NATURAL REGENERATION AND REFORESTATION IN THE PEAT SWAMP FORESTS OF SARAWAK

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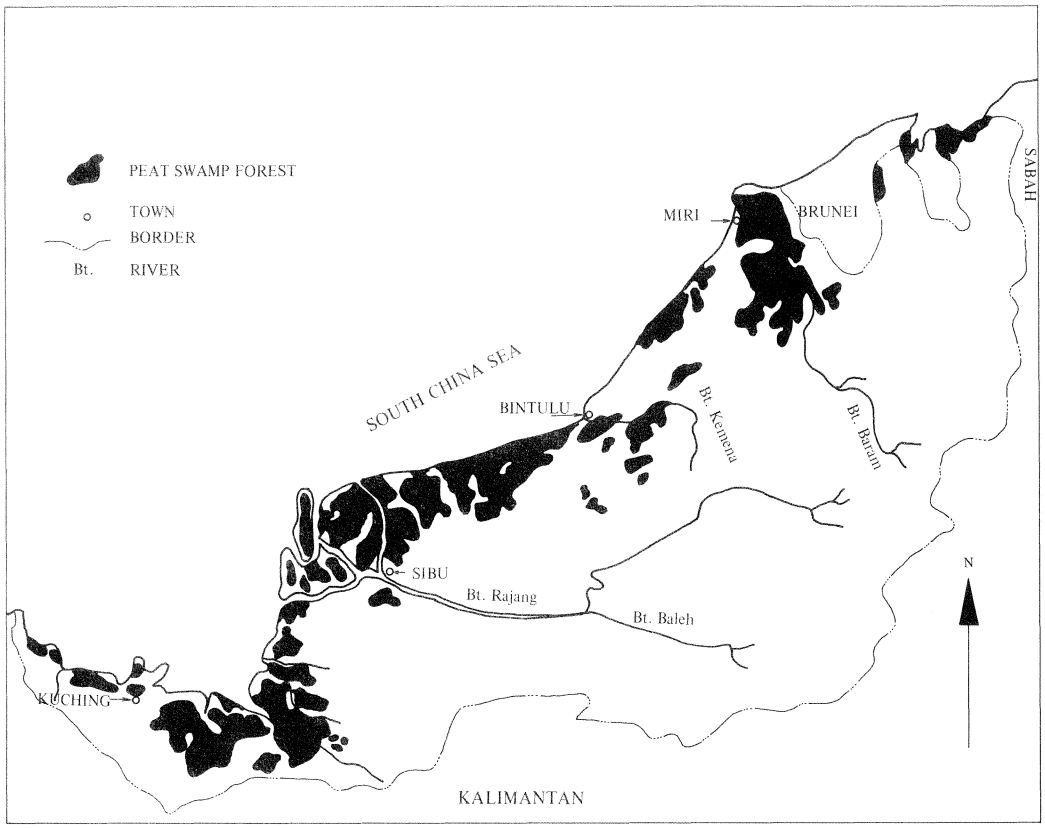
Introduction

The Peat Swamp Forests have played a major role in the economic development of the State of Sarawak since 1947. In fact, they were the first forests to be logged commercially due to their easy access and the occurrence of the highly valuable timber species Ramin *(Gonystylus bancanus)*.

The Peat Swamp Forests are located immediately behind the coastline and extend inland along the lower reaches of the main river systems. The forests extend over approximately 1.5 million hectares and the distribution falls into three distinct areas of concentration as illustrated in Map 1, in the vicinity of the towns of Simanggang, Sibu and Miri.



Map 1 The peat swamp forests of Sarawak

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Distribution and physical structure of the peat swamps

The distribution of the Peat Swamp forests is given in Table 1. It is to be noted that the entire area of the Peat Swamp Forests is public land. However, only 47 percent (Forest Reserves and Protected Forests) is under the legal control of the Forest Department.

Table 1 Distribution of peat swamp forest ('000 hectares)

Forest type	Forest reserves and protected forests	Stateland forests	Total
Mixed Swamp Forest	435	739	1,174
Alan Batu Forest	114	13	127
Alan Bunga Forest	68	8	76
Padang Alan Forest	37	4	41
Padang Paya Forest	35	2	37
Total	689	766	1,455

The peat swamps are physically characterized by a convex structure which becomes increasingly pronounced the further the swamps are from the sea. The coastal swamps on the island of Pulau Bruit, for example, rise, in the form of a dome, the central point of which is 4 metres higher than its outer margin whereas in the inland peat swamps of Naman Forest Reserve, the centre of the dome lies some 9 metres higher than the outer margins.

The gradient of the dome structure is steepest near to the perimeter; in the case of the Naman Swamps, a gradient of 7 metres was recorded in the first mile. Towards the centre, the gradient can be as low as 0.3-0.6 metre per mile.

The depth of the peat tends to increase with distance from coast e.g. 7 metres in Pulau Bruit compared to 15 metres in Naman.

Studies (Anderson, 1961) into the structure and development of the Peat Swamp Forests suggest that they represent a succession from coastal mangrove swamps through the build-up of land as the mangrove extends seawards.

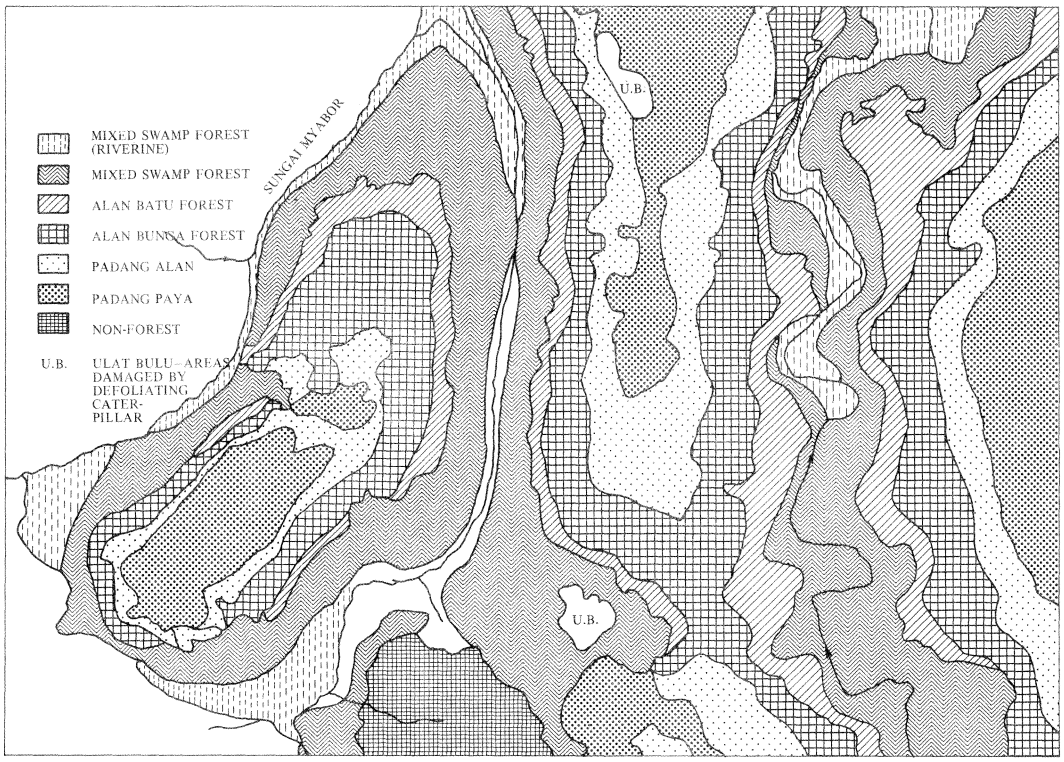
The peat is a mass of semidecomposed and undecomposed woody material containing roots, branches and tree trunks at all levels. Reports on laboratory tests of peat samples from the Loba Kabang area indicated a loss on ignition of 76 to 94 percent. The same samples had pH values of 3.9 to 4.2. Samples from the centre of a peat swamp at Labok Pasir had a loss on ignition of 98 to 100 percent and pH values of 3.3 to 4.2. Plant nutrients are extremely low.

The subsoil of the peat swamp is a stiff clay which is white or yellow in colour.

Forest types in the peat swamp forest

There exists in the Peat Swamp Forest a catena of forests from the edge to the centre of each peat swamp. Anderson divided this into six types or phasic communities which are distinct in structure, physiognomy and flora. Not all 6 types are developed everywhere. A summary of Anderson's work has been provided by Whitmore (1975).

For practical planning, the Forest Department has grouped the various phasic communities into five distinct forest types each of which occurs in a precise and reasonably predictable pattern in the form of concentric rings which surround the convex dome structure within each individual peat swamp.



Map 2 Forest type map, Beluru forest reserve (Part)

The pattern of forest type location is illustrated in Map 2. The pattern is generally in the following sequence:

Mixed Swamp Forest on the outer rim
Alan Batu Forest
Alan Bunga Forest
Padang Alan Forest
Padang Paya Forest at the apex of the dome

A brief description of each forest type is given in the Appendix.

Management and logging in the peat swamp forest

The old-growth peat swamp forest is worked on an empirical harvesting period of 45 years. A series of Regional Management Plans (R.M.P.) has been drawn up for the swamp forest. Each R.M.P. usually encompasses a group of permanent forest areas (management units), each of which is self-sustaining.

Prior to licensing the forest for logging, an inventory is taken of the forest area from which a reliable minimum estimate of the timber volume above a desired cutting limit is obtained. Based on

this estimate, the annual cut is then prescribed for each of the areas covered by the R.M.P. An area of forest that would give the annual yield is then demarcated as the annual coupe. The minimum girth limits may vary slightly between concessions but generally are:

(i) 106 cm. overbark for Ramin (*Gonystylus bancanus*)

(ii) 140 cm. overbark for

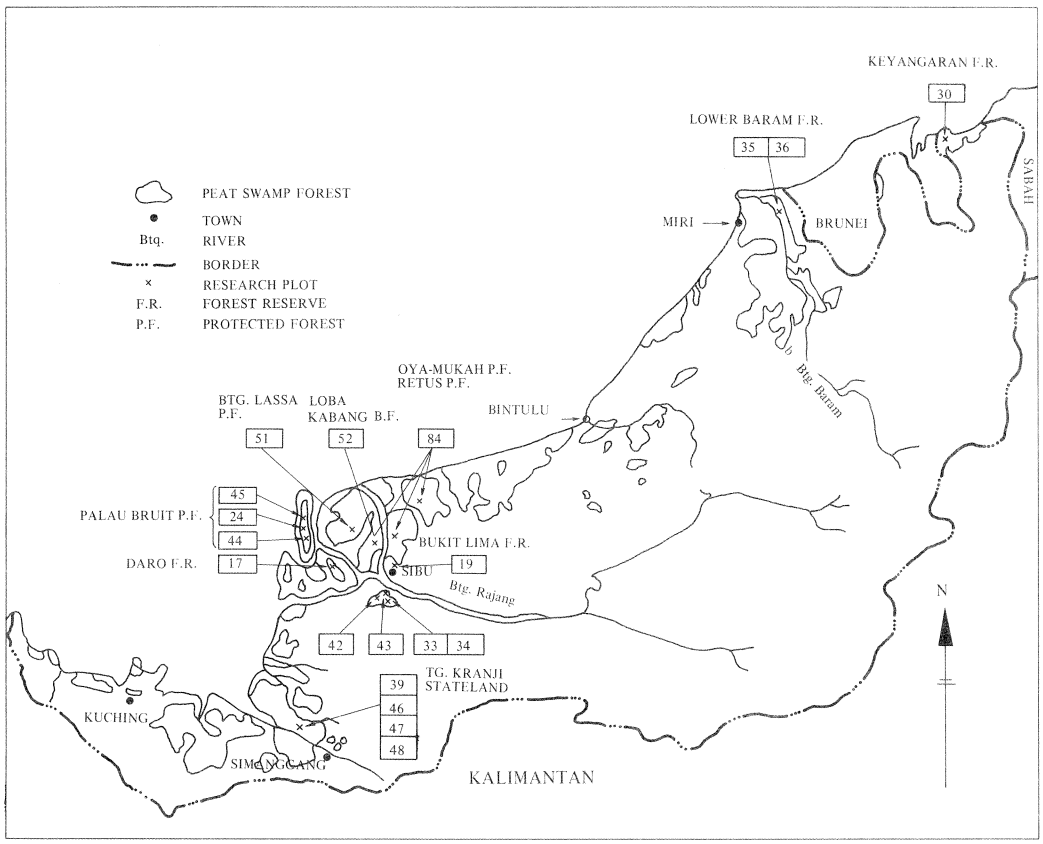
Kapur (*Dryobalanops rappa*)
Jongkong (*Dactylocladus stenostachys*)
Sepetir (*Copaifera palustris*)

(iii) 148 cm. overbark for all other species.

Approximately 12,000 hectares of the Peat Swamp Forests in the permanent estate are logged annually. The average commercial yield is 85 m^3 per ha. Of the swamp species, Ramin has the highest value. Over the last eight years from 1970-1977, there has been an annual increase of 6 percent in real value of the sawnwood production from the peat swamp forests 95 percent of which consists of Ramin.

Research studies in the peat swamp forests

A list of silvicultural research investigations in the Peat Swamp Forests is given below. The location of the various research plots is given in Map 3.



Map 3 Location of research plots in peat swamp forest of Sarawak

Investi-gation	Title and description	Status as of June 1, 1978	Research plot No. (Year established)	Forest area
1	Amount of Regeneration of desirable species present after exploitation in Mixed Swamp Forest	Active	Diagnostic Sampling	Throughtout Sarawak
2	To determine if silviculture is worthwhile in poor quality logged MSF (forest types 3.1 and 3.5 in the Sarawak Inventory Code)	Closed	Regeneration Sampling	Matu-Daro P.F.
3	Effect on undergirth trees of girth-limit fellings in MSF	Active	24, 33 (1953, 1957)	Pulau Bruit P.F. Naman F.R.
4	Effect on the regeneration of desirable species of 4 poisoning treatments in MSF 10 years after logging (Series 1)	Active	42 (1961)	Naman F.R.
5	Effect on the regeneration of desirable species of 4 poisoning treatments in MSF 10 years after logging (Series 2)	Active	43, 44 (1961)	Naman F.R., Pulau Bruit P.F. P.F.
6	Effect of a second silvicultural treatment designed to favour the leading desirables in MSF first treated 24 years previously	Active	17 (1940)	Daro F.R.
7	Growth of Ramin (*Gonystylus bancanus*) in virgin MSF	Closed	19, 30 (1954)	Bukit Lima F.R., Kayageran F.R.
8	Effect of key tree poisoning on the growth of Ramin in virgin MSF	Closed	19 (1950)	Bukit Lima F.R.
9	Survival and growth of planted seedlings of Ramin	Closed	–	Bukit Lima F.R.
10	Effect on the regeneration of Ramin of 4 poisoning treatments designed to favour this species in MSF 10 years after logging	Dormant	45 (1962)	Pulau Bruit P.F.
11	Relative Importance of some factors in the cost of G1 silvicultural treatment in MSF	Active	Office investigation	
12	Numbers of trees of different species in the broad size classes being poisoned in G1 silvicultural treatment in MSF with a view to amending the lists of obligatory and desirable species	Active	Office investigation	
13	Effect on the regeneration of desirable species of 6 poisoning treatments in heavily felled MSF immediately after logging	Active	52 (1969)	Loba Kabang (S) P.F.

Investi-gation	Title and description	Status as of June 1, 1978	Research plot No. (Year established)	Forest area
15	Amount of regeneration of desirable species present immediately after felling in Alan Swamp forest	Active		Regeneration Sampling throughout Sarawak
16	Effect on undergirth trees of girth-limit felling in Alan Swamp forest	Dormant	34 (1957)	Naman F.R.
17	Effect on the regeneration of desirable species of 2 poisoning treatments in Alan Swamp forest immediately after logging	Dormant	51 (1968)	Batang Lassa P.F.
18	Survival and growth of naturally-regenerated Alan (*Shorea albida*) in logged Alan Bunga forest	Closed	35, 36 47 (1956, 56, 65)	Lower Baram F.R. Tg. Kranji Stateland
19	Survival and growth of planted wildings of Alan (*Shorea albida*) in Alan Bunga forest immediately after logging	Active	39 (1962)	Tg. Kranji Stateland
20	Suitable spacing for planting wildings of Alan (*Shorea albida*) in Alan Bunga forest immediately after logging	Active	46 (1965)	Tg. Kranji Stateland
21	Suitable size of wildings of Alan (*Shorea albida*) for planting in Alan Bunga forest immediately after exploitation	Dormant	48 (1962)	Tg. Kranji Stateland
52	Effect of a second silvicultural treatment on the growth of final crop trees in MSF first treated at F + 10, 20 years after logging (Extension of Investigation 5)	Active	43, 44 (1972)	Naman F.R., Pulau Bruit P.F.
54	Line-planting trials of *Shorea albida* in logged Alan Bunga forest immediately after logging	Active	RP84 (1975)	Loba Kabang (S) P.F. Retus P.F., Oya-Mukah P.F.

The main conclusions that can be drawn from the various research investigations are summarized under each of the three main commercial forest types.

Mixed swamp forest

The logged-over Mixed Swamp forest is regenerating well naturally. Diagnostic sampling in areas 10-51 years after logging reveals adequate to heavy stocking of desirable species which are well-distributed. Studies on growth rates give some evidence of stagnation of growth especially of light-demanding species 10-15 years after logging.

Silvicultural treatment aimed at eliminating vegetation competing with a potential crop tree within 10 m × 10 m quadrats 10 years after felling appears to have a stimulating effect on the growth of such fast growing species as Geronggang *(Cratoxylon spp.)* Kapur paya *(Dryobalanops rappa)*, the swamp Merantis *(Shorea* spp.) and Jongkong *(Dactylocladus bancanus)*.

Ramin *(Gonystylus bancanus)* regeneration is not developing well in the logged-over forest. Although this species is generally present as advance growth, there were very few stems of this species less than 20 cm. in diameter in most areas 20 years ago, after logging.

The species Ramin tends to flower and fruit annually but the resultant seedlings do not seem to be able to compete with other faster growing light-demanding species.

In silvicultural treatment experiments, especially those carried out immediately after felling, there is a problem of distinguishing the effects of logging and those resulting from silvicultural treatment in the form of poison-girdling. The overall response of trees and stands is influenced by a combination of the logging and poisoning intensities. An evaluation of the responses to logging must take account of the simultaneous responses to logging and the effect of the initial status or stocking of the stand. Analysis of "treatment effects" in many cases shows no significant differences between treatments but this is not due to a lack of response but to the statistical and experimental difficulties of demonstrating the real effects with variable materials and methods.

Alan swamp forest (Alan batu forest)

In Alan Swamp forest, although a high percentage of Alan *(Shorea albida)* seedlings are present after logging, they are quickly submerged by competing vegetation; and not all of those that survive may reach merchantable size in time for the next cut. The complete absence of Alan in the sapling and pole-timber sizes is common in recently-logged (and unlogged) Alan Swamp forests.

In one area, Alan regeneration which occupied 28 percent of the stocking of potential crop trees immediately after logging had dropped to 2 percent over a period of 17 years. In these areas, fast-growing species like Ako *(Xylopia coriifolia)*, Medang *(Litsea* spp.) and Geronggang *(Cratoxylum* spp.) make large gains after logging. Species like Jongkong *(Dactylocladus stenostachys)*, Ketiau *(Ganua* spp.) and Semayur *(Shorea inaequilateralis)* with medium rates of growth showed about 20 percent gain in distribution. Slower-growing species like Keruntum *(Combretocarpus rotundatus)*, Rengas *(Melanorrhoea* spp.) Nyatoh *(Palaquium* spp.) and Ramin *(Gonystylus bancanus)* decreased in distribution by about 30 percent.

Alan bunga forest

Unlogged Alan Bunga forest is made up primarily of Alan *(Shorea albida)* trees 40 to 70 cm. in diameter with few other species in the stands. Stands tend to be fairly uniform and may contain high volumes.

Surveys and research studies show that newly-logged Alan Bunga forest shows sufficient Alan regeneration. However, repeated evaluations of exploited areas and surveys of stands cut for various lengths of time indicate that ample stocking of Alan at the time of cutting may not be enough to assure development of a stand of Alan for the next crop. Other species, some of which are not capable of reaching merchantable size, are crowding out the Alan and taking over dominance of the stands.

All of the studies of logged Alan Bunga stands displayed a steady reduction with time in the

percentage of Alan and especially in potential crop trees of Alan. One example of fairly old cutting showed a complete absence of Alan among the potential crop trees 19 years after logging.

As in the logged Alan Swamp Forests, there is no shortage of regeneration in cutover Alan Bunga Forests. Studies show an abundance of regrowth especially in the *Xylopia -Litsea* group of colonising species and Keruntum (*Combretocarpus rotundatus*) and Kerukup *(Shorea pachyphylla)*.

Line-planting trials of logged Alan Bunga forest indicate that this is a possible technique for reforesting and enriching the forest. However, the species like almost all the other Dipterocarp species has very irregular seed years. Because of this fact, it is difficult to obtain seeds of this species.

Recommendations for future research

The numerous research investigations that have been drawn up will continue to provide a lot of quantitative data on the behaviour of logged and virgin Peat Swamp Forests. However, from the above review, the following recommendations are made for supplementary research in these forests.

In the Mixed Swamp forest, research should be reactivated on the development of Ramin *(Gonystylus bancanus)* regeneration especially seedlings and saplings in the logged areas. Intensive studies should be carried out on the ecological requirements of this species. Such studies could be combined with laboratory and greenhouse studies so that a viable technique might be devised to improve the dominance of this species in the second and subsequent cut forests. Such studies will have important economic significance as illustrated by the appreciation in value of sawn Ramin timber over the last 8 years (Table 2).

Table 2 Export value of sawn Ramin (1970–1977)
(M$ per m^3)[1)]

1970	1971	1972	1973	1974	1975	1976	1977
162.21	172.51	178.38	415.65	283.67	272.68	422.55	395.04

[1)] M$1.00 = US$0.44 approximately

The value has not fallen below M$350.00 per m^3 since mid-1976. As pointed out earlier, the figures represent an annual increase of about 6% in real value over the eight-year period. As the area of old-growth Ramin stands is diminishing annually, it may be confidently predicted that the value of this species will continue to increase in the future.

In silvicultural treatment experiments, little efforts have been made in the past to distinguish between the effects of logging and subsequent poisoning (or other canopy-opening) treatments. This has led to the difficulty in monitoring and interpreting the real effects of treatment. In future experiments, it is important to recognise that any interference with the forests affects the stem numbers, species composition, growth rates, volume production, recruitment and mortality simultaneously. Therefore, the objective of the experiment must be clearly stated especially with regard to the growth parameters to be tested or compared because a simple inquiry into one variable will be inadequate and may be misleading.

In treatment experiments, it is essential before defining treatments to assess their probable impact on structure, stocking and composition of the forests. The choice of instructions should ensure that the impacts are likely to be sufficiently and consistently different from each other. This would avoid the danger of applying treatments which look very different in the prescriptions but which overlap broadly in their physical impact as had happened in the past.

In Alan Bunga Forest, studies should be initiated on methods of rooting cuttings of *Shorea albida* to provide planting stock of this species in the investigation on planting as a reforestation

technique. Such studies would include hormonal studies and mist propagation techniques. At the same time, studies should be done on methods of inducing the flowering and seeding of *Shorea albida* a year or two ahead of logging. These studies would be important in case replanting proves not to be an economically viable technique.

Information from these supplementary studies and from a refinement in investigative techniques would enable the Forest Department to manage effectively and efficiently a forest resource which will continue to play a very significant role in the economy of Sarawak.

References

1) ANDERSON, J.A.R. (1961): Peat Swamp Forests of Sarawak and Brunei in relation to their Silviculture. Vol. I University of Edinburgh, Unpublished Ph.D. thesis.
2) WHITMORE, T.C. (1975): Tropical rain forests of the Far East. Clarendon Press. Oxford, 282 pp.

APPENDIX

Description of forest types in the peat swamp

Mixed Swamp Forest

The Mixed Swamp Forest occupies the peripheral zone of the generally concentric bands of forest types within the peat swamp. It is the area of steepest gradient in the dome structure of the swamp.

These forests are characterized by a wide variety of species including the commercially valuable Ramin *(Gonystylus bancanus)*, Jongkong *(Dactylocladus stenostachys)*, Geronggang padang *(Cratoxylum glaucum)* and the Swamp Merantis *(Shorea* spp.). The canopy of the primary forest stands is uneven and dense and is essentially multistoried in composition. Dominant trees may have heights of between 30 to 45 metres and diameters of 56 centimetres to well over 81 centimetres.

It is the most extensive and important of all the peat swamp forest types, covering some 80 percent of the total peat swamp area.

Alan Batu Forest

The structure of Alan Batu Forest in its primary condition is similar to that of Mixed Swamp Forest, except that the forest is dominated by large trees of Alan *(Shorea albida)*. The total number of species is only slightly less than in Mixed Swamp Forest. The few Mixed Swamp Forest species not represented are largely replaced by species most commonly found in interior areas of the peat swamps.

The widely spaced dominant Alan trees are usually more than 45 metres tall with diameters frequently exceeding 117 centimetres. These large Alan trees are nearly all hollow and many are dead-topped. Nevertheless, the outer cylinder of sound wood produces a type of sawnwood which is in increasingly popular demand on both local and international markets.

Alan Bunga Forest

Primary stands of Alan Bunga Forest are characterized by virtually pure stands of even-canopied Alan *(Shorea albida)* containing 125 to 175 trees per hectare having a height range of 46 to 58 metres, a diameter range of 40 to 76 centimetres and clear boles in excess of 30 metres. The gross volume of Alan in these stands may be as high as 440 cubic metres per hectare, which is substantially greater than the gross volume of commercial species in any other forest type within the peat swamps.

The forest type generally has no middle storey; and the lower storey, although moderately dense, is composed of very few species.

Shorea albida produces two quite distinctly different types of commercial timber and these can be equated to the two main forest types of Alan. The Alan Batu Forest produces a dense, heavy wood favoured for general construction and railway sleepers, having an average air dry density of 54 lbs. per cubic foot with between two and three times the strength properties of Alan Bunga.

Alan Bunga is a medium density wood of some 43 lbs. per cubic foot. Thus the two types though composed of the same primary species, are totally different from the view point of management and utilisation.

Padang Alan Forest

Mature stands are usually dense and pole-like between 175 to 450 stems per hectare. They have small crowns, and are stunted in appearance. The height of trees in these stands may reach 30 to 36 metres, with large numbers of trees having diameters of 20 to 40 centimetres. These are stands of almost pure *Shorea albida* with wood properties identical to those of Alan Bunga.

Padang Paya Forest

This is actually a group of several minor types which, for practical convenience, are combined as one forest type. They are small in area, fragmentary in occurrence and of little commercial importance at the moment although the pulping potential of the species is being investigated.

One minor type, similar to Padang Alan Forest but not dominated by Alan, is characterized by dense stands of pole size trees which may reach rather high volumes. The stands may be dominated by Medang *(Litsea* spp.) Geronggang padang *(Cratoxylum glaucum)*, Bintangor *(Calophyllum* spp.), Keruntum *(Combretocarpus rotundatus)* and/or other minor species.

Discussion

Bratawinata, A.A. (Indonesia): 1) What are the other species of economic importance besides those you listed? 2) Why is there any difference in the number of species between the mixed swamp forest and the other types?

Answer: 1) I have not listed all the commercial species being extracted by the loggers. We should add to these the 4 swamp Merantis *(Shorea* spp.), Jelutong *(Dyera* spp.), Semayur *(Shorea inequilateralis)* and Mersawa *(Anisoptera* spp.). In all, the loggers extract about 20 - 30 species depending on the market. In our regeneration studies we are using a list of 45 species including all the commercial species and others which may become merchantable in the future. 2) The decrease in species diversity observed as one proceeds towards the center of the swamp may be primarily linked with decreasing moisture and increasing acidity.

Arihara, M. (Japan): I would like to get some information about the damage caused by insects and pests in Sarawak in each type of forest.

Answer: Apart from the Alan areas, there has been no serious damage caused by insects or diseases. In the Alan areas we often see trees completely defoliated by caterpillars. As no outbreaks have occurred in the last ten years this caterpillar has not yet been identified.

Prasert B. (Thailand): Have you observed *Melaleuca leucadendron* species in the peat swamp forests of Sarawak?

Answer: The occurrence of these trees is confined to the Alan areas. This particular species is more typical of what is locally known as "Keranga forest" or heath forest.

Willan, R.L. (FAO): Are the most valuable species such as Ramin not climax species and therefore unable to compete with fast-growing pioneer species? If so, should not emphasis be on marketing of the fast-growing pioneers rather than on the difficult task of regenerating Ramin?

Answer: Yes. In fact, the number of desirable species has been increased from 14 to 45 species and includes the fast-growing species such as *Dryobalanops* and *Dipterocarps*.