provides a comprehensive account of these forests which is true to this day.

Noakes (1951, 1952) observed that (i) no systematic investigation into the problem of regeneration had ever been attempted, perhaps because the treatment of mangrove forest had gradually come to be regarded as standardized; and as natural regeneration was expected to succeed over two-third of the annual coupe, planting was not unduly expensive and the rotation was long enough to "even off" the differences, (ii) productive ability of *Rhizophora* spp. was high; fruiting began at four years of age and though the number of seed varied considerably from year to year, there was sufficient seed available to re-stock all felling areas within two or three years, (iii) *Achrostichium aureum* (Piai) which occurred throughout the whole range of *Rhizophora* forest responded readily to full light and acted as a nurse to the existing seedlings; and if there were no seedlings then few could get in through tidal waves. Such areas could only be stocked by retaining seed bearers, (iv) the adverse influence of slash on the regeneration could be minimised by constant vigilance to ensure that all utilizable wood was removed from the felling area, and by lowering the rotation age thereby reducing the crown size of the final crop, (v) water could play an effective role in the dispersal of seeds of *Rhizophora* spp. and in natural regeneration only after the slash and most of the stilt roots of the felled trees had decayed, and (vi) large areas could not be regenerated with coppice seedlings or artificially.

Dixon (1959) questioned the role of the water-borne fruits in the normal process of natural regeneration of *Rhizophora* forest and suggested that the continuous disturbance by subsequent tides was the main cause for poor regeneration; he also pointed out that though the earlier workers had been aware that young seedlings of *Rhizophora* damaged by logging could recover by coppice shooting, there was no information available as to the number of seedlings capable of coppicing after the final felling; he maintained that while the larger blanks were filled up by planting two years after exploitation, the smaller blanks were filled up naturally after about seven years, provided that weeds such as *Derris uliginosa* and *Achrostichium aureum* did not choke the site.

The situation has changed much during the last two to three decades. Firstly, with the rise in population and increased demand for the mangrove wood, the area of exploitation has inadvertently been extended which will require more effort to ensure natural regeneration in the residual stands. This applies to the Peninsula as well to Sabah and Sarawak. Secondly, the high cost of planting and shortage of staff at all levels to regenerate the deficient areas in the stipulated period are likely to restrict future planting. Thirdly, adequate quantities of seed may not be available for planting. Fourthly, large areas of forest have been classified as unproductive in Matang Mangrove Reserve on the grounds that the crop consists of *Bruguiera* spp. Dixon (1959) pointed out that areas now due for felling carry a much greater proportion of this species in the crop. According to Mohd. Darus (1969) more than 500 acres of potential *Rhizophora* forest in Matang Reserve were degraded on account of the presence of *B. parviflora*.

Paul Chai (1974, 1975) draws attention to many problems faced in regenerating the exploited mangrove forests of Sarawak: mounds, wherever they exist, are almost immediately invaded by *A. aureum* which become particularly abundant in the exploited areas; the soil in the area is greyish brown, thick and sticky clay and is non-porous and insufficiently aerated; regeneration of *Rhizophora* spp. and *Bruguiera* spp. on this type of soil was found to be very scarce except on the soft mud near river and stream banks. The seedlings do not get anchored easily, and even if they do, most of them fail to develop. The Sarawak Forestry Department plans to study the enrichment planting of logged-over areas as a means of regenerating the mangrove forests and removal of slash in experimental logging blocks to ascertain the possibility of improving the regeneration environment.

Abdul Manap and Srivastava (1975) have suggested that studies be carried out to ascertain the rate of decomposition of slash after logging and its effect on natural regeneration.

Yusuf (1977) suggested that there is a need for more intensive studies before logging is extended over large mangrove areas because the swampy habitat is also believed to be an important nursery for many species of marine fish and prawns. Recent studies in Sabah have shown that 82 per cent of the prawns exported from Sabah were of a species that spends a greater part of its lfe cycle in swamps and are caught in the coastal waters close to swamps.

Silviculture

The silviculture of the mangrove forests is fairly simple compared to that of the inland forests because the former are more homogenous and uniform. A clear felling system is used. All useless species left behind after harvest are slashed or poisoned. In many worked-over stands, blanks form about 25–30 per cent of thr harvested area. These areas are planted with *Rhizophora* spp. usually two years after logging when most of the slash has decomposed. In the *Achrostichium aureum* dominated areas planting is recommended immediately after logging. The seeds of *R. mucronata* are planted at 6′ × 6′ and those of *R. apiculata* are spaced at 4′ × 4′. The planting operation is normally carried out during the months of July – November to coincide with the fruiting season of *Rhizophora* spp.

There are three thinnings, all mechanical, in a 30-year rotation cycle: I. thinning at the age of 15 years with 4′ stick; II. thinning at the age of 19–20 years with 6′ stick and III. thinning at the age of 25–26 years with 7′ stick. The current silviculture prescriptions are described by Mohd. Darus (1969).

METHOD OF STUDY

(i) *Description of the experimental area*

This investigation was undertaken in the Matang Mangrove Reserve. All the study plots are situated in the Port Weld range (Table 1). The areas chosen for the present study belong to inundation classes III and IV (Watson, 1928) representing a typical *Rhizophora* type which forms the greater part of these swamps. Seventy to ninety per cent of the growing stock is dominated by *Rhizophora* species, *R. apiculata* and *R. mucronata.* The other inundation classes were not covered in the present study because they could be too wet or too dry and would have introduced an additional factor which affects natural regeneration. These sites were selected for detailed sampling because they were typical sites where no factor had apparently adversely affected the progress of natural regeneration. However, a clear differentiation between the two inundation classes is not apparent particularly in regard to the quality of crop and the regeneration environment.

(ii) *Field procedures*

In the collection of data on the composition, distribution, and progress of regeneration and percentage survival of the seedling crop of two age classes, i.e. 12 months and 24 months after logging, Linear Regeneration Sampling procedure (LRS 1) (Anon, 1975) was adopted. This method has been standardized for the assessment of natural regeneration in the inland dipterocarp forests and was successfully used by Liew *et al.* (1977) in Sabah mangroves. A base line was drawn along a convenient boundary, such as a channel or compartment limits, and sampling lines were laid out on this base line at intervals of 10 chains. Milliacre quadrats were laid out contiguous to one another on the right side of each sampling line. The occurrence of seedlings of different species was recorded in the milliacre quadrats by complete count in three height classes, viz., H_0 (0–1′), H_1 (1′–5′) and H_5 (5′–10′).

RESULTS AND DISCUSSION

(1) *Composition of seedling crop*

As many as nine species were recorded in areas 12 months after felling, viz., *Rhizophora apiculata, R. mucronata, Bruguiera parviflora, B. gymnorrhiza, B. sexangula, B. cylindrica, Avicennia* species, *Exoecaria agallochia* and *Heritiera littoralis.* In areas 24 months after felling, the latter three species were not encountered. However, at both stages, *Rhizophora* species were the dominant constituents and *B. parviflora* was the most important associate in terms of frequency, density and abundance. In areas 12 months after felling, *Rhizophora* species seedlings constituted over 70 per cent of the crop (except in plot 3) and together with *B. parviflora,* made up over 99.9 per cent of the seedlings. In areas 24 months after felling, the proportion of *B. parviflora* was further reduced. The crop became more pure with over 96 per cent of the seedlings belonging to *Rhizophora* species, mainly *R. apiculata* (Table 2, Fig. 1 and 2). *R. mucronata* was present in the soft mud along the banks of the rivers and channels. The discussion that follows deals with different aspects of the two most important species.

(2) *Abundance of natural regeneration*

A wide variation was noted in the density of *Rhizophora* species in different plots, 12 months after felling (Table 3). It was possible to deter-

TABLE 1
Sampled sites and date of sampling

Stage	Date of Sampling	Compt. No.	Plot No.	Coupe No.	Area (acre)	No. of milliacre quadrats
1. 12 months after felling	8.11.76	18(A)	1	1/75	30.0	304
	8.11.76	18(B)	2	53/74	32.0	410
	9.11.76	27(A)	3	27/74	34.0	227
	9.11.76	27(B)	4	13/75	24.0	265
Total Acreage					120.0	
2. 24 months after felling	8.10.76	18	5	28/74	43.5	393
	11.11.76	39	6	35/73	46.5	460
	3.11.76	41	7	3/74	20.0	194
Total Acreage					110.0	

TABLE 2
Percentage Stocking by Species

Stage	Plot No.	*Rhizophora* spp.	*B. parviflora*	*Rhizbphora* spp. & *B. parviflora*	*B. parviflora* & other spp.	*Other* spp.
12 months after felling	1	77.09	22.87	99.96	22.91	0.05
	2	85.49	14.44	99.93	14.51	0.07
	3	42.85	57.15	100.00	0.00	0.00
	4	85.23	14.77	100.00	0.00	0.00
	Av.	72.67	27.30	99.97	9.36	0.03
24 months after felling	5	97.08	2.65	99.73	2.92	0.27
	6	98.72	1.04	99.76	1.28	0.24
	7	96.15	1.86	98.01	3.85	1.98
	Av.	97.32	1.85	99.17	2.68	0.83

TABLE 3
Abundance of seedlings in different plots, 12 months after felling

Plot No.		Number of plants per acre	
		Rhizophora spp.	*B. parviflora*
1		5417	1607
2		4088	691
3		1647	2197
4		3654	633
Mean/acre		3701	1282
Standard Error		781	378
S.E.%		21	29
95% Confidence limit	Lower Confidence limit per acre	1219	80
	Upper Confidence limit per acre	6183	2484

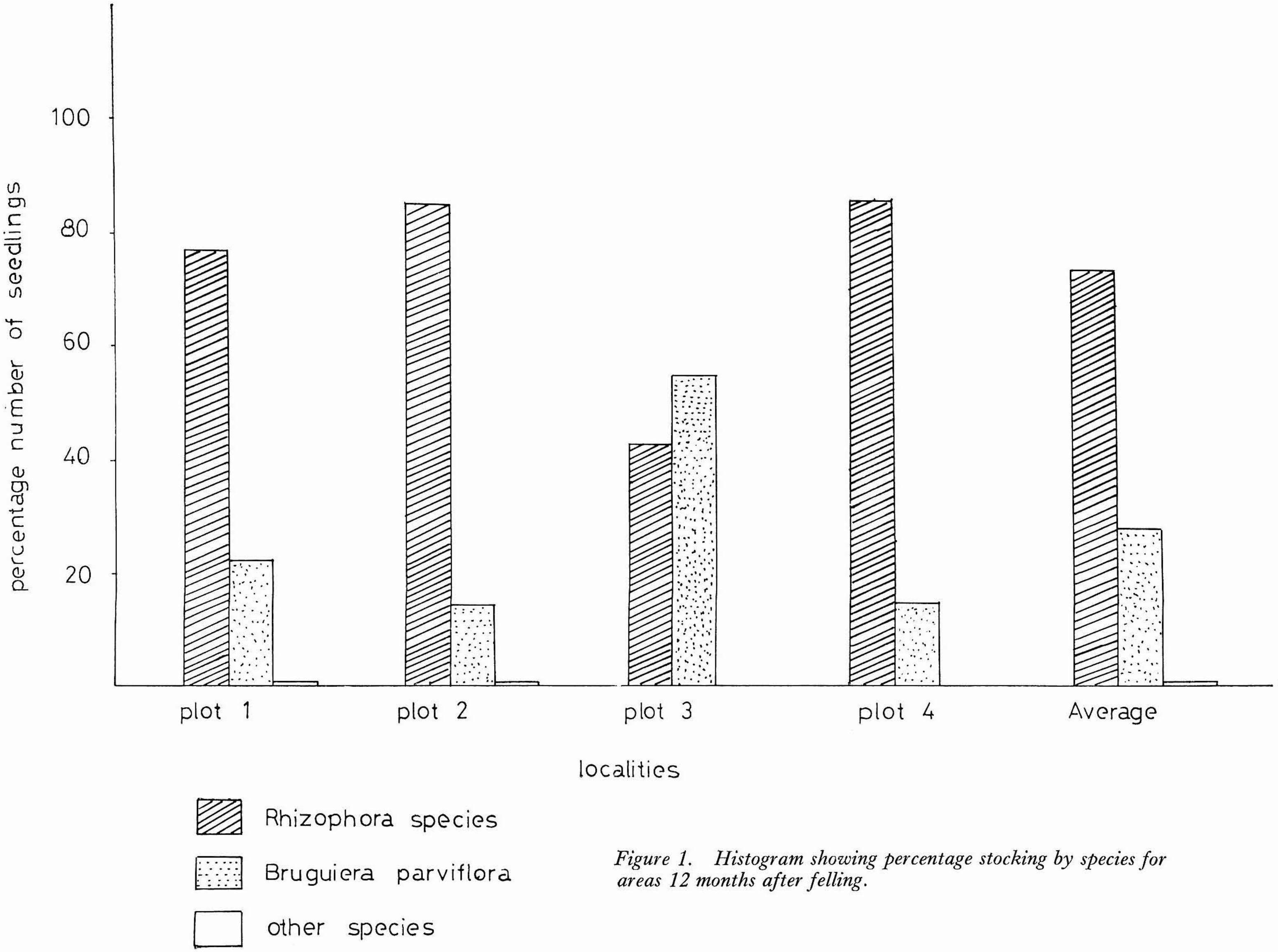

Figure 1. Histogram showing percentage stocking by species for areas 12 months after felling.

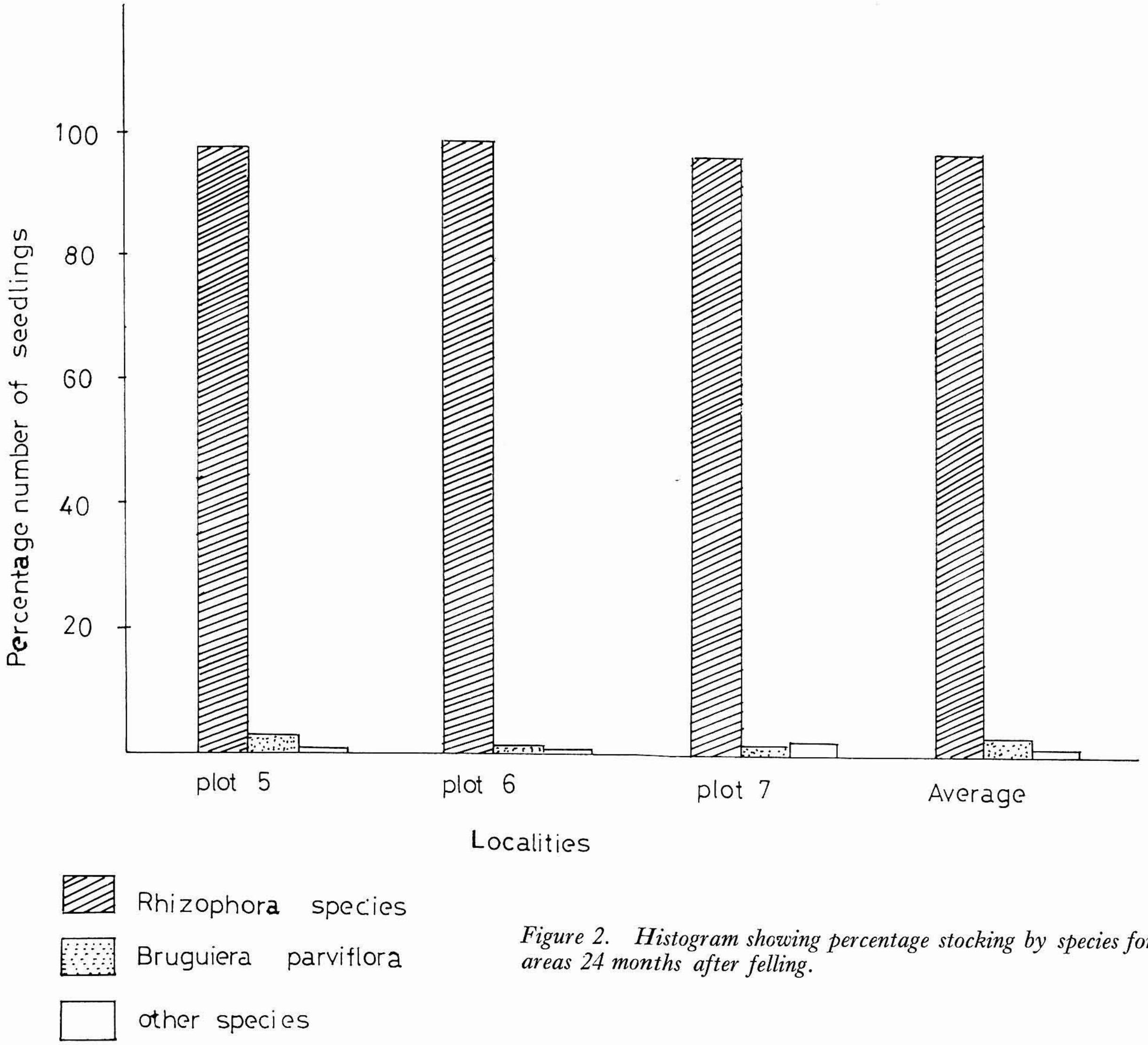

Figure 2. Histogram showing percentage stocking by species for areas 24 months after felling.

mine the coefficient of variation for a complete count of the seedlings was carried out. The maximum number of seedlings (5417/acre) was recorded in plot 1 and the minimum (1647/acre) in plot 3. The variation in the case of *B. parviflora* was greater (c.v. = 59 per cent) than in *Rhizophora* species (c.v. = 42 per cent). *Rhizophora* seedlings outnumbered *B. parviflora* by nearly three times. There were, on an average, 3701 seedlings of *Rhizophora* species per acre with a standard error of 21 per cent and a range of 1219 – 6183 seedlings per acre compared to 1282 seedlings per acre of *B. parviflora* with a range of 80–2482 per acre with a standard error of 29 per cent ($P<0.05$).

At this stage the most abundant height class in both species was H_1 (the seedlings between one to five feet), accounting for 91 per cent of the seedlings of *Rhizophora* species and 85 per cent of *B. parviflora*. The other two classes were poorly represented, H_0 having the least number of seedlings in *Rhizophora* species and H_5 in *B. parviflora*. The number of seedlings of *B. parviflora* was four times that of *Rhizophora* species in H_0 class. But in H_1 and H_5 height classes, *Rhizophora* species seedlings were three and seven times more abundant than *B. parviflora* respectively. These two characteristics i.e. predominance of *Rhizophora* species and *B. parviflora* and H_1 height class appear to be typical of this age group. The two species made up 90 per cent of the residual stand.

The analyses of different aspects of density of seedlings in areas 24 months after felling are shown in Tables 5 and 6. It is evident that the magnitude of variation in the number of seedlings of the two most dominant species i.e. *Rhizophora* species (c.v. = 24 per cent) and *B. parviflora* (c.v. = 36 per cent) was reduced. In the case of *R. apiculata,* the number of seedlings varied between 2526 – 4125 per acre in different plots

TABLE 4
Number of seedlings per acre in different height classes, 12 months after felling

Plot No.	*Rhizophora* spp.			*B. parviflora*			Total			Grand Total
	H_0	H_1	H_5	H_0	H_1	H_5	H_0	H_1	H_5	
1	130	5123	163	243	1333	30	373	6456	193	7022
2	6	4025	56	166	491	34	172	4516	90	4778
3	6	1103	538	115	2003	79	121	3106	617	3844
4	8	3196	450	58	554	21	66	2750	471	4287
Av.	38	3362	302	146	1095	41	185	4457	343	4984
%	1.0	90.8	8.2	11.4	85.4	3.2	3.7	89.4	6.9	–

TABLE 5
Abundance of seedlings in different plots, 24 months after felling

Plot No.		Number of plants per acre	
		Rhizophora spp.	*B. parviflora*
5		2526	69
6		3477	37
7		4125	80
Mean/acre		3376	62
Standard Error		464	13
S.E. %		14	21
95% Confidence limit	Lower confidence limit per acre	1379	6
	Upper confidence limit per acre	5374	118

TABLE 6
Number of seedlings per acre in different height classes, 24 months after felling

Plot No.	*Rhizophora* spp.			*B. parviflora*			Total			Grand Total
	H_0	H_1	H_5	H_0	H_1	H_5	H_0	H_1	H_5	
5	32	2494	0	28	41	0	60	2535	0	2595
6	0	1064	2413	0	13	24	0	1077	2437	3514
7	60	2090	1975	0	15	65	60	2105	2040	4205
Av.	31	1883	1463	9	23	30	40	1906	1492	3438
%	1	56	43	15	37	48	1.2	55.4	43.4	–

with an average of 3376 seedlings per acre and a range 1397 – 5374 ($P<0.05$) and a standard error of 14 per cent. In the case of *B. parviflora,* the number varied between 37 – 80 per acre in different plots with a mean of about 62 seedlings per acre and a range of 6 – 118 ($P<0.05$) and a standard error of 21 per cent. At this stage *Rhizophora* species seedlings were even more abundant, being about 50 times as many as those of *B. parviflora* seedlings.

H_1 was still the predominant height class though the number of seedlings of *B. parviflora* was slightly more in H_5 than in H_1. The proportion in H_1 seedlings, however, decreased substantially from 91 per cent to 57 per cent in *Rhizophora* species and from 85 per cent to 37 per cent in *B. parviflora* within a year. H_0 class was very poorly represented. In all cases *Rhizophora* seedlings were more abundant than *B. parviflora,* H_0 (3 times), H_1 (81 times), H_5 (nearly 50 times). This indicates that there was almost no addition to the natural regeneration in the form of new recruitment during the two years after felling; the present crop of seedlings, which shows progressive height growth, is the one which survived the onslaught of the final felling.

(3) *Mortality*

In general, there was a decrease in the number of seedlings with time after logging. As against an average of 3701 seedlings per acre of *Rhizophora* species 12 months after felling, there were 3376 seedlings per acre of these species 24 months after felling. A much higher rate of mortality was observed in the seedling crop of *B. parviflora.* There were, on average, only 62 seedlings per acre 24 months after felling compared to 1282 seedlings per acre 12 months after felling (Tables 3, 5).

While a low rate of mortality in the seedlings crop of *Rhizophora* may be due to "natural thinning" of the excess number of seedlings in a few over-crowded patches, the cause for the sharp drop in the number of *B. parviflora* seedlings are not easy to find. It may be due to both inter- and intraspecific competition. Almost all species found in the swamp are light demanders and therefore the high rate of mortality of *B. parviflora* seedlings in these areas may be due to shade created by the more vigorously growing *Rhizophora* seedlings. The analysis also showed that most of the dead seedlings of *B. parviflora* were smaller, belonging to height classes less than five feet. The death of the young seedlings could also be due to heat and dehydration brought about by the decomposition and collapse of stilt roots, stumps and other remains of the felled trees with time, thus depriving the young seedlings of shade. The movement of partially decomposed slash during flooding can be another cause. In fact, Watson (1928) considered movement of semi-decomposed slash due to tidal action one of the most important causes of mortality of tender seedlings which accounts for blanks in the logged-over areas. The damage caused by the attack of crabs or monkeys (Noakes, 1951) appears to be negligible in the naturally regenerated stands at this stage. Liew *et al* (1977) also noted large scale mortality of *B. parviflora* seedlings with time.

(4) *Adequacy of natural regeneration*

(i) 12 months after felling

In the inland forests, an area is considered adequately regenerated naturally if it has a minimum stocking of 300 well distributed seedlings of important timber species per acre with an allowance for 10 – 12 per cent mortality (Anon, 1975). However, no such criterion exists for any species of mangrove swamps in the Peninsula. The figure acceptable for inland forests would not apply to the mangrove swamp species because the growth rates of the species and the silviculture system are different.

In the residual stands of the mangrove forests, even if each milliacre plot contains a minimum of one seedling, the stocking would be only 1000 seedlings per acre which is far below the desired stocking needed for the development of a productive stand. It is assumed (Sani, 1977) that the number of stems present at the time of final felling varies between 500 – 800 per acre and planting with *Rhizophora apiculata* is carried out at $4' \times 4'$ yielding 2722 seedlings per acre. The number of stems per acre after the first, second and third thinning will be 2722, 1210, 889, respectively. These computations take into account normal rate of mortality, if any, so as to yield a well stocked stand at the time of final felling. This means that there should be a minimum of three seedlings per milliacre plot in the regenerated stands before the first thinning is carried out if a potentially productive stand for the next rotation is to be developed.

On the basis of the above assumption, for an area to be adequately stocked, there must be at least 54.45 per cent of the total milliacre plots with five seedlings each, or 68.06 per cent containing at least four seedlings per plot, or 90.75 per cent with at least three seedlings per plot in order to have at least 2722 stems per acre at the time of first thinning.

The average number of the seedlings (irrespective of height) of the preferred species (*Rhizo-*

phora spp.) per acre is more than 2722 except in plot 3 which carried only 1647 seedlings per acre (Table 3). The analysis of the basic data further indicates that the seedlings are evenly dispersed in all the stands sampled in the present study. As many as 60 per cent of the plots had two or more seedlings and the blanks constituted only about 25 per cent of the plots. This is probably due to the fact that the crop on the most productive sites in this area is homogenous, mainly of *Rhizophora* species.

Plot 3 (Tables 3 and 4) shows an interesting distribution pattern of *Rhizophora* species and *B. parviflora* seedlings. The site seems to favour the growth of the latter. By studying such sites in detail it is possible to identify the factors responsible for the emergence of this 'weed' species on a large scale in a typical and potential *Rhizophora* stand after final felling.

(ii) 24 months after felling

At this age also, as is evident from the tables 5 and 6, plots 6 and 7 have more than an adequate number of seedlings of the preferred species on the same criteria. Only plot 5 is slightly understocked. However, the percentage of blank plots is increased slightly indicating that there has been no new recruitment during this period either through water-borne seeds or from the seed bearers. It was surprising to note that there was a significant decrease in the number of *B. parviflora* seedlings during this period. It comprised only 2.5 per cent of the total area. This appears contradictory to the observations of workers who had noted that this species tended to increase in number with age in the regenerated stands. It is probable that the incidence of *B. parviflora* after felling is greater in other inundation classes, such as V and VI, though it may dominate even potential *Rhizophora* stands, as in the case of plot 3 (Tables 3 and 4). Similar observations were made by Dixon (1959) and Mohd. Darus (1969). It is also possible that *B. parviflora* might start appearing three or four year after felling, ultimately forming an important associate of *Rhizophora* species. Further studies of more age classes, at least up to the stage of I thinning, and in the remaining inundation classes, need to be undertaken to determine the factors responsible for the predominance of *B. parviflora* in a typical *Rhizophora* type.

It was further noted that the number of *Rhizophora* seedlings of H_1 class had gone up to 1463 per acre (Table 6) as against only 302 seedlings per acre (Tables 4) during the period of one year. This indicates the rate of growth of this species under favourable conditions. On the other hand there was a sharp drop in H_1 height class of *B. parviflora* seedlings from 1095 seedlings per acre (Table 4) at 12 months after felling to only 23 seedlings per acre (Table 6) at the end of 24 months. The probable reasons for this decrease have already been stated.

CONCLUSIONS

On the basis of the present study in a *Rhizophora* species dominated forest on inundation classes III and IV, the following conclusions can be drawn:

1. *Rhizophora* spp. and *B. parviflora* are the most important species in the residual stands at 12 and 24 months after felling. Seedlings of other species are rarely present.

2. There is no large scale mortality in the *Rhizophora* seedlings with time.

3. A large number of *B. parviflora* seedlings died between 12 and 24 months after final felling probably because of severe competition from *Rhizophora* seedlings, or exposure and dehydration, or both.

4. Most of the stands sampled in the present study were found to be adequately stocked, 12 and 24 months after felling.

ACKNOWLEDGEMENTS

The authors are indebted to the Director of the Perak State Forest Department and Encik Nik Answar bin Nik Salleh (A.D.F.O. Taiping) for permission and help in various forms to carry out the survey. Thanks are also due to Enchik Zainuddin, En. Khairi, and En. Majid, members of the staff of Port Weld Range, for their assistance.

Special thanks are due to Professor Haji Abdul Manap Ahmad, the Dean Faculty of Forestry, Universiti Pertanian Malaysia, for approval of the project, and for his encouragement, critical suggestions, and for providing the field staff (Encik Harun, Encik Rahim, Encik Haidzir and Encik Ahmad). The authors are also thankful to Dr. G.M. Bonnor and Mr. M.N. Asthana for their help in the data analysis.

Lastly, one of us (DK) wishes to thank his friend Abdullah Sani and his family for their hospitality during the period of his stay at Taiping.

REFERENCES

ABDUL MANAP AHMAD and SRIVASTAVA, P.B.L. (1975): Effects of logging in mangrove vegetation in Peninsular Malaysia. U.P.M. (Unpublished).

ABDULLAH SANI BIN SHAFFIE. (1977): Effect of logging on the natural regeneration of *Rhizophora* species under the current silvicultural practices in Matang Mangrove Reserve. B.S. Thesis (Unpublished), Universiti Pertanian Malaysia.

ANON. (1975): A guide to Linear Regeneration Sampling One (LRS – 1). Pamphlets, Forest Department, Malaysia.

DIXON, R.G. (1959): A working plan for the Matang Mangrove Forest Reserve, Perak. Forest Department Publication.

LIEW, T.C., DIAH. MOHD. NOR, and WONG, Y.C. (1977): "Mangrove exploitation and Regeneration in Sabah." A New Era in Malaysian Forestry. Kuala Lumpur (Ed. Sastry, Srivastava and Manap), Universiti Pertanian Malaysia.

MOHD. DARUS HJ. MAHMUD. (1969): Rancangan Kerja bagi hutan simpanan paya laut Matang Perak. Forest Department Publication.

NOAKES, D.S.P. (1951): Notes on the Silviculture of the Mangrove Forests of Matang, Perak. *Malayan For.* **14(4)**: 183–196.

—— (1952): A working plan for the Matang Mangrove Forests, Perak. Forest Department. Federation of Malaya Publication.

PAUL, P.K. CHAI. (1974): The potential of Mangrove Forests in Sarawak. *Malayan For.* **37(4)**: 284–288.

—— (1975): Mangrove Forest of Sarawak. *Malayan For.* **38(2)**: 108–110.

WATSON, J.G. (1928): Mangrove Forests of the Malay Peninsula. *Malayan For. Rec.* **(6).**

YUSUF NAIR. (1977): An appraisal of the economic potential of Mangrove swamps, M.S. Thesis (Unpublished), Universiti Pertanian Malaysia.

(Received 28 August 1978)