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MANGROVE EXPLOITATION AND REGENERATION IN SABAH

by

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Summary

The current management system in the exploitation of mangrove wood for chips is briefly outlined. The forest conditions following logging are examined. The study shows that Beus Forest type carries an average stocking of 6,148 per hectare including seedlings compared to 8,699 per hectare in Bakau/Bangkita Forest type. Density of stocking varies remarkably in the latter where it was found that the abundance of regeneration generally decreases from coast inland. The pattern of species distribution after logging shows that *Bruguiera parviflora* and *Rhizophora apiculata* are the dominant species of Beus Forest and Bakau/Bangkita Forest types respectively. Approximately 61% of the stocking recorded in the former whereas 70% in the latter are under 5 ft. in height.

It was found that in Beus Forest type the survival percentage of the stocking ranges from approximately 18 to 58% 28 months after felling. The causes of the high mortality rate are not known. The authors conclude that mangrove logged-over forest should be sampled at an acceptable intensity and interval to determine the success of regeneration in view of the continuous high mortality rate under the current management system.

Introduction

The coastal belt of Sabah is characterised by mangrove swamp forests covering an area of 365,345 hectares (fig. 1). Those mangrove forests extend many kilometers along major waterways. The Sabah Forest Inventory report (1973) covers a great deal of detail pertaining to stocking, species and size class distribution of all mangrove forest types. This information has been useful for management and yield prediction. However, the report does not cover management systems and stocking of seedlings and small pole-size trees in the regenerating pool.

The economic importance of mangrove forests, past and present has been outlined by Liew (1970). As two chipping plants are already established in Sabah, mangrove forests will continue to play an important part in the social economic development of the State. For example, apart from the earnings derived from revenue and foreign exchange each of the chipping complexes employs more than 1,500 workers. Therefore, continuous supply of mangrove wood for the mills should be assured and management of mangrove forests should be in line with sustained yield principles. In this context, mangrove forest should be successfully regenerated following exploitation. To date no work has been written on regeneration studies of

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mangrove forests following large scale exploitation in Sabah. The aim ot this paper is to examine the abundance, species distribution and mortality of the residual stand including seedlings following exploitation.

Management

Prior to 1970 mangrove extraction was confined to a small scale. Cutting of mangrove forests never exceeded 300 hectares per annual coupe at one locality. In all cases selection felling in the form of a minimum girth system was adopted. The girth limit imposed varied with the management and utilization objectives. For example, for those forests alloted for production of charcoal all commercial mangrove species less than 20.5 cm (8 inches) diameter were classed as prohibited trees. On the other hand in the exploitation for firewood or fishing stakes the minimum diameter imposed was down to 10.16 cm (4 inches). In either case the forests were subject to clear felling if the forests were even sized or even aged. Owing to the small scale of exploitation no problems were experienced in regeneration.

In 1970 the Forest Research Branch was directed to explore the various mangrove management systems practised in other countries and to formulate a practical management system for extraction of mangrove wood for chips. This was considered necessary as the annual cut amounts to 2.000 - 4,000 hectares at one locality which might lead to severe coastal erosion should the forests fail to regenerate. The management system formulated was partly based on the study done by Liew (1970). He found that those mangrove forests which were exploited in the past carried uneven-sized stands and the component of trees smaller than 10.16 cms diameter (4 inch) excluding seedings is not less than 600 stems per hectare (Liew 1970). This finding formed the basis of the current management system i.e. Minimum Girth System. The details of the system may be summarised as follows: -

1. A belt of half chain of mangrove forest along the coast or estuaries, or waterways is forbidden to be exploited or disturbed. It serves to prevent soil erosion and acts as a seed source for regeneration.

2. All commercial species greater than 10.16 cm (4 inch) diameter are to be felled and removed except in areas where the stand is even-aged or even-size, where seed tree retention should be imposed. 40 seed trees per hectare may be retained. The mangrove officer is responsible for imposing this regulation where necessary. Upon failure to extract and remove commercial trees as specified the company may be fined up to M$ 10 per tree. Normally this ruling is not imposed because any commercial trees left standing may serve as seed trees.

3. Non-commercial species such as *Avicennia* sp. and *Xylocarpus granatum* greater than 10.16 cm diameter must be felled by the companies though removal of these species from the site is optional. The companies may be fined up to M$ 10 per tree if they fail to comply with this regulation. This ruling is imposed with the intention of eliminating the non-commercial species from the stand.

4. The felling operation must be systematic. Several compartments may be worked at one time but extraction in these compartments must be completed before further compartments are allowed to be opened.

The management system is similar to that practised in Indonesia. According to Versteegh (1952) *Rhizophora* forests had been successfully managed by clear felling with retention of 40 seed per hectare evenly distributed. As *Rhizophora* species are light demanders opening up of forest canopy would stimulate the growth of seedlings provided that they are not exposed to extreme environmental factors e.g. high temperature and strong wind or similar agencies.

Regeneration

As heavy equipment is not used in mangrove extraction, it is expected that damage to regeneration would be negligible. Corpuz (1972) has given an account of the method of felling and transportation. Basically trees are felled by chainsaw, cut up into billets, and manhanded into small boats or small rail trucks. In short timber extraction is mainly manual requiring a large labour force (Corpuz 1972). This would suggest that the amount of regeneration before and after logging should be almost the same.

Abundance of Regeneration

The density of seedlings and residual trees is variable (Table 1 & 2). The variation in stocking appears to be less in Cowie Harbour Forest Reserve (Table 1). From the 9 randomised 0.1 acre sample plots (0.047 Ha) the mean stocking is 6,148 per hectares (2,488 per acre) with a standard error of 16.77%. According to the inventory report the forest around Cowie Harbour is classified as Beus Forest type. Though the sampling intensity is low the results indicate that the stocking following logging ranges from 3,771 to 8,525 seedlings hectare — 1 at the 95% confidence limit.

The results obtained from Elopura Forest Reserve under the same sampling method seem unreliable as the abundance of seedlings and residual trees ranges from 21 to 802 per plot (0.047 hectare). According to the analysis, the mean is 4,253 trees per hectare with a standard error of 44.1%. This forest is classified as Bakau/Bangkita type. As there is great variation in the sampling results, it was decided that Systematic Linear Milliacre

TABLE 1

ABUNDANCE OF SEEDLINGS TWO MONTHS AFTER LOGGING
(Plot size = 0.04 hectare)

Plot No.		Tawau (Cowie Harbour F.R.)	Elopura F.R.
		No. of trees	No. of trees
1		87	348
2		234	21
3		241	77
4		209	105
5		218	69
6		472	38
7		305	76
8		—	48
9		90	138
10		384	802
Mean/Plot		248.89	172.2
Mean/hectare		6,148	4,253
Standard Error		41.74	75.9
SE %		16.77	44.08
95% confidence Limit	Lower per hectare	3,771	12
	Upper per hectare	8,525	8,494

Sampling (LSM) should be used to provide a better perspective of the stocking. Table 2 shows the density of regeneration from coast inland. Generally the abundance of seedlings per unit area decreases as sampling moves inland. For example the sea front belt (0 – 5 chains) carried an average stocking of 23,650 per hectare compared to 3,976 per hectare in areas 45 chains away from the shore. The less regeneration in inland areas may be caused by environmental factors. It seems evident that more accurate assessment of stocking could be obtained if the forests are stratified according to the perpendicular distance to the shore. However, the abundance of seedlings and residual trees in various zones is high according to 4 lines of linear milliacre sampling (Table 2).

Species and size class distribution

The most abundant single species recorded in Beus Forest type is *Bruguiera parviflora* amounting to 57.88% of the regenerating stand (Table 3). The other species constituting the remaining percentage in the order of abundance are *Rhizophora apiculata, Rhizophora mucronata,* Ceriops tagal and *Xylocarpus granatum.* All species recorded are commercial with the exception of *Xylocarpus granatum* which forms approximately 3% of the population.

The Bakau/Bangkita Forest type is dominated by *Rhizophora apiculata* comprising 56.11% or 2,368 per ha. of the regenerating stand from the study of ten 0.1 acre randomised plots (Table 4). From the systematic sampling using L.S.M., *Rhizophora apiculata* was also recorded as the most abundant species (Table 5). The other species recorded in the order of abundance are *Rhizophora mucronata, Ceriops tagal, Xylocarpus granatum, Bruguiera parviflora* (Table 4, 5). From Table 5 it may be noted that *Rhizophora mucronata* occurs as far as 45 chains from the sea coast though the distribution of the species is normally confined to a narrow belt near the sea. From this trend of distribution this species may occur beyond this belt. It is also interesting to note that *Rhizophora apiculata* shows a decreasing trend in population from coast inland. The pattern of distribution may reflect that there is frequent inudation coupled with deep mud formation.

The regenerating forest types under study show remarkable resemblence in size class distribution. Approximately 60.9% of the stand in Beus Forest type is under 5 feet in height compared to just over 70% in Bakau/Bangkita Forest types. About 10% or 267 stems per acre are over 5 cm in girth in Beus Forest type (Table 3). These are the potential trees which we hope will grow into large size trees in the next cut. In the case of Bakau/Bangkita Forest type trees larger than 5 cm girth only constitute about 5% or 88 stems per acre (Table 4).

Mortality

The study of the regeneration of Bakau/Bangkita Forest type (R.P. 410) was established recently. To date no data are available on mortality in this forest type. This section only covers details of mortality rate of regenerating mangrove Beus Forest type (R.P. 375) which was established more than 2½ years ago.

The results indicate that seedlings die at a high rate during the period of 28 months from felling (Table 6). The percentage of survival varies from one plot to another, ranging approximately from 18% recorded in plot No. 1 to 58% in plot No. 2 : the end of 28 months. The results surprisingly show that mortality rate is unaffected by density of seedlings. (Table 6). There is also no evidence from the study indicating that mortality rate

would decline with time from felling. From further analysis data show that most of the dead seedlings were small belonging to size class of less than 5 feet in height mainly of *Brugueira parviflora*.

28 months from felling, the stocking with the exception of Plots 1 and 9 was adequate, averaging 890 seedlings and or small pole-sized trees per acre, for development into productive high mangrove forest provided that the mortality rate of seedlings would be on the decline. The present study could by no means predict whether a Beus Forest type dominated by *Bruguiera parviflora* can be successfully managed by a minimum girth system.

The causes of the high mortality are not known. Competition may be considered as one of the factors in those densely stocked plots e.g. 7 of the 9 plots under study are stocked with well over 200 seedlings per plot or 2,000 per acre. On the other hand the most abundant seedlings and or pole-sized trees are under 5 cm girth and competition cannot account for the major cause of mortality. However, according to past observation *Brugueira parviflora* as seedlings or as small pole-sized trees as sensitive to exposure e.g. high temperature, wind etc. These agencies may have been responsible for the high casualty rate.

The mortality study was based on the results of eight 0.1 acre plots over a period of 28 months from felling. In view of the low sampling intensity the authors suggest that the exploited mangrove forests should be sampled at a higher intensity at intervals of two years. This will provide more accurate information for foresters to determine the adequacy of the current management system.

Conclusion

The study indicates that logged-over mangrove forests carry dense regeneration immediately following logging. In the case of Beus Forest type it was found that young seedlings of *Bruguiera parviflora* continue to die at a high rate as a possible result of canopy opening. In the light of this high mortality, the regeneration of this forest type warrants further investigation. The authors suggest regeneration should be sampled at a higher intensity and regular intervals to determine further the adequacy of the minimum girth system, for if the system failed to work it would result in serious coastal erosion after exploitation.

Though no detailed data are available for regeneration of Bakau/Bangkita Forest type, it is expected that mortality rates of young seedlings will be lower as *Rhizophora* spp. are light demanders.