It can be considered that the stands selectively cut contain giant trees of non-commercial species and that the crown composition may become unbalanced after selection cutting. It is necessary to investigate the change of diameter growth with the lapse of years, viz. to prepare the site index concerned with the species composition, tree height and breast height diameter. Based on the research, it will be necessary to establish detailed rules for working according to the site index and the rotation, with ecological consideration made, in the adoption of the TPI (Indonesian Selection Cutting System).

(5) Damage to succeeding trees by logging

i. Sebulu

1) Stand selectively cut immediately before

To see the growing state of the succeeding trees of 10 cm or more in breast height diameter, a plot of 10 m × 10 m was set at a place (Fig. 30, A-2) apart from cut trees in the surveyed location of Fig. 22, for investigation. As a result, as shown in Figs. 31 and 32, 1,000 living trees were observed per ha. They were 15 to 33 m in tree height and 11 to 44 cm in breast height diameter. The number of trees of commercial species was 1 in the plot area, which means only 100 per ha. Damage to the stems caused by logging was not observed.

Then, to see the growing state of the succeeding trees of 5 to 19 cm in breast height diameter, four plots of 10 × 10 m each were set at a place (A-1) less damaged by logging in Fig. 30, for investigation. As a result, the number of living trees per ha were 575 as shown in Table 18, and they were 3 to 20 m in tree height. Of them, the number of trees of commercial species per ha were 125. Of the total number of living trees, 375 trees were damaged per ha, accounting for 45% of the whole. Most of the damage was the breaking of stem and tree top.

Furthermore, four plots of 5 × 5 m each were set at each of the 3 places (Fig. 30, A-1, B-1 and C-1). The results of the investigations are shown in Table 19 and Fig. 33. At place A, respectively two trees grew per 25 m^2 in 3 plots. They were 6 to 15 m in tree height and 6 to 9 cm in breast height diameter. No damage was observed at all. At place B, 1 and 2 trees grew respectively in two plots out of four plots. They were 6 to 8 m in tree height and 5 to 7 cm in breast height diameter. No damage was observed at all either in this place. At place C, 6 and 3 trees grew respectively in two plots out of four plots. They were 5 to 15 m in tree height and 5 to 18 cm in breast height diameter. No damage was observed either.

In the surveyed location of Fig. 22, furthermore, 16 plots of 25 m^2 were set similarly at the center (Fig. 30, B) in the logging road surmised to have been damaged most heavily. The results of the investigation are shown in Table 20. The number of living trees were 51 per 400 m^2, viz. 1,275 per ha. They were 3 to 24 m in tree height and 2 to 31 cm in breast height diameter. The damaged coditions of these forest trees are shown in Tables 8 to 12. The damage included the debarking of stem or base, stem breaking or branch breaking by felling, and the debarking of base by log skidding as the main phenomena. The number of trees of commercial species were 4 per 400 m^2, viz. 100 per ha. Of them, three trees (75%) had been damaged by way of debarking, stem breaking, branch breaking, etc. during felling.

Then, 16 plots of 25 m^2 were set at a place (Fig. 30, C) where cut trees remained, not being carried out in the surveyed location. The results are shown in Table 21. The number of living trees were 61 per 400 m^2, viz. 1,525 per ha. They were 3 to 14 m in tree height and 2 to 4 cm in breast height diameter. These trees were damaged by way of stem bending, stem debarking, crown breaking, branch breaking, stem breaking, etc., and the rate of

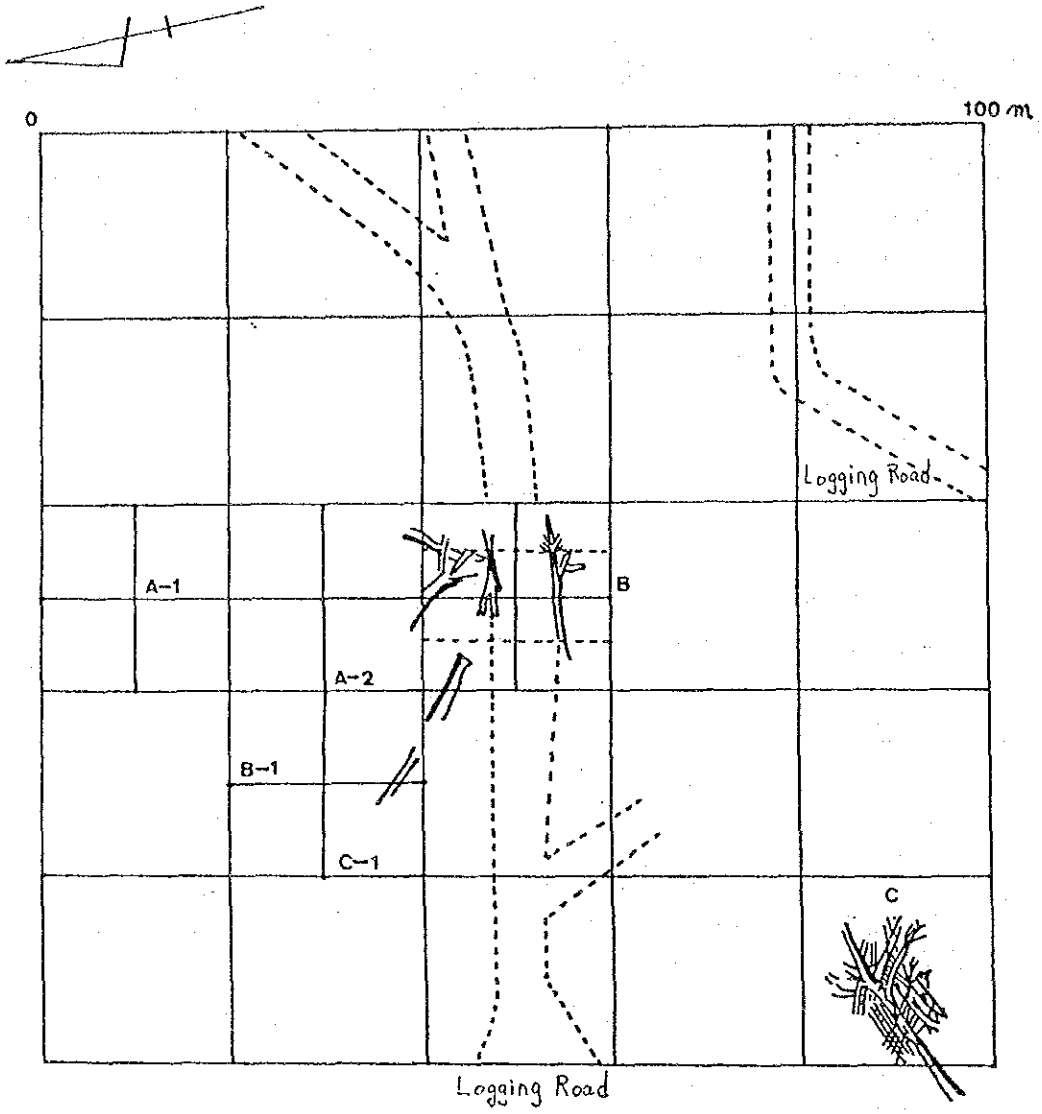
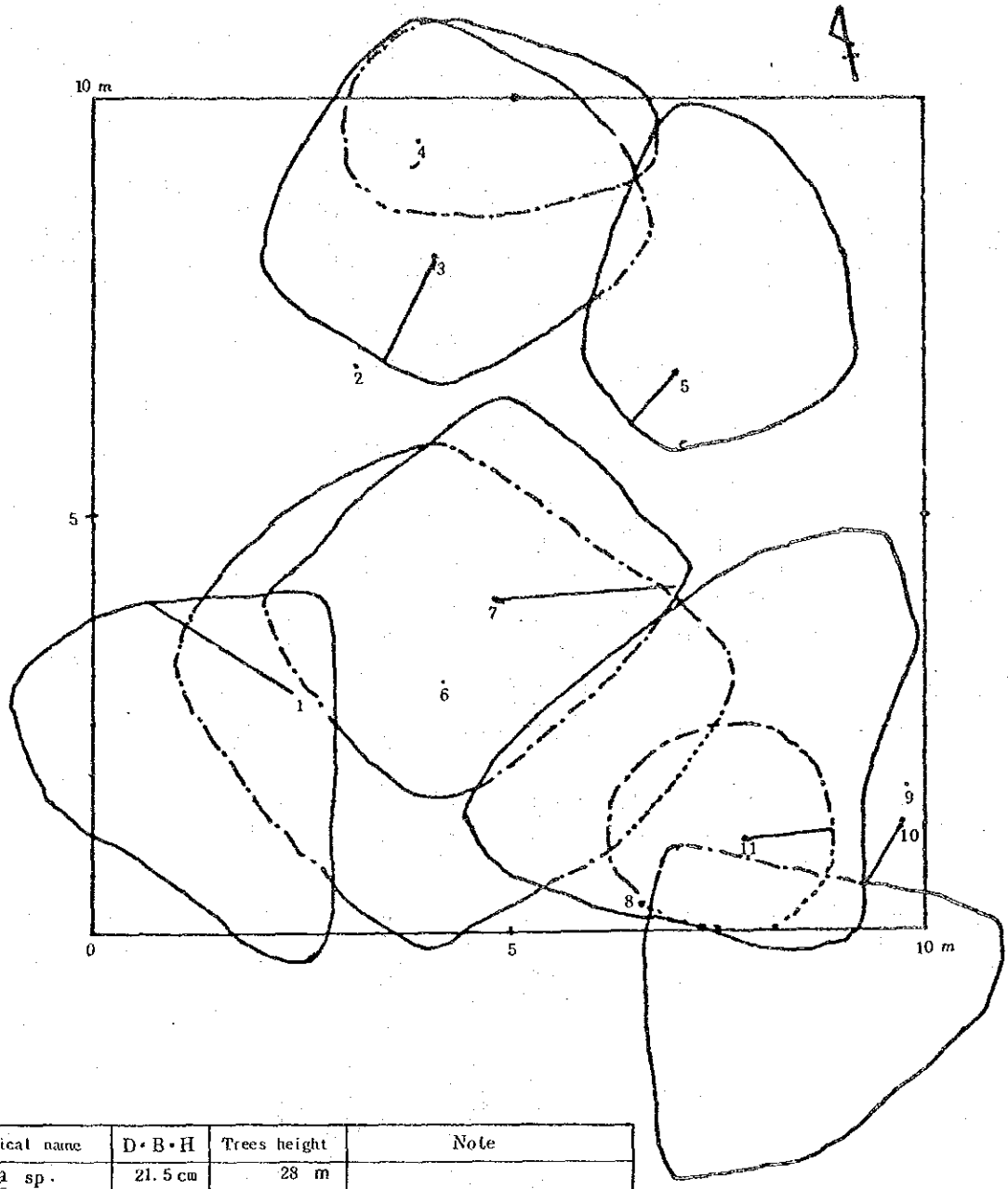


Fig. 30 Surveyed locations for saplings in a stand selectively cut immediately before in Sebulu



No	Botanical name	D·B·H	Trees height	Note
1	Litsea sp.	21.5 cm	28 m	
2	Shorea ovalis	38.0		100 × 100 m Quadrat No 1,O
3	Santiria sp.	14.0		
4	Baccaurea sp.	11.0		
5	Polyalthia sp.	13.0		
6	Polyalthia sp.	13.5	18	
7	Eugenia sp.	27.0	21	
8	Litsea sp.	26.0	31	
9	Eugenia sp.	44.0	33	100 × 100 m Quadrat No 2
10	Parinari sp.	15.0	22.5	

O : Commercial tree species

Fig. 31 Succeeding trees in a stand selectively cut immediately before in Sebulu

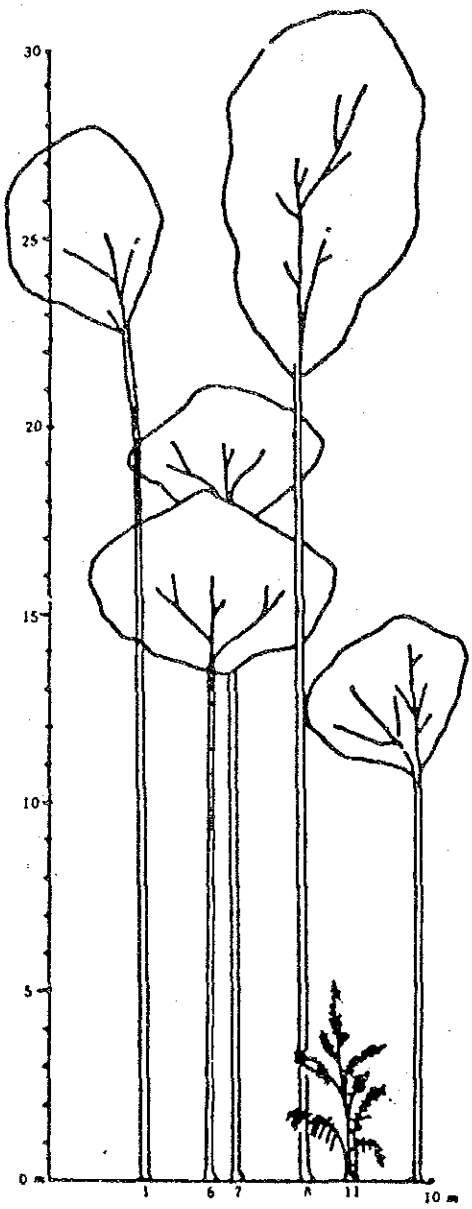


Fig. 32 Succeeding trees in a stand selectively cut immediately before in Sebulu

Table 18 Succeeding trees in a stand selectively cut immediately before in Sebulu

No	Species	Height (m)	Clear length (m)	DBH (cm)	Crown Size (m) 1	2	3	4	Kind of damage A	B	C	D	Notes
	Section 1												
1	Cryptocaria sp	11		19	dead tres								
2	Hopea sp	19		12	no	crown			stem	break	down		○
3	Phoebe sp	6		6	no	crown			top	break	down		
4	Aporosa sp	12		14	no	crown			stem	break	down		
5	Antidesma sp	11		7	no	crown			bending				
6	Eusideroxilon zwageri	12		10	1.0	3.0	2.5	2.0					○
7	Gironira sp	3		6	no	crown			break	dowr	3 meter	from ground	
	Section 2												
8	Litsea sp	12		8	—	—	3.2	1.5	Branch	break	down		
9	Shorea ovalis	17		9	1.2	2.0	2.0	1.5	Top	branch	break	down	○
10	Cryptocaria sp	20		17	2.0	3.0	2.4	1.5	Bark damage the ground		7 meter	from	
	Section 3												
11	Monocarpia sp	12		8	2.0	—	—	—	top	crown	break	down	
12	Eugenia sp	18		12	—	3.0	2.8	—	top	crown	break	down	
13	Knema sp	19		13	1.5	1.0	1.0	1.8					
14	Parinari sp	16		8	—	2.0	2.0	—					
15	Shorea ovalis	18		17	no	crown			fall	down			○
16	Eugenia sp	20		19	no	crown			fall	down			
17	Actinodaphne sp	19		12	2.0	3.0	2.0	3.0					
	Section 4												
18	Eugenia sp	16		12	—	3.0	2.0	2.5	Top crown bark damage 2 m. from ground		break	down	
19	Polyalthia sp	17		9	1.8	1.5	2.0	1.8					
20	Glocidion sp	17		9	3.0	—	—	—	Bending				
21	Xanthophyllum sp	14		18	no	crown			stem	break	down		
22	Eugenia sp	13		9	fallen tree								
23	Shorea laevis	15		8	fallen tree								○

○: Commercial tree species

Table 19 Succeeding trees in a stand selectively cut immediately before in Sebulu

№	Species	Height (m)	Clear length (m)	DBH (cm)	Crown Size(m) 1	2	3	4	Kind of damage A	B	C	D	Notes
A	Plot 1												
1	Canarium sp.	7.5	6	6.0					—	—	—	—	—
2	Sterculia sp.	14.0	12	9.0					—	—	—	—	—
	Section 2												
3	Rhodamia sp.	6.0	5.0	8.5					—	—	—	—	—
4	Cryptocaria sp	10.0	7.0	6.5					—	—	—	—	—
	Section 3												
5	Litsea sp.	15.0	7.0	7.0					—	—	—	—	—
6	Mallotus echinatus	7.0	4.0	8.5					—	—	—	—	—
	Section 4												
	empty		empty										
B	Plot 1												
	EMPTY		EMPTY										
	Section 2												
	EMPTY		EMPTY										
	Section 3												
1	Actinodaphne sp	6.0	4.0	5.0	—				—	—	—	—	—
	Section 4												
2	Monocarpia sp.	8.0	6.5	7.0					—	—	—	—	—
3	Eugenia sp.	7.0	5.0	7.0					—	—	—	—	—
C	Plot 1												
1	Ostrodes macrophullum	7.0	5.0	10.0					—	—	—	—	—
2	Dillenia sp	15.0	12.0	18.0					—	—	—	—	—
3	Eugenia sp.	12.0	8.0	11.0					—	—	—	—	—
4	Sindora sp	5.0	4.0	5.0					—	—	—	—	—
5	Dacryodes sp	7.0	6.0	6.0					—	—	—	—	—
6	Canarium sp.	15.0	14.0	7.0					—	—	—	—	—
	Plot 2												
	EMPTY			EMPTY									
	Plot 3												
7	Ellipanthus sp	7.0	5.0	8.0									
	Santiria sp.	14.0	12.0	12.0					—	—	—	—	—
9	Santiria sp.	11.0	8.0	12.0					—	—	—	—	—
	Plot 4												
	EMPTY			EMPTY									

Notes : A – Vine plants
B – Fungi
C – Insects
D – Clear bole

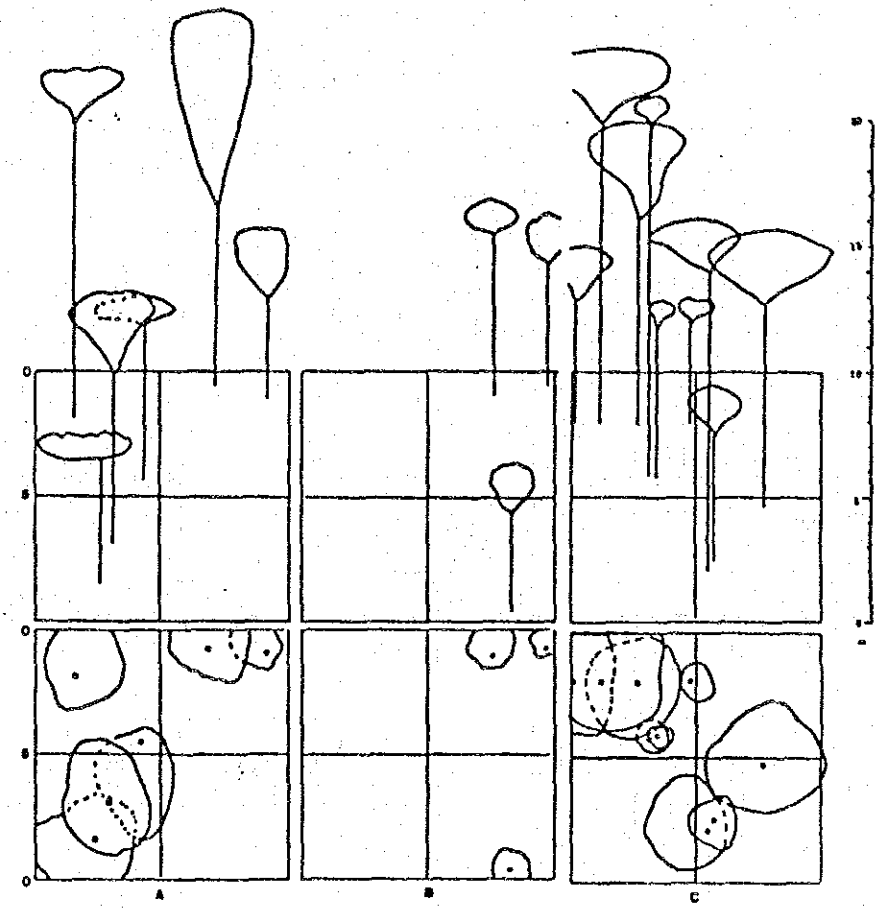


Fig. 33 Succeeding trees in a stand selectively cut immediately before in Sebulu

Table 20 Growing and damaged conditions of succeeding trees

No.	Species Section I	Height (m)	Clear length (m)	DBH (cm)	Crown Size(m) 1	2	3	4	Kind of damage A	B	C	D		Note
1	Ochanostachy sp	24		20	—	2	5	3	Branch damage					
2	Monocarpia sp	12		13	2	—	3	—	Top crown break down					
3	Shorea leprosula	11		6	1	1	—	1.2	Bark damage 3.0m above ground					○
4	Dillenia sp	14		2.5	—1	0.5	0.2	—	Crown damge					
5	Antilesma sp	11		9	—	4	—	—						
	Section 2													
6	Levistonia sp	8		25	—	—	—	—	Crown and bark above ground				damage 1 m	
7	Litsea sp	23		19	1	5	—	—						
8	Eudiandra sp	24		17	3	3	—	2						
9	Myristica sp	17		8	1.2	1	1.2	1						
10	Sindora sp	11		5	2	1	2	1.4						
11	Rhodamia sp	13		9	0.5	1.5	2	1						
	Section 3													
12	Shorea laevis	21		31	—	—	—	—	Broken stem					○
13	Madhuca sp	13		11	1	1.2	1.5	2						
14	Shorea laevis	21		17	2	2	0.5	2.5	Top break down					○
15	Cryptocaria sp	21		14	2.3	2.8	1.0	—	Top break down					
	Section 4													
16	Polyalthia sp	11		11	—	—	—	—	Broken stem					
17	Polyalthia sp	22		15	3	1.5	2.8	3						
	Section 5													
18	Cryptocaria sp	21		14	—	2	—	—	Top break dawn					
19	Goniothalamua sp	3		12	—	—	—	—	Stem break					
20	Monocarpia sp	3		12	—	—	—	—	Stem break					
21	Aglaia sp	11		5	—	—	—	—	Stem break					
	Section 6													
22	Knema sp	8		3.5	—	—	—	—	Bending					
23	Antidesma sp	7		2.5	—	—	—	—						
24	Section 7													
24	Strombosia sp	6		2	—	—	—	—						
25	Rhodamia sp	7		5	—	—	—	—	Stem break down					
26	Mallotus sp	4		4	—	—	—	—	Stem break down					
	Section 8													
27	Rhodamia sp	6		3	—	—	—	—						

No.	Species	Height (m)	Clear length (m)	DBH (cm)	Crown Size(m)				Kind of damage				Notes
					1	2	3	4	A	B	C	D	
28	Cryptocaria sp	6		2	—	—	—	—					
	Section 9												
29	Heritiera sp	7		4	—	—	—	—	Bending Leaned by big branch				
30	Mallotus sp	7		2	—	—	—	—					
31	Mallotus sp	6		2	—	—	—	—	Branch damage				
32	Mallotus sp	3		2	—	—	—	—					
	Section 10												
33	Millettia sp	6		2	—	—	—	—					
34	Mallotus sp	3		2	—	—	—	—					
	Section 11												
35	Aporosa sp	6		2.5	—	—	—	—					
36	Xantophyllum sp	11		4.5	—	—	—	—					
37	Xantophyllum sp	6		3	—	—	—	—					
	Section 12												
38	Baccaurea sp	7		2.5	—	—	—	—	Leaned by Small Log				
39	Millettia sp	6		2.5	—	—	—	—	—〃—				
40	Carallia sp	5		2.0	—	—	—	—	—〃—				
41	Eugenia sp	4		2.0	—	—	—	—	Broken stem				
	Section 13												
42	Trema sp	4.5		2.0	—	—	—	—	Broken stem				
43	Eugenia sp	13		4.0	—	—	—	—					
44	Shorea ovalis	11.5		4.5	—	—	—	—					○
	Section 14												
45	Santiria sp	7.5		2.5	—	—	—	—	Top break down				
46	Antidesma sp	7		3.0	—	—	—	—					
47	Mallotus sp	14		7.0	—	—	—	—					
	Section 15												
48	Trioma sp	6		5.5	—	—	—	—					
49	Ardisia sp	6		3.0	—	—	—	—					
	Section 16												
50	Gironniera sp	6		2.0	—	—	—	—					
51	Mallotus sp	7		3.0	—	—	—	—					

○: Commercial tree species

damage reached 79% of the whole. The number of trees of commercial species was large, 550 per ha, but 77% of them were damaged by way of stem breaking, stem bending, stem debarking, branch breaking, etc.

As for the production of large diameter trees of Dipterocarpaceae, the possibility of successful planting in a clear cut area is still not so large. Therefore, no other method can be considered than the present selection cutting method to promote the regeneration of succeeding trees for culture, or enrichment planting such as undergrowth.

Many of the virgin forests are stipulated to be cut according to the TPI system. It has been clarified that the succeeding trees which have been regenerated and are being grown as expected are being damaged by cutting, in this case. Since the felled trees were 20 to 40 m in tree height and 20 to 40 m in crown width, the succeeding trees were observed to have been broken or bent at stem or debarked at stem or base in a very wide area (Photos 9 to 14). In addition, it is said that once damaged, the trees may have their deterioration or death promoted by the climatic conditions of high temperature and high humidity. Therefore, it must be recognized that when large diameter trees are cut and carried out in a compound storied forest, the stand may be damaged in meshes.

Moreover it is widely known in the world that the pressure of the wheels of yarding tractors and disturbed soil seriously affect the growth of succeeding trees. Tropical rain forests are poor in the physicochemical properties of soil and can store less nutrients in their soils. These matters must be seriously considered.

Table 21 Damage to succeeding trees in a stand selectively cut immediately before in Sebulu

No.	Species	Height (m)	Clear length (m)	DBH (cm)	Crown Size(m) 1	2	3	4	Kind of damage A	B	C	D	Notes
	SECTION 1												
1	Glocidion sp	7		2.5									
2	Ikurlcoma	3		2.5									
3	Shorea leprosula	6		2.0									○
	Section 2												
4	Eugenia sp	3		3.5		Top break down							
5	Shorea leprosula	9		4.0									○
6	Shorea laevis	8		4.0									○
	Section 3												
7	Aglaia sp	7		3.0									
8	Urophylum sp	9		3.5	1	Bending							
9	Hopea sp	12		4.0		Top breaking down							○
10	Hopea sp	8		3.5		Top breaking down							○
	SECTION 4												
11	Shorea ovalis	10		4.0		Stom break down no Cown							
12	Gironniera sp	8		2.5		Bark damage 2m from ground							
13	Hopea sp	11		3.0		Bending							
14	Litsea sp	8		2.5									
	SETION 5												
15	Shorea leprosula	11		3.0		Bending							○
16	Shorea sp	14		4.0		Bending							
	SECTION 6												
17	Shorea sp	12		4.0		Bark damage±4 m above ground							○
18	Rhodamia sp	11		2.5		Bark damage 3 m above ground branch damage							
19	Antidesma	9		2.0		Bark damage, Bending Top crown break down							
	SECTION 7												
20	Milletia sp	8		2.5		Bending							
21	Glocidion	10		2.0		Bending							
22	Nephelium sp	11		3.5		Bending							
23	Shorea sp	12		2.5		Bending							
	SECTION 8												
24	Glocidion sp	11		3.0		Crown damage							
25	Shorea sp	12		3.0		Crown damage							
26	Actinodaphne	13		4.0									
27	Mallotus echinatus	7		2.0									
	SECTION 9												
28	Milletia sp	11		2.5		Crown damage Bending							
29	Glocidion	13		4.0									
30	Aporosa sp	11		3.5		Bark damage 7m above ground							

No	Species	Height (m)	Clear length (m)	DBH (cm)	Crown Size(m) 1	2	3	4	Kind of damage A	B	C	D	Notes
	SECTION 9												
31	Milletia sp	11		2.5	Top crown damage				Bending				
32	Glocidion sp	13		4.0									
33	Litsea sp	11		3.0	Bending								
34	Shorea ovalis	10		3.0									○
	SECTION 10												
35	Baccaurea sp	11		4.0	Crown damage								
36	Glocidion sp	14		4.0	Bending								
37	Aporosa sp	11		3.5	Bark damage 2 m abive grouwn								
	SECTION 11												
38	Hopea sp	9		4.0	Top crown break down bark damage under crown								○
39	Shorea laevis	9		3.0									○
40	Glocidion	11		4.0	Top crown break down								
41	Rheomonium sp ?	13		3.0	branch damage								
	SECTION 12												
42	Rhemonium sp?	14		3.5	Bending								
43	Glocidion sp	11		2.5	Bending								
	SECTION 13												
44	Shorea smithiana	12		4.0	Branch damage								○
45	Shorea smithiana	13		3.5	Exellent								○
46	Shorea leavifolia	10		2.5	Exellent								○
47	Aglaia sp	9		2.0	〃								
48	Shorea leavis	9		3.0	Bending								○
49	Shorea leavis	11		3.0	Bending								○
	SECTION 14												
50	Shorea laevis	14		3.0	Fall down								○
51	Shorea laevis	12		3.0	Fall								○
52	Shorea laevis	11		3.5	Fall								○
53	Eugenia sp	12		4.0	Branch damage								
54	Canarium sp	15		4.0	Branch damage								
	SECTION 15												
55	Aporosa sp	11		3.5	Excellent								
56	Strombosia sp	14		4.0	Excellent								
57	Milletia sp	12		4.0	Excellent								
58	Osteris sp	11		2.5	Crown damage								
	SECTION 16												
59	Litsea sp	10		3.5	Excellent								
60	Iodenron sp	11		4.0	Branch damage								
61	Rhodamnia sp	11		3.0	Stem break down								

○ Commercial tree species

Photo 9 Damage to a succeeding tree by a felled tree

Photo 10 A succeeding tree was broken by a felled tree

Photo 11 Succeeding trees were debarked at stem by a felled tree

Photo 12 A succeeding tree was debarked at base by a felled tree

Photo 13 A succeeding tree was broken by a felled tree

Photo 14 A succeeding tree was debarked by logging

For the above reasons, it is required of the researchers to minimize the damage caused to succeeding trees by felling and logging, in executing the TPI system. In more details, it is necessary for example to set plots by the quadrate method in a virgin forest, for investigating all the forest trees, to test the influences by various methods of felling and logging, to examine how damage is caused by the belt transect method, etc., and to research into the process of growth of damaged trees. Furthermore, it is necessary to prepare data for establishing detailed rules for working, suitable for each stand by testing the respective sites.

(6) Regeneration, flourishing and vanishing of saplings

i. Sebulu

1) Virgin forest

In the large virgin forest shown in Figs. 18 and 19, a plot of 5 m × 5 m was set in November, 1980, to investigate the species, breast height diameters and the number of trees. As for the trees of 2 to 4 cm in breast height diameter, the results are shown in Table 22.

The number of living trees were 8,400 per ha. The minimun tree height was 2.5 m, and the maximum value, 8 m. No damaged tree was observed at all. Of them, the number of trees of commercial species was 1,200, accounting for 14% of the whole.

Similarly, a plot of 1 m × 10 m was set, to investigate the growing states of trees of 2 cm or less in breast height diameter. The results are shown in Table 24.

The number of trees per ha were 75,000. The minimum tree height was 0.2 m, and the maximum value, 3.5 m. As for vitality, 24% of the whole was low, 33.3%, medium, and 42.7%, high. The number of trees of commercial species were 14,000, accounting for 18.7% of the whole. As for the vitality of commercial species, 57.1% was high, 35.7, medium, and 7.1%, low.

Table 22 Growing states of small diameter trees in a virgin forest in Sebulu

No.	Species	Height (m)	Clear length (m)	DBH (cm)	Crown Size (m)				Kind of damage				Notes
					1	2	3	4	A	B	C	D	
	Section 1												
1	Diospyros sp.	4.0		2.0									○
2	Artocarpus sp.	5.0		4.0									
3	Ixora sp.	4.5		2.0									
4	Durio sp.	4.0		2.0									
5	Urophylum sp.	7.0		5.0									
	Section 2												
6	Monocarphia sp.	3.5		2.5									
7	Myristica sp.	2.5		2.0									
8	Aporosa sp.	8.0		3.0									
9	Chlorophylum sp.	4.5		3.0									
10	Baccaurea sp.	3.5		2.0									
11	Mallotus sp.	3.5		2.0									
	Section 3												
12	Scorodocarpus sp.	9.5		4.0									
13	Caralia sp.	4.5		2.5									
14	Ardicia ?	3.0		2.0									
15	Shorea leprosula	4.0		2.0									○
16	Myristica sp.	4.6		3.0									
17	Eusideroxylon zwageri	4.0		2.0									○
	Section 4												
18	Litsea sp.	7.0		4.0									
19	Eugenia sp.	8.0		2.5									
20	Nephelium sp.	3.5		2.0									
21	Cryptocaria sp.	8.0		4.0									

Notes : A--Vine plants, B—Fungi, C—Insects, D—Clear bole

○ : Commercial tree species

Table 23 Growing states of species in a virgin forest in Sebulu

No	Species	DBH (cm)	Height (cm)	Vitality			Notes
				1	2	3	
	Section 1						
1	Eusideroxylon zwageri		230			+	○
2	Eusideroxylon zwageri		240			+	○
3	Ellipanthus sp.		350		+		
4	Cryptocaria sp.		100		+		
5	Pandanus sp.		130		+		
6	Pandanus sp.		135		+		
7	Pandanus sp.		120		+		
8	Pandanus sp.		120			+	
9	Pandanus sp.		140			+	
10	Pandanus sp.		160	+			
11	Pandanus sp.		85			+	
12	Pandanus sp.		115			+	
13	Pandanus sp.		115		+		
14	Pandanus sp.		140		+		
15	Eusideroxylon zwageri		90			+	○
16	Urophylum sp.		50			+	
17	Milletia sp.		170		+		
18	Shorea laevis		25		+		
19	Dillenia sp.		25		+		
20	Litsea sp.		30		+		
21	Eugenia sp.		28			+	
22	Litsea sp.		35	+			
23	Pandanus sp.		103	+			
24	Pandanus sp.		140			+	
25	Eusideroxylon zwageri		200			+	○
26	Pandanus sp.		168			+	
27	Eusideroxylon zwageri		80			+	○
28	Scorodocarpus sp.		30		+		
29	Milletia sp.		35			+	
30	Eugenia sp.		20		+		
31	Hospeldia sp.		24		+		
32	Eugenia sp.		30	+			
33	Eugenia sp.		35	+			
34	Eugenia sp.		70		+		
35	Eugenia sp.		80			+	
36	Honastales sp. ?		30			+	
37	Eusideroxylon zwageri		35		+		
38	Pandanus sp.		78			+	○

№	Species	DBH (cm)	Height (cm)	Vitality			Notes
				1	2	3	
39	Baccaurea sp		56	+			
40	Milletia sp		75	+			
41	Garcinia sp		80	+			
42	Mallotus echinatus		40		+		
43	Gironira sp		55			+	
44	Gironira sp		65	+			
45	Eusideroxylon zwageri		48	+			○
46	Polyalthia sp		60			+	
	Section 2						
47	Eusideroxylon zwageri		40			+	○
48	Eusideroxylon zwageri		45			+	○
49	Eusideroxylon zwageri		100		+		○
50	Eusideroxylon zwageri		40			+	○
51	Mallotus sp		80	+			
52	Baccauria sp		170			+	
53	Mallotus sp		168		+		
54	Chlorodiciodendron sp		56			+	
55	Endospernum		40	+			
56	Garcinia sp ?		60	+			
57	Mallotus echinatus		67	+			
58	Ixora sp		30		+		
59	Ixora sp		35			+	
60	Eusideroxylon zwageri		65		+		○
61	Ixora sp		70	+			
62	Ixora sp		38		+		
63	Popowea sp		48			+	
64	Ixora sp		60			+	
65	Ixora sp		58			+	
66	Ixora sp		70			+	
67	Shouroria sp		38	+			
68	Milletia sp		48	+			
69	Garcinia sp		48	+			
70	Shorea leprosula		60		+		○
71	Urophyllum sp		78		+		
72	Milletia sp		40			+	
73	Gironira sp		100			+	
74	Pternandra sp		100			+	
75	Myristica sp		30		+		

Note : 1. Bad 2. Average 3. Excellent

○: Commercial tree species

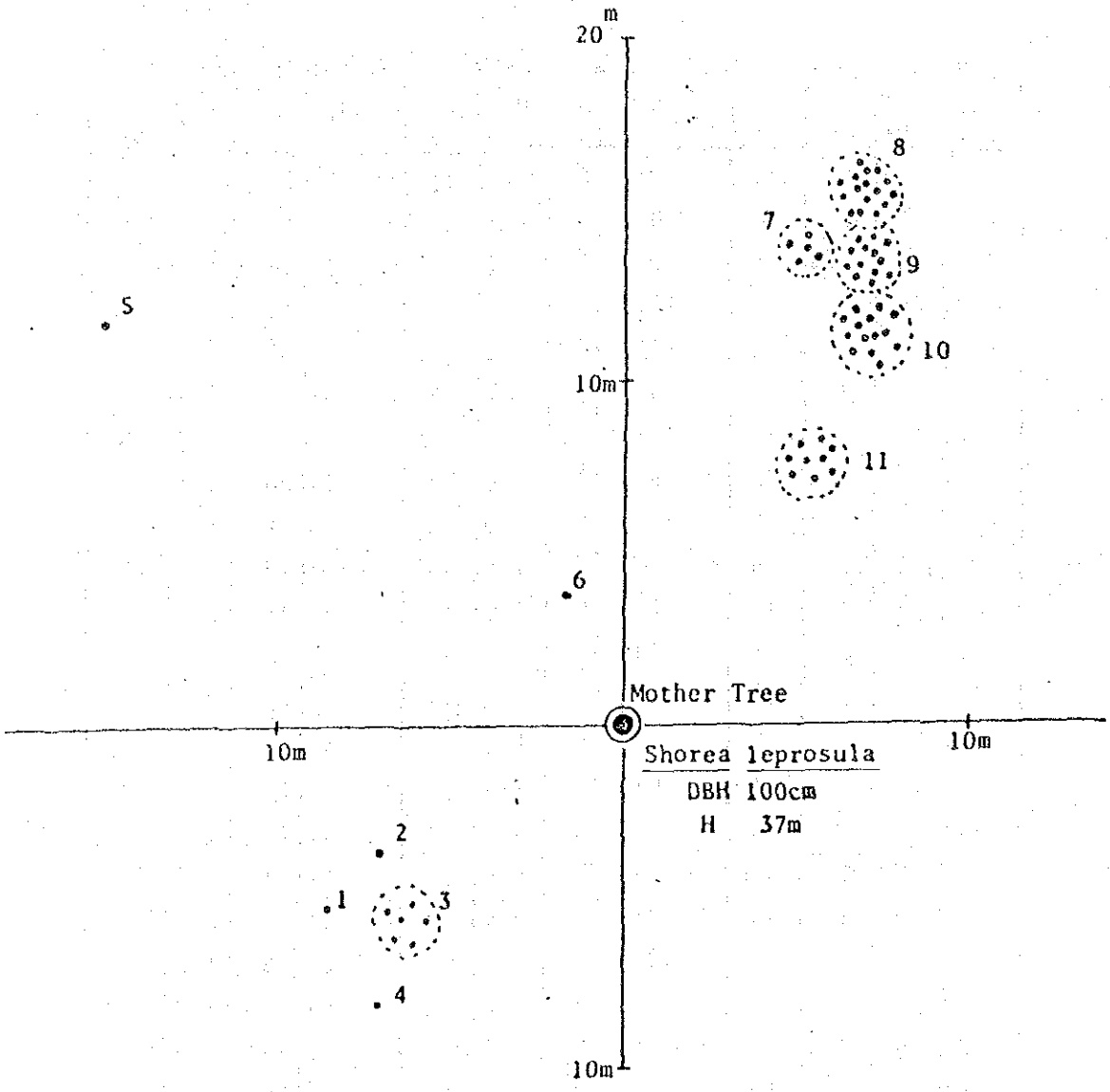
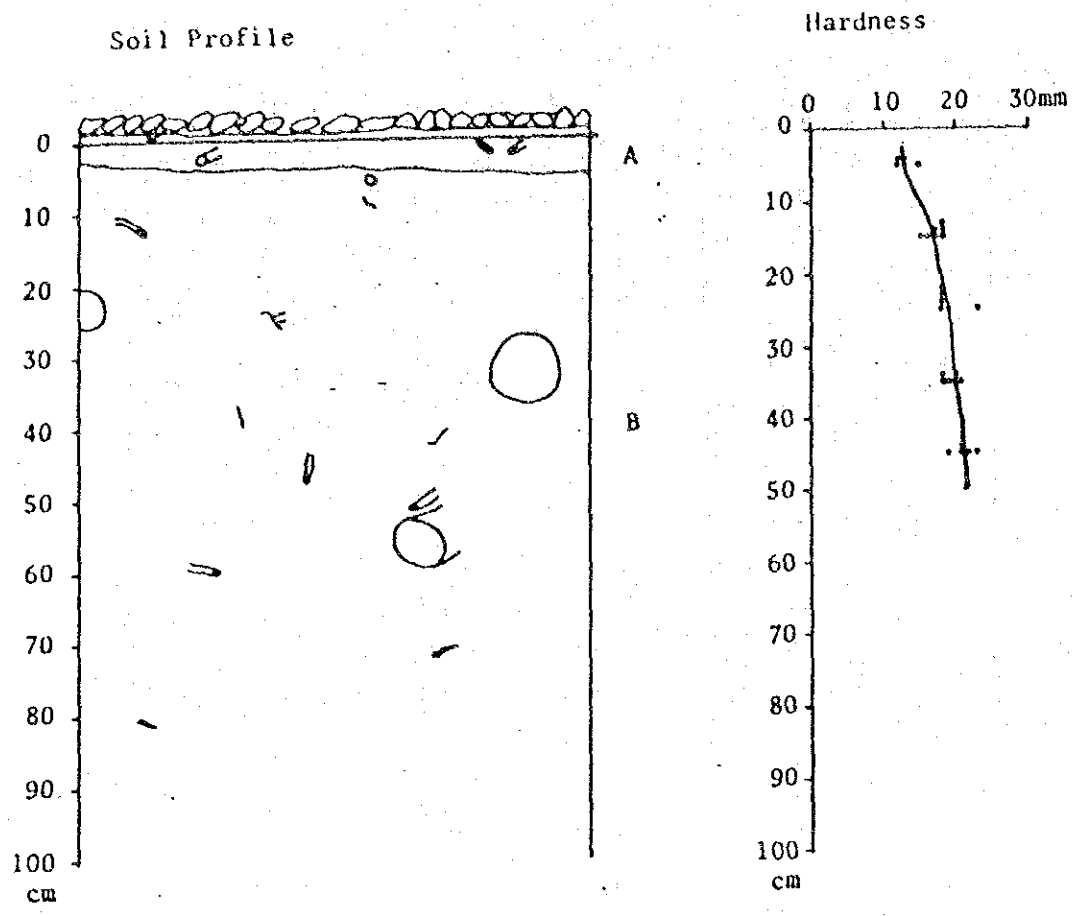


Fig. 34 Regeneration of saplings of Shorea leprosula in a virgin forest in Sebulu

Table 24 Sizes of Shorea leprosula saplings in a virgin forest in Sebulu

No.	H cm	D mm	CD cm	No.	H cm	D mm	CD cm	No.	H cm	D mm	CD cm
1	37	5	40	8)	15	2.0	13	10 1)	16	1.3	15
2	6	2	13	9)	18	1.4	13	2)	15	1.2	12
3 1)	8	1.5	15	10)	17	1.4	14	3)	15	1.1	13
2)	13	1.2	12	11)	13	1.7	11	4)	13	1.2	13
3)	20	1.8	14	12)	12	1.2	9	5)	15	1.2	14
4)	7	2.2	14	13)	12	1.5	8	6)	12	1.0	11
5)	12	1.2	10	14)	12	1.4	10	7)	20	1.3	10
6)	13	1.2	10	15)	11	1.0	10	8)	20	1.4	11
4	51	4.4	41	16)	9	0.9	8	9)	11	1.2	11
5	220	20.5	145	9 1)	17	1.6	12	10)	17	1.5	15
6	17	1.5	13	2)	10	1.0	11	11)	18	1.4	11
7 1)	8	1.0	11	3)	15	1.1	15	12)	16	1.2	8
2)	7	1.2	14	4)	14	1.4	13	13)	10	0.8	11
3)	15	0.9	9	5)	15	1.4	14	14)	14	1.0	12
4)	15	1.1	11	6)	16	1.4	12	11 1)	17	1.8	14
5)	21	1.2	15	7)	15	1.4	16	2)	11	1.7	12
8 1)	16	1.3	17	8)	20	2.0	15	3)	14	1.9	16
2)	20	1.5	14	9)	8	0.9	8	4)	16	1.4	14
3)	17	1.3	11	10)	7	0.9	9	5)	19	1.5	5
4)	18	1.7	14	11)	13	1.0	13	6)	15	1.8	13
5)	15	1.3	9	12)	9	0.0	8	7)	13	1.3	11
6)	17	1.4	10	13)	16	1.5	17	8)	10	0.9	12
7)	12	1.3	15					9)	8	0.8	8
								mean	17.9	1.7	14.8

H: Sapling height D: Basal diameter CD: Crown diameter



Layer	Colour	Texture	Structure	Moisture	Root
A	7.5YR3/3 dark brown	clay	massive	humid	a little
B	7.5YR8/6 light yellow orange	clay	massive	humid	a little

Layer	PH		PF			Effective water content
	H_2O	KCl	1.8 w%	3.0 w%	(1.8-3.0w%)	l/m^3
A	3.82	3.39	26.9	21.9	5.0	75.0
B	4.51	3.92	29.1	24.4	4.9	70.5

Fig. 35 Soil profile and pH of the surveyed location in a virgin forest in Sebulu

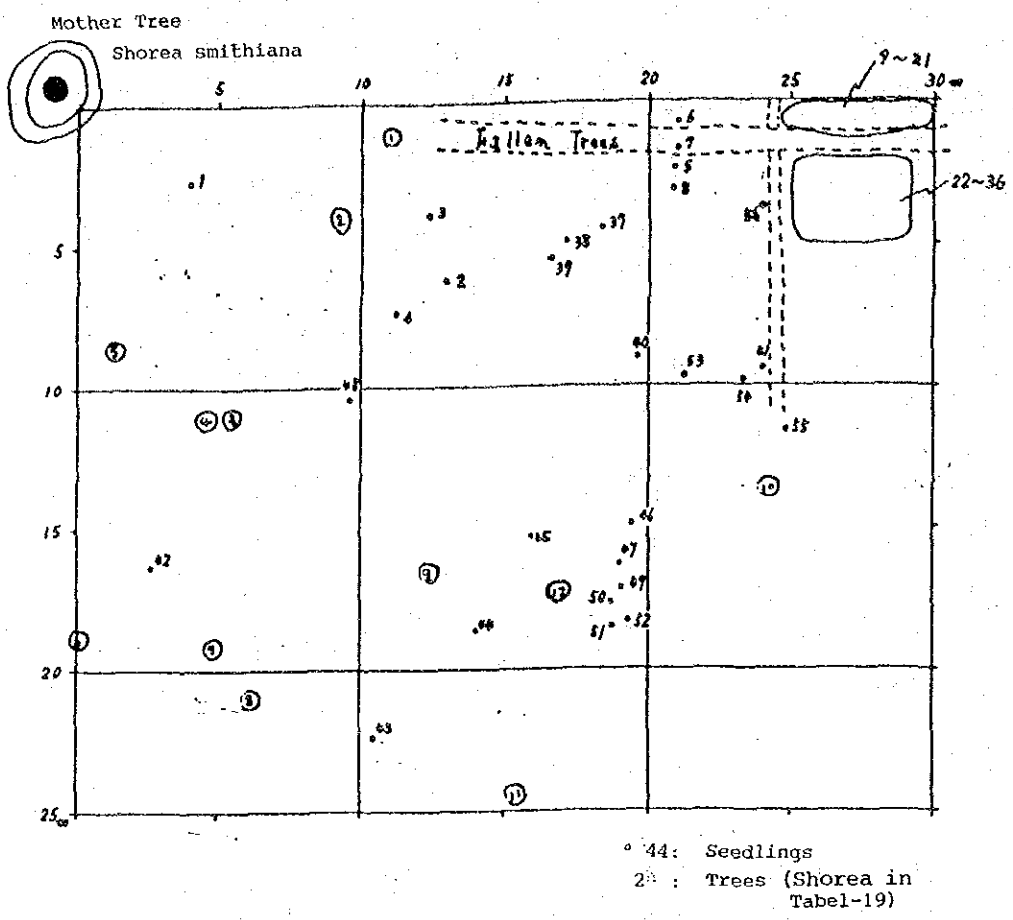


Fig. 36 Regeneration of Shorea smithiana saplings in a virgin forest in Sebulu

Table 25 Distribution of tall trees in the surveyed plot in a virgin forest in Sebulu

No.	Species	Diameter (cm)	Tree height(m)
1	Hopea mengarawan	68	30
2	Hopea mengarawan	71	45
3	Hopea mengarawan	43.5	25
4	Margaram	27	22
5	Melaleuca leucadendron	52	27
6	Shorea laevifolia	25	18
7	Barringtonia sp	72	45
8	Margaran	34.5	20
9	Shorea sp.	41	34
10	Merkunit	28.5	18
11	Medas	37.5	17
12	Kacang	29	19

Table 26 Distribution of medium trees in the surveyed plot in a virgin forest in Sebulu

Species	D(cm)	H(m)	Species	D(cm)	H(m)
Meranbuus	7	8	Jambu-Jambu	11	12
Artocarpus elasticus	15	10	Madhuca magnifica	10.5	12
Dacryodes rostrata	6.5	7	Tristiropsis sp	14	16
Meranti putih	12.5	10	Bawaitaw	16	15
Bawaitaw	10.5	9	Nyatoh	14	16
Dacryodes rugosa	12.0	13	Madhuca magnifica	9.5	11
Prunus javanicus	6.5	10	Dardaram	9	12
Myristica villosa	11.0	12	K. Kacang	8	5
Dacryodes rostrata	6.5	6	K. Kacang	6	5
Heraaram	14.0	20	Shorea laevifolia	7	6
Daravam	16.0	22	Meanus	8	12
Madhuca magnifica	7.0	9	K. Kacang	12	10
Daraaram	10.5	12	K. Punaw	7.5	9
Dryobalanops larceolafa	10.0	10	Dacryodes rostrata	6.5	7
Medang	8.5	9	Prunus javanicus	12	14
Medang	7.0	9	Madhuca magnifica	10	12
Meranti putih	9.5	10	Buah jentikaw	14.8	15
Madhucu magnifica	8.5	7	Dryobalanops sp	10	12
Arang	6.0	7	Madhuca magnifica	8.5	10
Madhucu magnifica	15.5	20	Mempuws rasa	7.5	6
Mergaram	21.0	15	Dryobalanops sp	7.5	8
Planchania valida	8	12	Dryobalanops sp	14.5	16
Bawaitaw	18	20	B. Muyang	6	7
Madhuca magnifica	9	10	B. Muyang	15	18

Table 27 Sizes of Shorea smithiana saplings in a virgin forest in Sebulu

Seedling No.	H (cm)	D (mm)	CD (cm)	NL
1	850	66	190	-
2	19	3	25	2
3	21	2	23	2
4	13	3	29	2
5	27	3	25	3
6	23	3	16	1
7	19	2	18	3
8	23	3	30	2
9	20	2	26	2
10	19	2	27	4
11	25	2	28	2
12	27	2	30	3
13	22	3	30	3
14	26	3	29	4
15	18	2	25	3
16	23	3	24	3
17	26	2	21	3
18	25	2	32	2
19	25	2	25	2
20	29	2	27	2
21	24	3	27	2
22	28	3	24	2
23	24	3	28	2
24	13	2	19	3
25	26	2	14	3
26	28	3	36	4
27	15	2	17	2
28	24	3	32	3
29	25	3	35	3
30	23	2	23	3

Seedling No.	H (cm)	D (mm)	CD (cm)	NL
31	28	3	33	2
32	30	2	32	3
33	12	2	20	2
34	28	2	29	2
35	21	2	27	3
36	23	3	29	2
37	20	2	25	2
38	24	2	29	3
39	34	3	31	3
40	23	3	25	3
41	22	3	16	2
42	24	2	24	2
43	23	3	29	3
44	22	2	24	3
45	22	2	33	3
46	21	3	31	2
47	21	3	32	3
48	13	2	21	2
49	26	3	30	3
50	13	2	23	2
51	20	2	25	2
52	21	2	26	2
53	20	2	28	3
54	19	2	28	8
55	20	2	28	2
56	167	11	72	15

(25m x 25m)

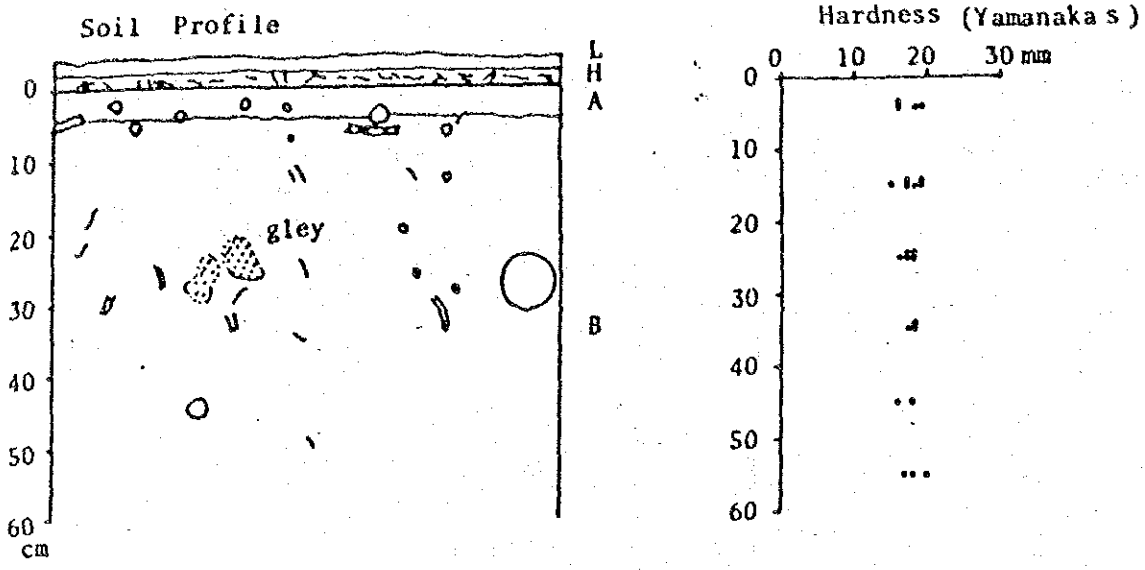
Then, in October, 1981, near the stand shown in Fig. 18 in a virgin forest where 489 tall and medium trees of 10 cm or more in breast height diameter grew per ha, the regeneration of Shorea leprosula species was investigated. The surveyed location was very infertile and low in productivity.

The results of investigation are shown in Fig. 34 and Table 24. The trees of the species were not regenerated evenly but grew in groups at specific places. The minimum tree height was 0.6 m, the maximum value, 2.2 m, and the mean value, 1.8 m.

Similarly near the stand shown in Fig. 18, the regeneration of species with Shorea smithiana as the seed tree (stem width 10 × 18 m) was investigated. The soil of the surveyed location was very acidic and low in water holding capacity as shown in Fig. 35. The results of the investigation are shown in Fig. 36 and Tables 25 to 27.

As can be seen, 896 saplings were regenerated relatively evenly on the whole. They were 0.13 to 8.5 m in sapling height, and the mean height was 0.4 m.

Furthermore in October, 1981, a plot of 30 m × 30 m was set in a virgin forest on flat land at 25 km inside from the K.T.I. office, to investigate the regeneration of Shorea smithiana. The soil was acidic as shown in Fig. 37, and the layer was soft and good in water holding capacity though the lower layer was very low in water holding capacity. The distribution of trees in the plot is shown in Fig. 38 and Table 29. The number of trees per ha were 222. The regeneration of saplings is shown in Fig. 38 and Table 29. The number of samplings per ha were 1,943. Saplings with 5 or more leaves each were assumed to grow well, and therefore, considered as succeeding trees. The number of them were 300 per ha. They were 8 to 140 cm in tree height, and the mean height was 23 cm.



Layer	Colour	Texture	Structure	Moisture	Root
A	7.5 YR 5/3 dull brown	clay	single grained	moderate	much
B	10 YR 7/4 dull yellow orange	heavy clay	massive	humid	a little

	PH		PF			Effective water content
Layer	H_2O	KCl	1.8W%	3.0W%	(1.8-3.0)W%	l/m^3
A	3.65	3.30	30.0	21.5	8.5	127.5
B	4.60	3.85	23.0	20.7	2.3	34.5

Fig. 37 Soil profile and pH of the surveyed plot in a virgin forest in Sebulu

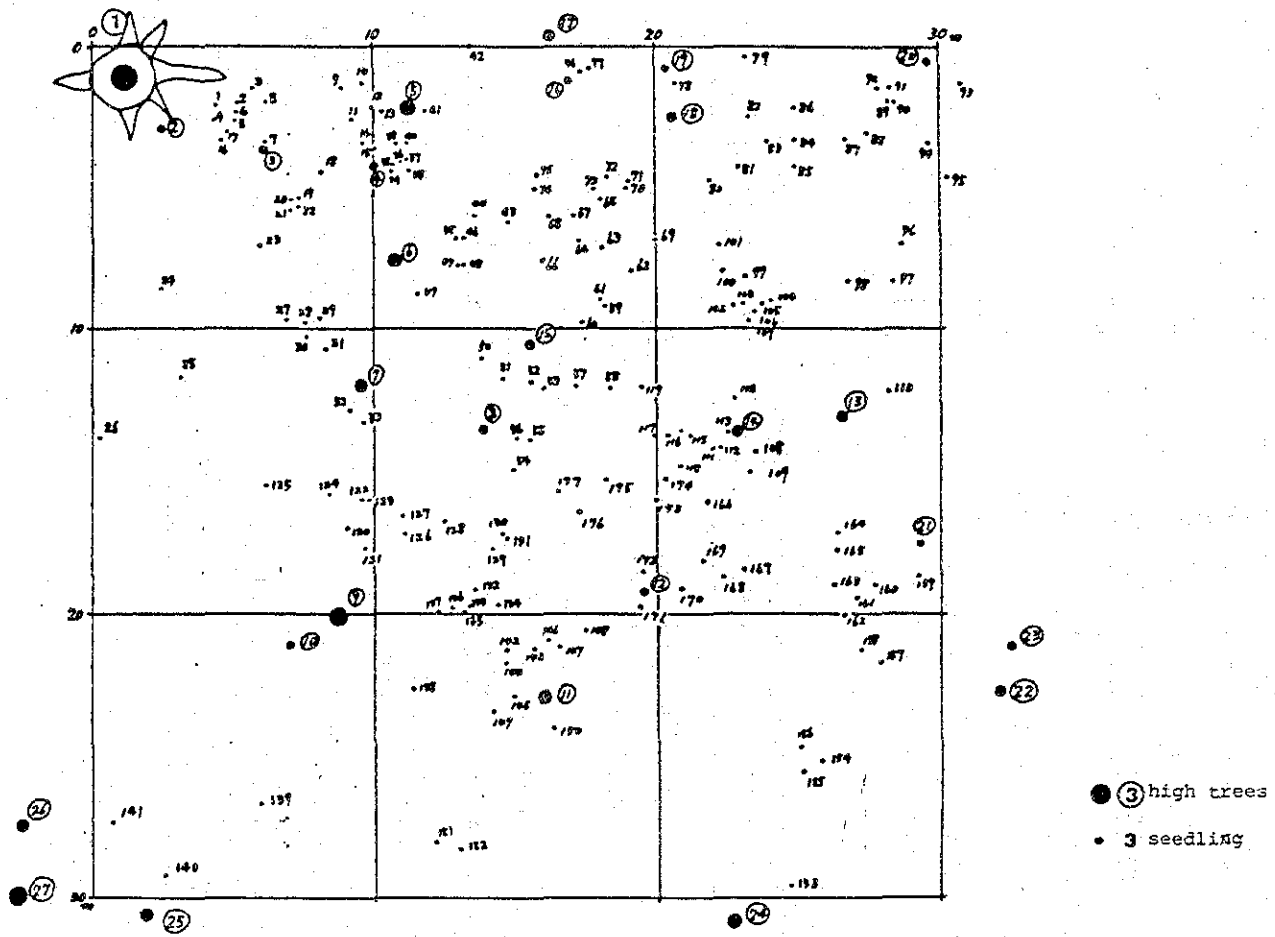


Fig. 38 Regeneration of Shorea smithiana saplings in a virgin forest in Sebulu

Table 28 Sizes of high trees in a virgin forest in Sebulu

Tree No.	Species	DBH (cm)	H (m)	C.D (m)
1	Shorea smithiana	144	30	30
2	Litsea firma	16	8	3
3	Eugenia cuprea	11	8.5	5
4	Shorea smithiana	20	13	3
5	Litsea firma	54	24	6
6	Cotylelobium malayanum	39	23	4
7	Eusideroxylon zwageri	37	16	8
8	Dillenia borneensis	24	18	2
9	Eusideroxylon zwageri	54	23	9
10	Dipterocarpus borneensis	22	17	5.5
11	Irvingia malayana	47	17	4
12	Litsea firma	21	11	3.5
13	Dillenia borneensis	35	12	4
14	Baccaurea spp.	30	16	3
15	Baccaurea spp.	23	14	4
16	Baccaurea spp.	17	11	6
17	Sindora wallichii	36	24	5
18	Litsea firma	28	16	3.5
19	Gymnacranthera contracta	17	13	1.5
20	Sindora wallichii	24	14	4
21	Baccaurea spp.	15	11	3
22	Durio oxleyanus	37	14	4
23	Baccaurea spp.	21	13	5.5
24	Durio oxleyanus	37	22	6
25	Eusideroxylon zwageri	33	16	4
26	Litsea firma	31	17	7
27	Litsea firma	54	25	6

Table 29 Sizes of Shorea smithiana saplings in a virgin forest in Sebulu

Seedling No.	H cm	D mm	CD cm	NL	Seedling No.	H cm	D mm	CD cm	NL
1	20	2	18	3	31	19	2	6	1
2	20	2	21	2	32	26	3	21	2
3	18	2	12	1	33	11	2	9	2
4	13	2	8	2	34	31	5	31	7
5	22	3	20	2	35	11	2	10	2
6	18	2	18	2	36	12	2	13	3
7	21	3	20	3	37	20	3	18	2
8	21	3	25	3	38	13	2	14	2
9	12	2	6	1	39	19	3	10	1
10	17	3	14	2	40	15	2	14	2
11	20	3	21	3	41	13	2	12	1
12	20	2	12	2	42	9	2	12	2
13	9	2	7	1	43	13	2	11	2
14	25	3	24	3	44	24	3	10	1
15	16	3	15	2	45	16	2	16	2
16	14	2	9	1	46	13	2	7	1
17	19	2	11	2	47	12	2	8	1
18	24	3	24	2	48	12	2	7	1
19	15	2	8	2	49	20	3	10	1
20	16	2	9	2	50	20	3	22	3
21	16	2	18	2	51	17	2	13	3
22	12	2	7	1	52	13	3	16	3
23	22	3	20	3	53	16	2	16	2
24	12	2	16	2	54	20	3	20	5
25	14	2	19	2	55	15	2	14	4
26	100	7	47	5	56	20	3	30	4
27	20	3	16	2	57	27	3	17	5
28	21	3	18	2	58	20	3	19	4
29	24	2	16	2	59	39	3	24	4
30	21	2	23	2	60	16	2	12	3

Seedling No.	H cm	D mm	CD cm	NL	Seedling No.	H cm	D mm	CD cm	NL
61	13	2	15	3	91	17	2	8	1
62	16	2	14	3	92	21	2	23	2
63	16	2	14	3	93	15	2	24	2
64	24	3	22	5	94	53	4	35	9
65	14	2	16	4	95	20	2	19	2
66	26	3	25	2	96	20	2	18	3
67	24	3	20	2	97	22	2	20	2
68	13	2	15	2	98	18	2	9	1
69	17	2	13	4	99	47	5	37	8
70	20	2	12	3	100	17	2	20	3
71	20	2	18	4	101	21	2	20	2
72	13	2	6	1	102	28	2	14	2
73	12	2	12	2	103	24	2	14	5
74	12	2	6	1	104	13	2	14	3
75	22	2	20	3	105	19	2	9	3
76	12	2	12	1	106	22	2	19	4
77	19	2	7	1	107	11	2	10	3
78	61	5	26	4	108	87	9	58	10
79	18	2	18	2	109	20	2	22	3
80	14	2	16	2	110	23	2	16	2
81	20	2	20	2	111	12	2	15	3
82	33	3	22	8	112	15	2	14	4
83	26	3	15	2	113	8	1	8	1
84	41	4	28	6	114	25	2	24	3
85	20	2	19	7	115	12	2	10	2
86	30	2	18	6	116	29	2	20	4
87	52	5	17	5	117	19	2	19	3
88	42	4	30	6	118	21	2	18	2
89	26	2	14	1	119	25	3	21	4
90	22	2	19	2	120	11	2	6	1

Seedling No.	H cm	D mm	CD cm	NL	Seedling No.	H cm	D mm	CD cm	NL
121	12	2	8	1	151	22	3	12	3
122	15	2	9	1	152	17	2	13	2
123	11	2	9	1	153	16	2	12	2
124	9	2	14	2	154	9	2	18	2
125	24	2	14	2	155	10	2	17	2
126	21	2	19	2	156	18	2	17	2
127	15	2	7	1	157	20	2	13	3
128	25	3	21	4	158	18	2	13	2
129	14	2	12	5	159	140	10	70	16
130	20	2	17	3	160	22	2	18	3
131	22	2	19	5	161	16	2	12	3
132	26	2	19	3	162	22	2	26	2
133	15	2	13	2	163	63	6	40	14
134	28	3	18	4	164	12	2	13	2
135	22	2	13	4	165	18	3	20	2
136	18	2	11	1	166	33	5	30	8
137	17	2	14	3	167	55	5	30	7
138	18	2	13	3	168	17	2	20	2
139	17	2	16	5	169	20	2	15	2
140	57	6	22	3	170	20	2	20	3
141	66	5	30	6	171	27	3	25	5
142	16	2	11	3	172	13	2	3	1
143	23	2	16	5	173	140	11	55	13
144	23	2	22	6	174	40	3	24	4
145	27	2	18	3	175	15	2	26	4
146	20	2	22	3	176	18	2	22	4
147	16	2	15	4	177	13	2	15	3
148	14	2	17	3					
149	18	2	21	2					
150	12	2	12	2					

H: Tree height D: Basal diameter CD: Crown diameter

NL: Number of leaves per tree

The investigation in a virgin forest in Sebulu was made at 5 places. The number of saplings of 2 cm or less in basal diameter regenerated were 750/ha to 75,000/ha. The number of saplings of 2 to several centimeters were 900 to 8,400/ha. The samplings of commercial species accounted for 14 to 19% of all the species.

2) Stand selectively cut immediately before

In the stand selectively cut immediately before shown in Figs. 22 and 23, five plots of 1 m × 10 m each were set in November, 1980 at a place where the damage by felling and logging was relatively small (Fig. 30, A-1), to investigate the growing stages of saplings. The results are shown in Table 29.

The number of living saplings were 16 in plot 1, 17 in plot 2, 14 in plot 3, 11 in plot 4 and 10 in plot 5, and the total number per 50 m^2 were 68, viz. 13,600 per ha. They were 10 to 493 cm in tree height, and the mean height were 133 cm. As for vitality, about 30% was low, but the remaining saplings were medium or high. Of them, the number of saplings of Shorea were 6, viz. 1,200 per ha. None of them was low in vitality, and most were medium.

At the same location, investigation was made by the belt transect method for an area of 1 m × 20 m at a place surmised to be damaged by logging (Fig. 30, C). The results are shown in Table 30. The number of living saplings per 20 m^2 were 78, viz. 39,000 per ha. They were 15 to 156 cm in tree height, and the mean height was 78 cm. The number of samplings low in vitality was small, accounting for 19% of the whole, with about 45% being medium and 36% being high. The saplings of commercial species accounted for 41% of the whole. The number of saplings of Shorea per ha were 12,000, accounting for 30.8% of the whole.

The number of the saplings regenerated in a place not damaged by felling and logging were 13,600 (1,200 trees of commercial species) per ha. On the other hand, the corresponding number in a place surmised to have been damaged were 39,000 (15,990 trees of commercial species) per ha, indicating a regeneration value of about

Table 30 Growing states of saplings

No	Species	DBH cm	Height cm	Vitality 1	Vitality 2	Vitality 3	Notes
	Section 1 (1×5)						
1	Milletia sp		124	+			
2	Ellipanthus sp		26	+			
3	Quercus sp		58			+	
4	Ellipanthus sp		23			+	
5	Shorea Smithiana		25		+		○
6	Baccaurea sp		61		+		
7	Quercus sp		73	+			
8	Ellipanthus sp		17			+	
9	?		48			+	
10	Trioma sp		27	+			
11	Dripetes sp		16	+			
12	Parinari sp		62		+		
13	Shorea leavis		10		+		○
14	Durio sp		105		+		
15	Urophyllum sp		270			+	
16	Malotus sp		62			+	
	Section 2						
17	Milletia sp		63		+		
18	Shorea laevifolia		244			+	○
19	Macaranga triloba		160			+	
20	Pandanus sp		170			+	
21	Pandanus sp		170			+	
22	Baccaurea sp		493		+		
23	Baccaurea sp		92		+		
24	Eugenia sp		235		+		
25	Eugenia sp		330		+		
26	Litsea sp		283	+			
27	Litsea sp		62	+			
28	Milletia sp		172	+			
29	Baccaurea sp		450			+	
30	Xantoxphylum		60	+			
31	Urophyllum sp		125	+			
32	Dripetes sp		250	+			
33	Trioma sp		24			+	
	Genera listed below were counted only and not been drawn into Diagram						
	Section 3						
34	Pterospernum sp		33	+			
35	Milletia sp		72			+	

No	Species	DBH cm	Height cm	Vitality 1	Vitality 2	Vitality 3	Notes
36	Milletia sp		25		+		
37	Eugenia sp		181		+		
38	Shorea laevis		475		+		○
39	Shorea laevis		43		+		○
40	Shorea laevis		205		+		○
41	Pterospermum sp		150			+	
42	Litsea sp		107			+	
43	Eugenia sp		127			+	
44	Eugenia sp		102	+			
45	Milletia sp		151		+		
46	Garcinia sp		430		+		
47	Quercus sp		386			+	
	Section 4						
48	Dripetes sp		163	+			
49	Pternandra sp		66	+			
50	Cryptocaria sp		53	+			
51	Cratoxylon sp		81			+	
52	Baccaurea sp		125			+	
53	Dipterocarpus		58			+	
54	Urophylum sp		24		+		
55	Mallotus echinatus		133	+			
56	Eugenia sp		184			+	
57	Pandanus sp		95			+	
58	Pandanus sp		28			+	
	Section 5						
59	Medimella sp		154		+		
60	Ellipanthus sp		152			+	
61	Eugenia sp		85				
62	Quercus sp		109		+		
63	Eugenia sp		109		+		
64	Litsea sp		300			+	
65	Milletia sp		109	+			
66	Eugenia sp		15	+			
67	Ellipanthus sp		37		+		
68	Ellipanthus sp		90		+		

Plot diagram : Note : 1. Bad 2. Average 3. Exellent

O: Commercial tree species

Table 31 Growing states of saplings

No.	Species	DBH cm cm	Height cm	Vitality 1	Vitality 2	Vitality 3	Notes
1	Shorea laevis		28.0			+	○
2	Dialium sp		100.0			+	
3	Litsea sp		89.0			+	
4	Shorea Leovis		125.0			+	○
5	Shorea leprosula		80.0		+		○
6	Mallotus echinatus		75.0	+			
7	Palaquium sp		145.0			+	○
8	Shorea laevis		38.0		+		○
9	Shorea laevis		45.0		+		○
10	Shorea laevis		78.0		+		○
11	Eugenia sp		65.0	+			
12	Monocarpia sp		145.0	+			
13	Knema sp		130.0	+			
14	Knema sp		80.0			+	
15	Canarium sp		38.0		+		
16	Polyalthia sp		47.0		+		
17	Hopea sp		156.0			+	
18	Aporosa sp		70.0		+		
19	Ixora sp		36.0	+			
20	Ixora sp		37.0	+			
21	Shorea leprosula		85.0			+	
22	Dacroides sp		85.0			+	
23	Diospyros		58.0		+		
24	Mallotus sp		75.0			+	
25	Hopea sp		75.0		+		
26	Dialium sp		125.0		+		
27	Palaquium sp		130.0			+	○
28	Dialium sp		100.0			+	
29	Madhuca sp		145.0			+	
30	Aporosa sp		115.0			+	
31	Madhuca sp		85.0			+	
32	Dacroides sp		85.0			+	
33	Dacroides sp		100.0		+		
34	Canarium sp		90.0		+		
35	Ixora sp		75.0		+		
36	Shorea smithiana		75.0		+		○
37	Dipterocarpus sp		38.0			+	○
38	Litsea sp		48.0			+	
39	Hopea sp		100.0		+		
40	Shorea laevis		130.0		+		○
41	Shorea laevis		120.0		+		○

№	Species	DBH cm	Haight cm	Vitality 1	Vitality 2	Vitality 3	Notes
42.	Shorea leprosula		110.0	+			○
43.	Shorea laevis		100.0	+			○
44.	Knema sp		38.0	+			
45	Aporosa sp		48.0		+		
46	Mallotus sp		30.0		+		
47	Dialium sp		25.0			+	
48	Aporosa sp		15.0			+	
49	Litsea sp		35.0			+	
50	Shorea leprosula		40.0		+		○
51	Shorea laevis		90.0		+		○
52	Shorea laevis		100.0		+		○
53	Shorea leprosula		45.0			+	○
54	Canarium sp		75.0	+			
55	Ixora sp		80.0	+			
56	Hopea sp		75.0		+		
57	Shorea smithiana		80.0		+		○
58	Diospyros sp		105.0		+		
59	Mallotus sp		17.0			+	
60	Polyalthia sp		25.0			+	
61	Eugenia sp		38.0		+		
62	Pandanus sp		78.0		+		
63	Ixora sp		115.0		+		
64	Pandanus sp		125.0			+	
65	Pandanus sp		150.0			+	
66	Polyalthia sp		80.0			+	
67	Polyalthea sp		80.0		+		
68	Shorea laevis		75.0		+		○
69	Shorea laevis		60.0	+			○
70	Shorea leprosula		30.0		+		○
71	Shorea smithiana		30.0		+		○
72	Dialium sp		40.0	+			
73	Polyalthia sp		80.0	+			
74	Litsea sp		90.0		+		
75	Shorea laevis		100.0		+		○
76	Shorea laevis		80.0		+		○
77	Shorea laevis		80.0			+	○
78	Aporosa sp		70.0	+			

Plot diagram :

Note : 1. Bad, 2. Average, 3. Exellent

O: Commercial tree species

Table 32 States of saplings in a stand selectively cut 10 years before in Sebulu

No	Species	Height (cm)	Vitality			Notes
			1	2	3	
1	Saraka sp	41		+		
2	Aporosa sp	20		+		
3	Litsea sp	15			+	
4	Shouroria sp	23		+		
5	Eugenia sp	20			+	
6	Mallotus sp	15		+		
7	Eugenia sp	15		+		
8	Ixora sp	22		+		
9	Urophyllum sp	20			+	
10	?	12	+			
11	Aporosa sp	25	+			
12	?	10		+		
13	Saraka	25			+	
14	Litsea sp	23			+	
15	?	10		+		
16	Glocidion sp	21		+		
17	Saraka sp	56			+	
18	Glocidion sp	15			+	
19	Glocidion sp	23			+	
20	Milletia sp	24			+	
21	Glocidion sp	10		+		
22	Eugenia sp	27	+			
23	?	20	+			
24	Cratoxylon sp	30		+		
25	Saraka sp	35		+		
26	Polyalthia sp	40		+		
27	Polyalthia sp	37			+	
28	Polyalthia sp	28			+	
29	Kompassia sp	35			+	
30	Milletia sp	18	+			
31	Milletia sp	19	+			
32	Glocidion sp	20	+			
33	Gironniera sp	115		+		
34	Pandanus	48			+	

№	Species	Height (cm)	Vitality			Notes
			1	2	3	
35	Antidesma sp	250			+	
36	Litsea sp	430			+	
37	Dripetes sp	30		+		
38	Shorea smithiana	430		+		O
39	Eugenia sp	51		+		
40	Urophyllum sp	48				
41	Ixora sp	20			+	
42	Ixora sp	25	+			
43	Baccaurea sp	63		+		
44	Litsea sp	20			+	
45	Litsea sp	28		+		
46	Pandanus sp	250		+		
47	Milletia sp	16		+		
48	?	25			+	
49	Antidesma sp	168			+	
50	Baccaurea sp	340			+	
51	Myristica	60			+	
60	Eugenia sp	35			+	
61	Urophyllum sp	17			+	
62	Baccaurea sp	19	+			

Note : 1 : Bad
2 : Average
3 : Exellent
O : Commercial tree species

3 times that in a place not damaged. Though this is a matter of only two places, the number of living saplings regenerated is surmised to be greatly depend on site conditions and stand conditions.

3) Stand selectively cut 10 years before

In the stand selectively cut 10 years before shown in Figs. 24 and 25, a belt transect of 1 m × 10 m was set, to investigate the regeneration and growing states of saplings in November, 1980. The results are shown in Table 32. The number of living saplings were 54,000 per ha. They were 10 to 430 cm in tree height, and the mean height was 52 cm. As for their vitality, about 18% grew poorly, 39%, ordinarily and 43%, very well. The number of saplings of commercial species were 1,000 per ha.

ii. Bukit Soeharto

1) Virgin forest

In November, 1980, 10 plots of 1 m × 1 m each were set at random in the large virgin forest shown in Figs. 28 and 29, to investigate the regeneration and growing states of saplings. The results are shown in Table 33.

The number of living saplings were 4 to 9 per plot, and the average number were 5.7, viz. 57,000 per ha. They were 10 to 400 cm in sapling height, and the average height was 80 cm. The number of commercial species were 11, accounting for 19% of the whole. As for vitality, about 5% of saplings were judged to be low, and most were judged to be medium.

iii. Sotek

1) Virgin forest

At a site about 78 km inside from the BFI office in Sotek, in a relatively bright and wide virgin forest, the saplings of Shorea leprosula were investigated in October, 1981. Since the soil existing near the seed tree was clayey, an aquifer was observed even though the place was close to a ridge top. There was also a

Table 33 Growing states of saplings in a virgin forest in Bukit Soeharto

No	Species.	H. (m)	Vitality. 1	2	3	Note
I/24	1. Shorea laevis	1.00		X		○
	2. Canarium sp.	1.30			X	
	3. Dillenia sp.	0.40			X	
	4. Eugenia sp.	3.50		X		
II/19	1. Calamus sp.	1.20			X	
	2. Pentrace sp.	0.20			X	
	3. Pandanus sp.	0.70				
	4. Shorea ovalis	0.70		X		
III/14	1. Palaquium sp.	1.20	X			Broken ○
	2. Oldenlandia sp.	0.20		X		
	3. Litsea sp.	0.20		X		
	4. Pentace sp.	0.10		X		
	5. Aporosa sp.	0.20		X		
	6. Calamus sp.	0.25			X	
IV/7	1. Shorea leprosula.	1.00			X	○
	2. Shorea laevis.	0.70		X		○
	3. Litsea sp.	0.40		X		
	4. Eugenia sp.	0.30	X			broken
	5. Milletia sp.	0.25		X		
	6. Lindesola sp.	0.20		X		
	7. Sterculia sp.	0.20		X		
V/8	1. Litsea sp.	1.00		X		
	2. Palaquium sp.	0.28		X		○
	3. Macaranga sp.	0.20			X	
	4. Milletia sp.	0.30		X		
	5. Ixora sp.	0.80			X	
	6. Urophyllum sp.	1.00		X		
	7. Eugenia sp.	0.15		X		
	8. Millettia sp.	0.20		X		
	9. Dillenia sp.	1.20		X		
VI/2	1. Shorea smithiana	1.20		X		○
	2. Mallotus echinatus.	1.10		X		
	3. Mallotus echinatus.	1.00		X		
	4. Litsea sp.	0.60			X	
	5. Aporosa sp.	0.30		X		
VII/1	1. Eurycoma sp.	0.70		X		
	2. Millettia sp.	0.90	X			leaf broken
	3. Antidesma sp.	1.40		X		
	4. Shorea leprosula.	0.90		X		○
	5. Shorea ovalis.	0.15		X		○
VIII/10	1. Sindora sp.	1.00		X		
	2. Milletia sp.	0.50		X		
	3. Ixora sp.	0.30		X		
	4. Mallotus sp.	2.00		X		
	5. Litsea sp.	1.70		X		
	6. Shorea leprosula.	4.00			X	
IX/11	1. Shorea ovalis.	0.80		X		○
	2. Shorea ovalis.	0.75		X		○
	3. Aporosa sp.	0.40		X		
	4. Aporosa sp.	0.30		X		
	5. Millettia sp.	0.15		X		
X/12	1. Santiria sp.	1.00		X		
	2. Ixora sp.	1.20		X		
	3. Litsea sp.	0.40		X		
	4. Milletia sp.	1.00		X		
	5. Shorea leprosula.	0.20		X		○
	6. Calamus sp.	1.10		X		

Note : Vitality 1 : bad
2 : ordinary
3 : excellent

No	Height (cm)	D (mm)	CD (cm)
1	75	6	60
2	110	6	90
3	112	7	80
4	140	10	80
5	98	9	45
6	91	7	50
7	96	10	37
8	148	13	90
9	273	14	140
10	325	20	190
11	92	7	55
12	111	6	55
13	25	3	15
14	140	16	90
15	108	8	70
16	128	10	70
17	259	14	140
mean	137.1	9.8	79.8

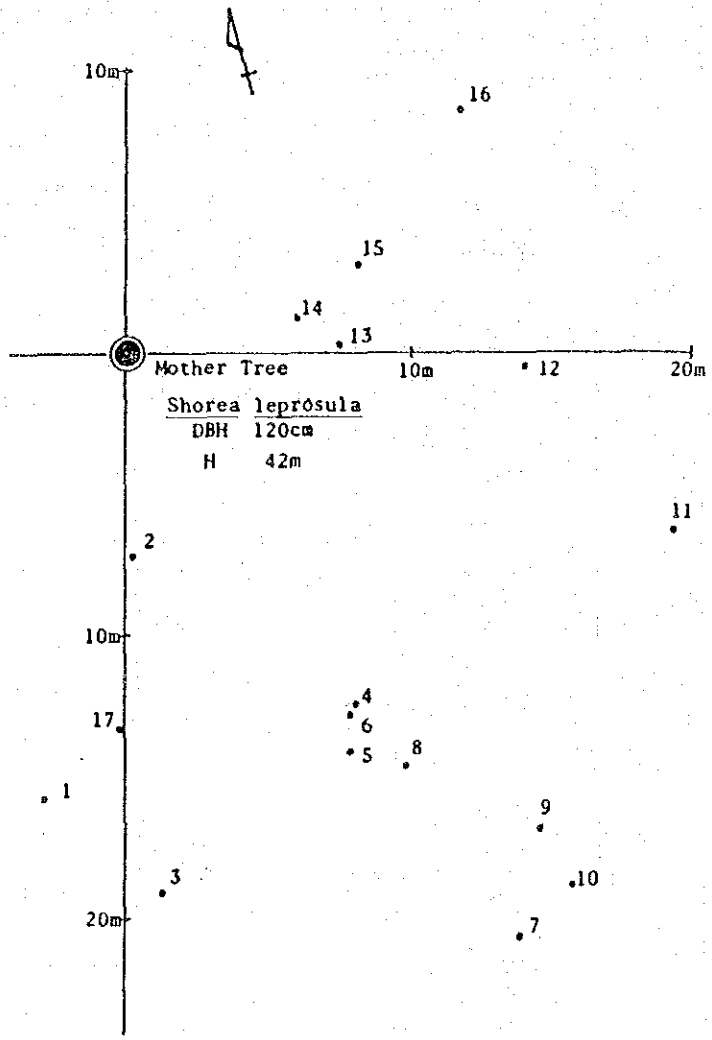


Fig. 39 States of Shorea leprosula saplings in a virgin forest in Sotek.

recessed area like a marsh. As for the states of saplings, as shown in Fig. 39, there were only 17 saplings in a semi-circle around the seed tree. They were 25 to 325 cm high above the ground, and the mean height was 137 cm. If the number of saplings is assumed to be 30 per seed tree, then the number per ha may not be expected to be so large.

2) Selection forest

Investigation was made in November, 1981 in a stand selectively cut 10 years before at about 12 km apart from the BFI office in Soetek. The states of seedlings of an almost rotten Shorea smithiana stump in a quarter circle around the stump are shown in Fig. 40. The number of seedlings were only 8, and they were 13 m in mean tree height and 10.6 cm in mean breast height diameter. If the number of seedlings per mother tree is more than 30, then the number cannot be said to be very large as in the case of a virgin forest.

iv. Lempake

In the virgin forests of Lempake practical training forests of Mulawarman University, two sites A and B were selected, to set survey locations, for investigating the saplings of Shorea smithiana. Site A is a slightly coarse stand, and for mother trees growing along a ridge top, the distribution of saplings in each semi-circle of 20 m on the downward slope was investigated. The results are shown in Fig. 41. For mother tree No. 1, the number of saplings were only 9 per 200 m^2, ans for mother tree No. 2, it was only 8 per 200 m^3. That is, the numbers per mother tree were 18 and 16, respectively being small. The mean sapling heights were 112 cm and 134 cm respectively.

The soil at Site B was sandy and the color was light. It was infertile. The distribution of saplings in a quarter circle of 30 m around a mother tree was investigated, and the results are shown in Fig. 42. The number of trees of 30 cm or more in breast height diameter were 5 per 900 m^2, and the number of saplings was 52 per 900 m^2.

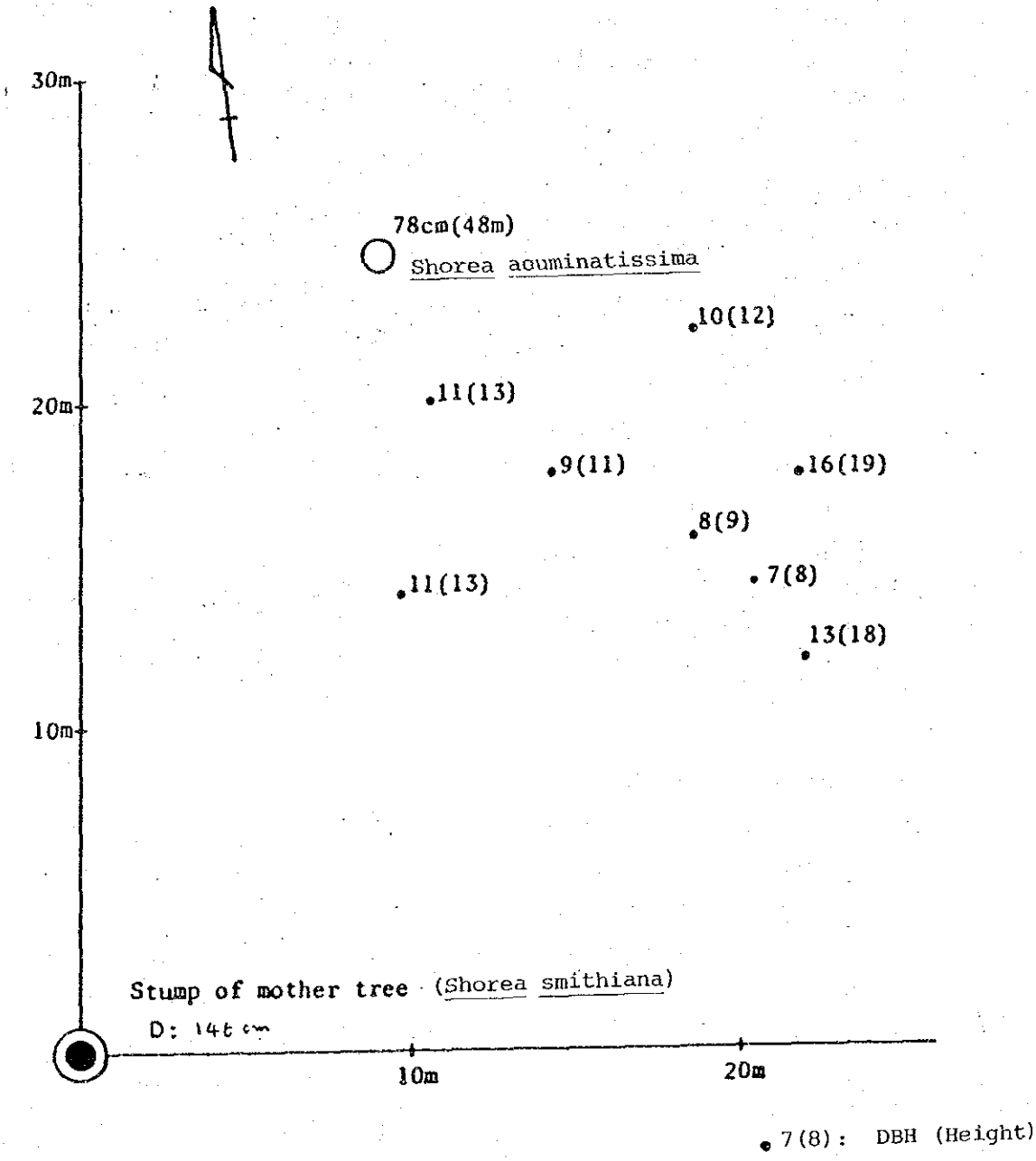
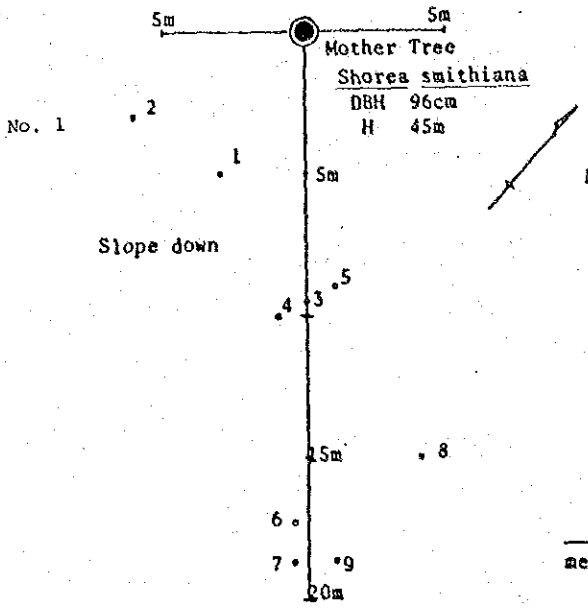
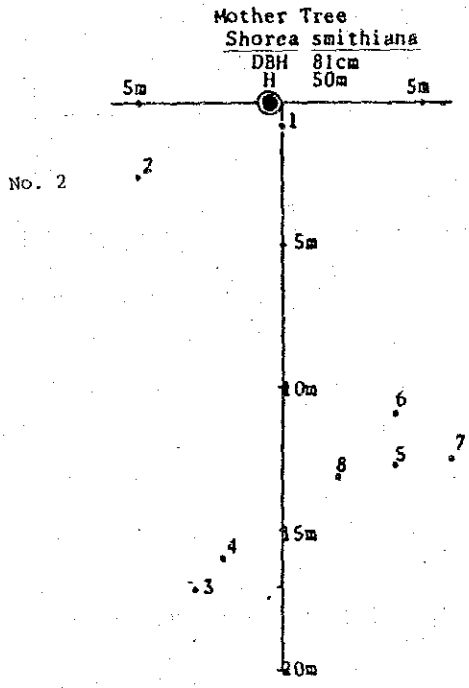


Fig. 40 Regeneration and growth of Shorea smithiana saplings in a stand selectively cut 10 years before in Soetek



No.	H cm	CD cm
1	52	54
2	225	118
3	254	76
4	33	25
5	49	35
6	99	56
7	83	30
8	150	51
9	60	41
mean	112	54



No.	H cm	CD cm
1	75	48
2	125	37
3	135	25
4	85	53
5	199	101
6	120	43
7	185	82
8	150	37
mean	134	53

Fig. 41 Regeneration and growth of Shorea smithiana at Site A in a virgin forest in Lempake

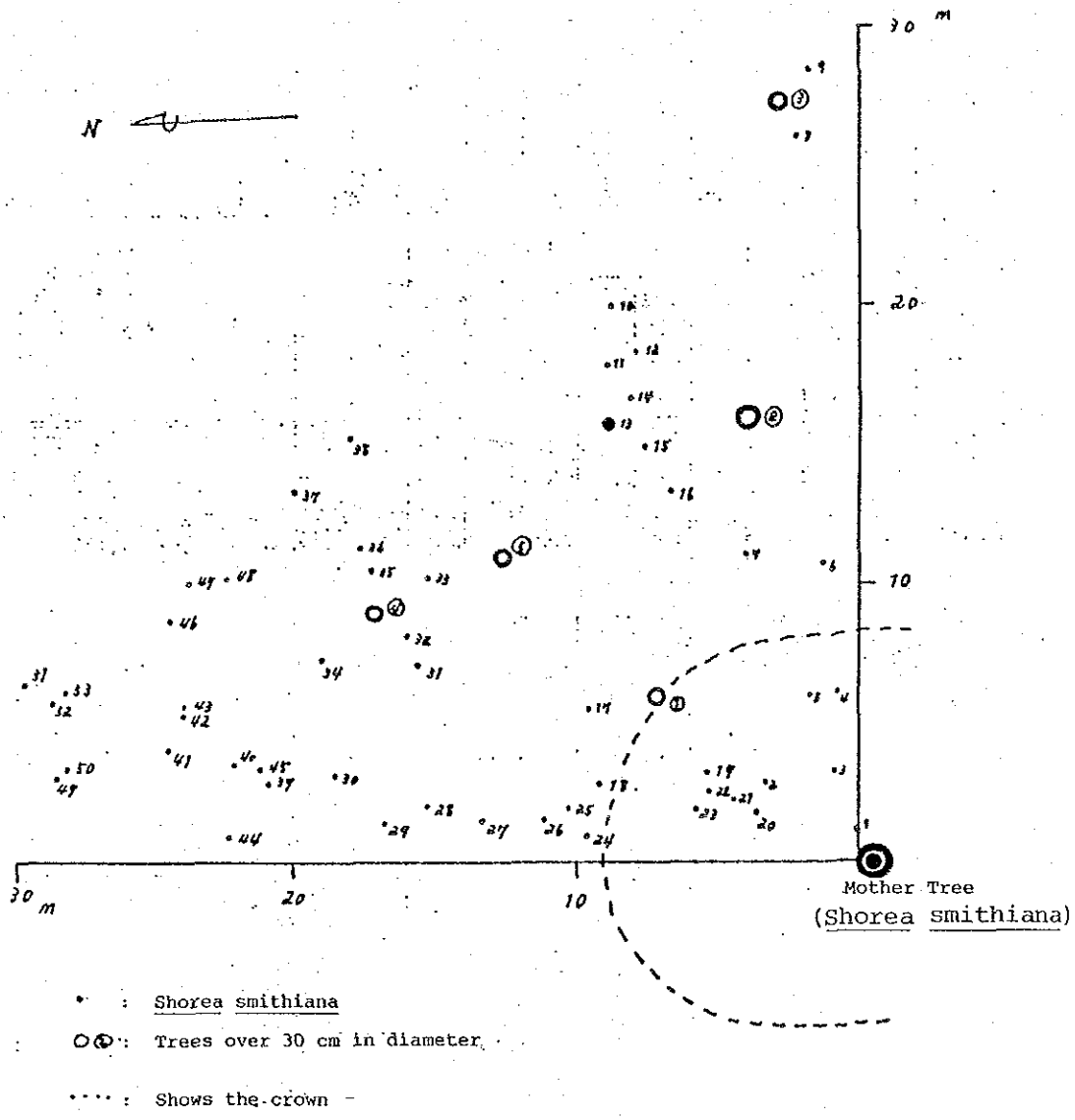


Fig. 42 Regeneration of Shorea smithiana saplings at Site B in a virgin forest in Lempake

The regeneration of saplings was small in Sotek and Lempake, but was large in Sebulu both in the virgin and selection forests. In the latter, the number of seedlings of commercial species is surmised to be also large.

Since the arrangement of mother trees, states of forest floor, etc. are different from stand to stand, the number of saplings regenerated is different to some extent and the difference is also caused by the difference in the conditions of surveyed location. However, the numbers of saplings regenerated were generally very large. However, large numbers vanished, and in a stand with decades of trees of 50 cm or more in breast height diameter as shown in Table 12, to balance between growth and cropping in long years by selection cutting is surmised to require some artificial control, considering the competition between plants, pest damage, etc.

As for succeeding trees as future stand constituting the species, since they grow under covering forests, the shade bearing capabilities of the respective species and the number of leaves per sapling affect growth more or less. If the number of leaves per sapling is 5; 1,000 saplings should grow in one hectare. Since the regeneration and growth of saplings is surmised to be affected by site conditions, especially such environment as quality of soil, density and growing states of upper trees, and light conditions by them, it is desired to consider the propriety of regeneration, rotation intervals, etc. from the present situations, and to discuss the method for studying them.

As to the growth of saplings growing in the lowest storey of a compound-storied forest, it is required to investigate the shade bearing capabilities of the respective species, measures their suitability for soil productivity and resistance against various kinds of damages, and to study the tending within the rotation, including the salvage cutting of forest trees forming the crowns of the lower storey, to incorporate ecological control in the detailed rules for working of TPI.

(7) Pest damage and growth disturbance of forest plants

i. Growth disturbance

As part of an investigation into growth disturbances in forest plants, samples of leaves of saplings recognized to have lesions were photographed in forests mainly containing trees of Dipterocarpaceae in Sebulu in September, 1980, and the photos were compared with the description in literature in Japan, to identify the names of the diseases. Identified diseases are described below.

1) Diseases of pines

a. Fox-tail (pathogen unknown, physiological disease?)

Fox-tail is considered to be hereditary[a)] rather than being caused by a pathogen, or since it is often observed in districts where rainfall occurs throughout the year, it is considered to be induced by any factor based on nature that cause this disease hereditarily[b)]. On the contrary, this disease was often observed in places with humus or fertile places. In this relation, in East Kalimantan, it is recognized that the disease appears on surface soils containing large amounts of nitrogen, phosphorus, etc.[c) d)]

In East Kalimantan, the afforestation of Carribbean pine and Merkusi pines have made considerable progress for the past 10 odd years. In future, it is desired to research into the conditions of normalizing the increase of tree age, in relation to site conditions, disease generation rate, etc. with the progress of afforestation.

b. Black root rot
(pathogen: Macrophomina phaseoli, syn. Sclerotium bafaticola)

This is observed in seedling beds, and 60 to 70 cm seedlings become dead and brown (Photo 16). If the bark of a dead seadling is removed at a portion close to the soil, many fine black points (sclerotiums of the pathogen) are observed on the surface of lignum and inside the bark.

2) Diseases of Eugenia

a. Algae leaf spot
(pathogen: Cephaleuros virescens)

These algae grow on leathery and smooth leaf surfaces (Photo 17). This disease often occurs in poorly ventilated dark and humid places with insufficient light. It is widely observed on the leaves of saplings of such species as Eugenia and Litsea.

3) Diseases of Vatica

a. Tar spot[8) 9)] (Pathogen: Phyllachora sp.)

Small yellow and circular spots are caused on the leaves, and at the center of each spot, a black bulging of 1 to 5 mm in diameter like a scab is formed (Photo 18). This disease occurs with saplings and young trees.

4) Others

Other symptoms which are surmised to be diseases, though the species or names are unknown, are shown in Photos 19 to 23 for reference.

In general, corpsucular sclerotial diseases are said to occur frequently at earth temperatures higher than 30°C, and are surmised to be liable to occur in the tropics. Seedlings of pines can be nursed in pots (Photo 24), and since they grow early to cover the ground surface in a short time, mass generation of diseases is assumed to not be great-occurs[8)]. There is a researcher who thinks it is effective to properly irrigate in the dry season when diseases threaten to occur intensively or in a place of sandy soil[10)]. Since the maximum temperature of East Kalimantan is about 32°C, the control of earth temperature is not so difficult. Therefore, it will be necessary to examine the influence of direct sunlight on the soil surface, humidity of soil, etc. before taking proper measures.

Photo 15 Fox tail of Merkusi pine
(Pinus merkusii Jungh et de Vries)

Photo 16 Corpuscular sclerotial, disease of pine?

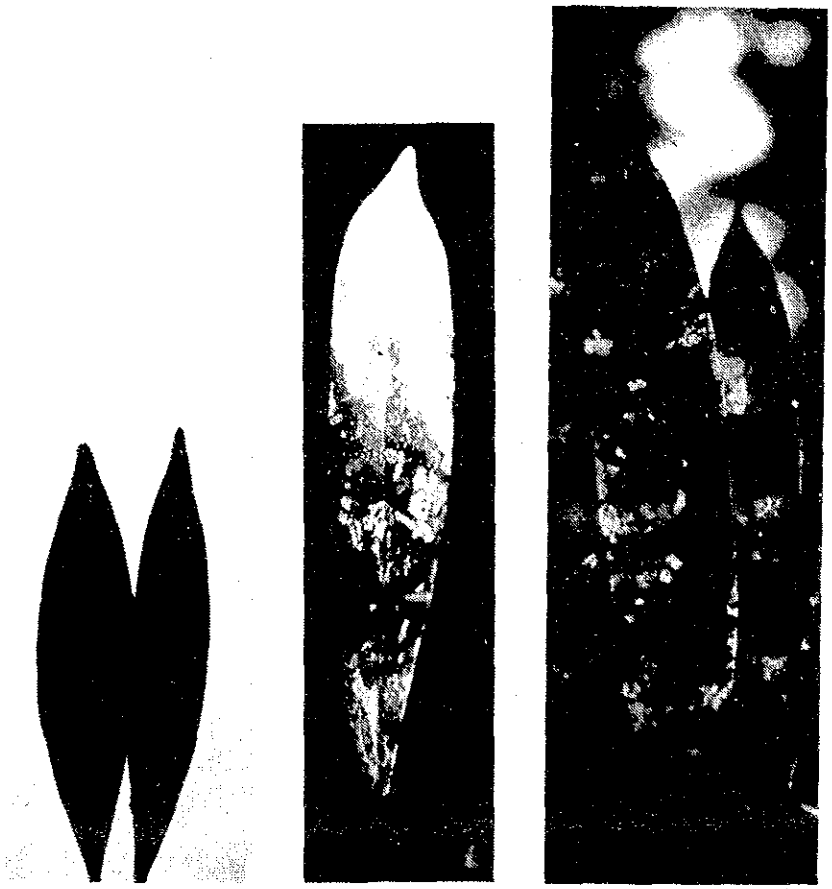


Photo 17 White alga (species unknown)

Photo 18 Black fat of Vatica sp.?

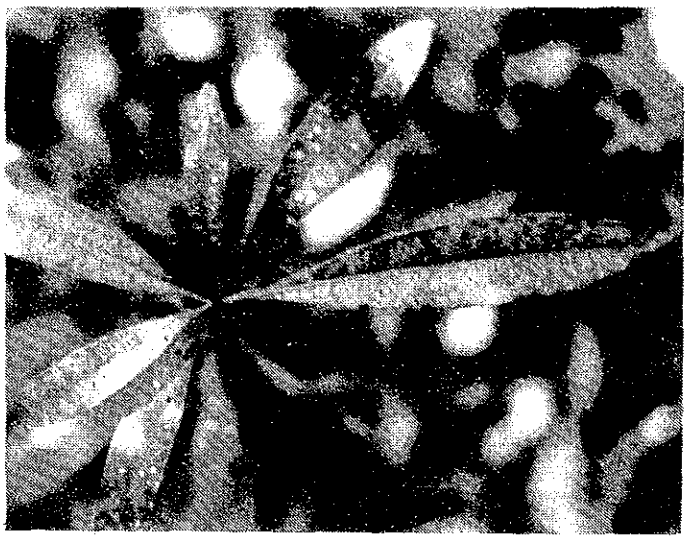


Photo 19 Tristania sp. (disease name unknown)

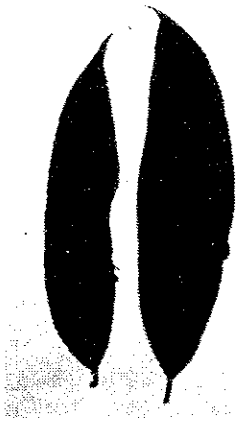


Photo 20 Litsea angulata
(disease name unknown)

Photo 21 (Species and disease
name unknown)

Photo 22 (Species and disease name unknown)

Photo 23 (Species and disease name unknown)

Photo 24 Pine seedlings nursed in pots

While algae and black fat which are also observed are not surmised to be so serious. In case of nursery, the frequent generation can be thoroughly prevented by enhancing ventilation and burning sick seedlings.

As for the problem of tree diseases in tropical rain forests, new diseases may be caused by the present mass selection cutting, regeneration, nursery operation, clear cutting and artificial regeneration, development of undergrowth and the drying and large fire of 1982 to 1983, and therefore it is required to precisely know the states of regeneration and to continue studies on the prevention of the diseases.

ii. Pest damage

With regard to the pest damage of forest plants, the following results were obtained by actual survey and the specimens or literature in Bogor Animal Museum.

1) Main pests injurious to forests and situations of damage in East Kalimantan

The pests observed in the virgin forests and planted forests in East Kalimantan are shown below.

a. Kinds of injurious pests observed in virgin forests and planted forests

Main pests injurious to forest trees observed in the virgin forests and planted forests of Lempake are shown in Table 34. As Coleoptera pests, Chaenius sp. and other 36 species were observed, and as Lepidoptera pests, Cosmopteryx pallidifasciella and other 53 species were also observed.

b. Main wood borers and situations of damage

i) Damage by Scolytidae, Platypodidae and Cerambycidae in and around Lempake

In and around Lempake, as wood borers, respectively five species of Scolytidae and Platypodidae such as Arixyleborus granulifer, A. hirsutulus, and Platypus curtus as Ambrosia

Table 34 List of main forest tree borers

1. Coleoptera

Chaenius sp.
Calleida tenuis
Cicindela aurulenta
Epicauta ruficeps
Hister chinensis
Paederus fuscipes
Carpophilus hemipterus
Tenebroides-kever
Triborium
Laemophloeus pusillus
Ahasverus-Kevertje
Typhaea stercorea
Anadastus filiformis
Agrilus acutus
Agrilus occipitalis
Attagenus undulatus
Anthrenus vorax
Lasioderma sp.
Formicomus ruficollis

Alphitobius piceus
Bruchus rouyeri
Araecerus crassiocornis
Cosmopolites sordidus
Calandra oryzae
Pivcalandra frumenti
Rhynchophorus ferrugineus
Xystrocera festiva
Xylotrechus javanicus
Xylotrechus quadripes
Glenea novemgutta
Brontispa longissima
Psylliodes balyi
Rhadinosa parvula
Lepidiota stigma
Leucopholis rorida
Holotrichia constucta
Euchlora viridis

2. Lepidoptera

Cosmopteryx pallidifasciella
Cosmopteryx dulcivora
Homona sp.
Argyroploce illepida
Enarmonia hemidoxa
Scirpophaga innotata
Ephestia cautella
Mymphula sp.
Nosophora sp.
Lamprosema indicata

Margaronia unionalis
Omphisa sp.
Maruca amboinalis
Pyrausta sp.
Parasa lepida
Scopelodes sp.
Thosea sp.
Striglina thermesioides
Artona sp.
Oreta sp.

Boarmia bhurmitra
Hyposidra talaca
Phalera raya
Stauropus alternus
Cerura liturata
Tarsolepis sommeri
Andraca sp.
Amsacta lactinea
Creatonotos gangis
Utetheisa
Samia cynthia
Agrotis interjectionis
Bombotelia jocosatrix
Earias sp.
Rivula atimeta
Plusia signata
Brithys sp.

Spodoptera mauritia
Leucania unipuncta
Prodenia sp.
Mocis frugalis
Parallelia palumba
Orgyia postica
Dasychira pennatula
Euproctis catala
Othreis fullonica
Herse convolvuli
Laphygma eyempta
Euthalia soorten
Catopsilia
Delias belisama
Papilio mennon
Papilio polytes
Chliaria othona

beetles, and five species of bark beetles such as Poecilips subcribrosus are dominant species, and in addition many wood borers such as Curculionidae, Brethidae and other Diptero carpus borers were observed.

Some bark beetles bore coarse barks of standing trees. Except in most cases, felled trees were damaged. For logs with bark on them, bark beetles bore under the bark, and xylem pests bore at the cross section. For debarked logs, as the sap oozing out of the surface just debarked dries, adult Ambrosia beetles begin to be parasitic, and bore circular holes of about their body sizes (0.8 to 3.0 mm). About 2 or 3 days later, dust like bars is discharged, and in several days, the sapwood is reached, and the corestock reached in several weeks. Larvae grow, eating Ambrosia which in cubated on the wall.

The pinholes of the logs collected on a forest road or timber yard are mostly formed on the lower half of each log, viz. on the side in contact with the ground, and when the logs are piled, pinholes are not able to in cubate generated on the logs placed above. As for the density of pinholes, in case of Putang, 197 pinholes were observed per 1 m^2. The pinholes remarkably lower the industrial value of wood creating knots, and promoting decay of the wood.

Pinholes include the usual pinholes and those formed in the xylem. The pinholes in the xylem are formed when weak young standing trees are bored to the corestock by beetles and keep on growing without being killed, to include the pinholes in the stem. The pinholes in the xylem are often erroneously recognized as usual pinholes[11]. The pinholes in the xylem are caused by a special factor, and the usual pinholes give a very higher rate of damage and are serious.

Lauan generally includes three major groups of yellow, white and red. The pinholes formed after felling are most liable to occur in yellow lauan, being followed by white and red

lauan in this order. The pinholes in the xylem which are said to be formed before felling are observed most in red lauan, and not observed in white or yellow lauan.

ii) Kinds of main pests injurious to forests and their damage effect expected to happen in future

The damage by pests expected to happen in future could not be confirmed locally because of the limited time, but can be discussed as follows; considering the environmental conditions.

According to Goda, et al.[12], Meranti is remarkably damaged by Ambrosia beetles (pinhole borers) who make innumerable small holes deep in the wood, and also by Xyleborini, Scolytoplatypus and Platypodidae of Scolytidae, and Lymexilonidae. It is damaged also by large pests such as Curculionidae and Cerambycidae.

Jozo Murakami[13] says that 3,225 species must be distributed in Kalimantan.

The species which must be noted in East Kalimantan for possible damage are as follows:

Ambrosia beetles

Scolytidae

Arixyleborus granulifer Fichhoff: Very small (Length ♀ 1.8∿1.9 mm ♂ 1.5 mm), ♀ blackish brown to black, ♂ yellowish red to reddish brown.

Arixyleborus hirsutulus Schebl: Very small (Length ♀ 1.75∿1.86 mm) yellowish brown to blackish brown.

Arixyleborus immitator Eggers: Very small (Length ♀ about 1.8 mm, ♂ about 2.1 mm), dark to blackwish brown, ♂ reddish brown

Xyleborus perforans Wollaston: Very small (Length ♀ 2∿2.5 mm, ♂ 1.6∿1.97 mm), yellowish red

Xyleborus punctatissimus Eichhoff: Large (Length ♀ 4.8 ∿ 5.07 mm, ♂ about 4 mm), yellowish brown on the former half of body and dark brown on the latter half

Platypodidae

Platypus curtus Chapuis: Large (Length ♀ 3.81 ∿ 4.47 mm, ♂ 3.38 ∿ 4.06 mm), brown to reedish brown

Platypus sp.: Medium (Length within about 3 mm)

Platypus sp.: Medium (Length about 3 mm)

Diapus quinquespinatus Chapuis: Small (Length ♀ 2.53 ∿ 3 mm, ♂ 2.31 ∿ 2.81 mm), dark brown

Diapus sp.: Large (Length about 6 mm), blackish brown

Bark beetles

Poecilips subcribrosus Blandford: Medium (Length 2.28 ∿ 3.88 mm), yellowish red to reddish brown

Poecilips sp.: Very small (Length about 2 mm)

Crypturgini sp.: Small (Length about 2.3 mm), reddish brown

Lymexilonidae sp.: Large (Length about 6.5 mm), blackish brown

Lymexilonidae sp.: Medium (Length about 3 mm), black (Identified by Dr. Teru Mabuchi)

In addition, in the survey of this time, many wood borers such as Curculiomidae, Brenthidae, Anthribidae and Cerambycidae were collected.

The damage to forests, standing trees and felled trees by these pests mostly occurs after felling, except that some bark beetles bore the bark of standing trees at corase portions, to spoil the bast.

Other damages to trees includes the boring under the bark by the lavae of Scolytidae and Cerambycidae[2].

When a standing tree is felled and debarked, sap secretes. The amount of sap and resin secreted depend on the species. In case of Yellow Meranti, sap dries early, and the resin amount is a little small compared with other species. The generation of pinhole damage depends on the species as shown in Table 35 and is surmised to be closely related to the amount of sap and resin secreted[2]

Table 35 Pinhole damage of respective species[2]

Specimen	Number of pinholes by Arixyleborus	Remarks
Red meranti	8	State of occurrence 10 days after debarking.
White meranti	69	
Yellow meranti	148	

Meanwhile, Merkusi pine and Melolonthidae are liable to be damaged. The pests shown in Table 36 "List of main tree pests" and in Figs. 43 to 48 are surmised to do large damage to planted forests, especially pole size trees.

Damage is observed in standing trees of virgin forests and plated forests, but in general it seemed that the standing trees in very vital virgin forests with natural balance kept were less damaged.

2) General prevention and extermination in forests

The pests of virgin forests and planted forests include those who eat leaves, those who eat branches and stems and those who eat roots. They also include those who live under the bark and those who bore the stem known as borers. Their damage is large. Borers are insects of Coleoptera such as Scolytidae, Platpodidae, Cerambycidae, Cuculio and Buprestis. Especially the damage to

forests by Scolytidae and Platypodidae is serious, and when they coexist with such injurious insects as Cerambycidae and Curculio, trees may be quickly killed.

Borer Scolytidae includes shot borers who eat the xylem and bark beetles who eat the bark. Shot borers include Ambrosia beetles who live on Ambrosia and other fungi incubating in the holes.

Forest pests can be prevented and exterminated chemically, physically, biologically and industrially. However for rational prevention and extermination, the respective methods of prevention and extermination must be combined, based on the precise knowledge of the physiology and ecology of the pests and site conditions; and for general prevention and extermination in natural adjustment, to restore the forest ecosystems. For example, chemical prevention and extermination is desirable to be used auxiliarily by sufficient utilization of chemicals. When the balance of a virgin forest has been destroyed by man, or especially in case of a planted forest, the general prevention and extermination are urgently required, and should be promoted in view of pest control.

The problems in the execution of general prevention and extermination based on chemical prevention and extermination by Goda, et al.[(2)] are as follows.

a. Studies on the safe and very effective extermination methods and preventive chemicals against wood borers

At Japanese ports for imports, an insecticide stipulated in the Plant Quarantine Standard and consisting of an oily mixture containing 0.5% of Sumithion and 2.5% of EDB (Table 37) is sprayed to the wood by 300 cc per m^2 surface to kill pests inside. However, the objective in Kalimantan is to prevent the damage beforehand, and it is surmised necessary to study and develop safe and very effective extermination methods and preventive chemicals against wood borers most suitable for the actual situations, and to test them before introducing them, based on the fact that the trees felled immediately before are

Table 36 List of main tree pests

(Tectona grandis)

Teak ambrosia beetle, (Xyleborus destruens)

Mulberry, Margaronia pyloalik (Lepidoptera, Pyralidae)

Sandal wood, (Santalum album L.)

Chionaspis sp

(Pinus merkusii)

White grubs

Lepidiota stigma F. Melolonthidae

Leucopholis rorida Melolonthidae

Holotrichia constucta Melolonthidae

Euchlora viridis Rutelidae

Dioryctria sp

(Scolytid)

Neohyorrhynchus niisimai

Hylesinus porcatus

Xylosandrus compactus

Xyleborus atratus

Xyleborus bicolor

Xyleborus interjectus

Xyleborus lewisi

Xyleborus minutus

Xyleborus mutilatus

Xyleborus semiopacus

Platypus solidus

Diapus aculeatus

Arixyleborus granulifer

Arixyleborus hirsutulus

Arixyleborus imitator

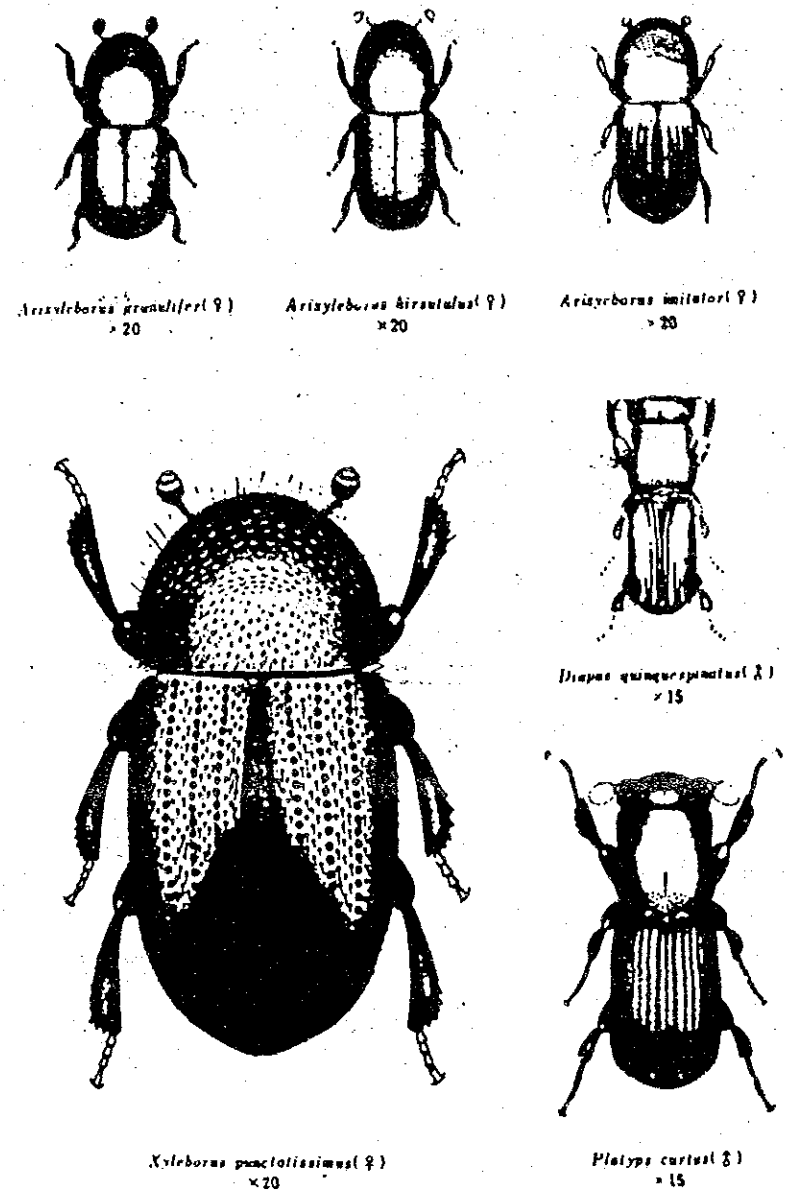
Platypus curtus

Diapus quinquespinatus

Xyleborus punctatissimus

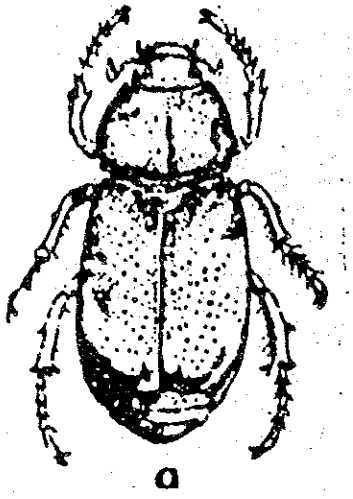
Xystrocera festiva

Main species of Ambrosia beetles

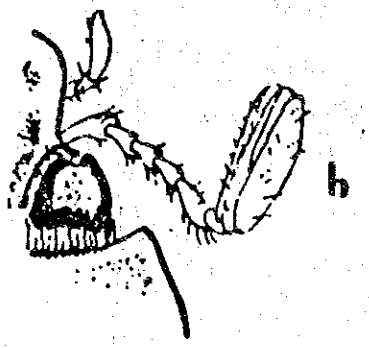


Drawn by Technical
Official Shizuo Ohno

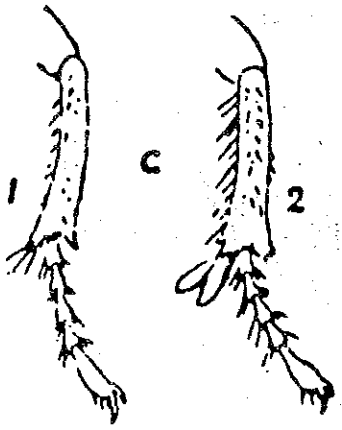
Fig. 43 Lauan pests of East Kalimantan



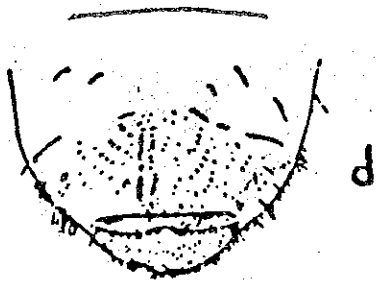
Whole



Head



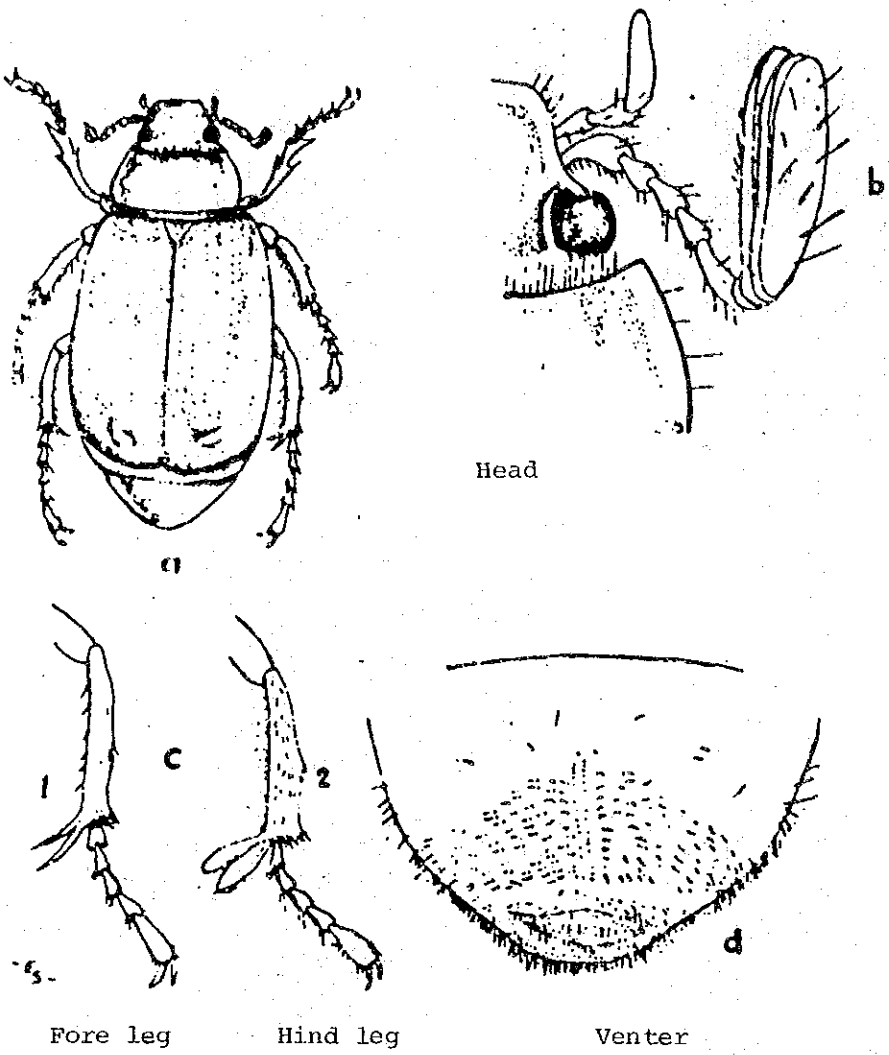
Fore leg Hind leg



Venter

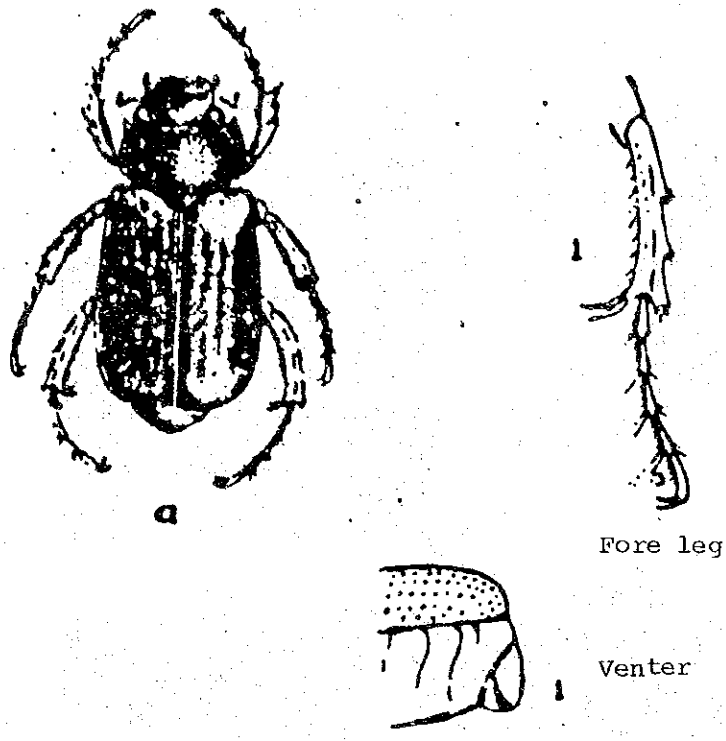
Leucophdis rorido Fabrisius: Intari & Natawiria (1973)

Fig. 44 A pest of Merkusi pine



Lepidiota stigma F Intari & Natawiria (1973)

Fig. 45 A pest of Merkusi pine



Holotrichia constricta Burm Intari & Natawiria (1973)

Fig. 46 A pest of Merkusi pine

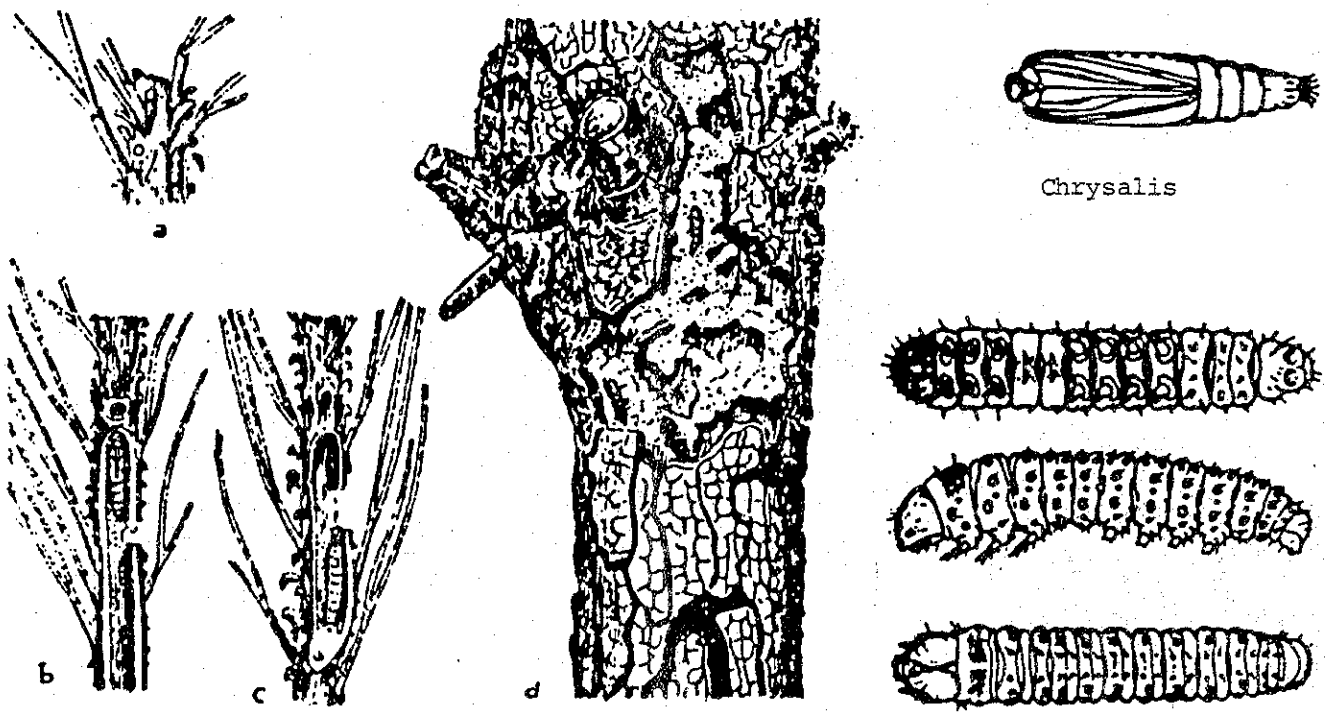


Fig. 47 A pest of Merkusi pine (Dioryctria sp) and damaged states

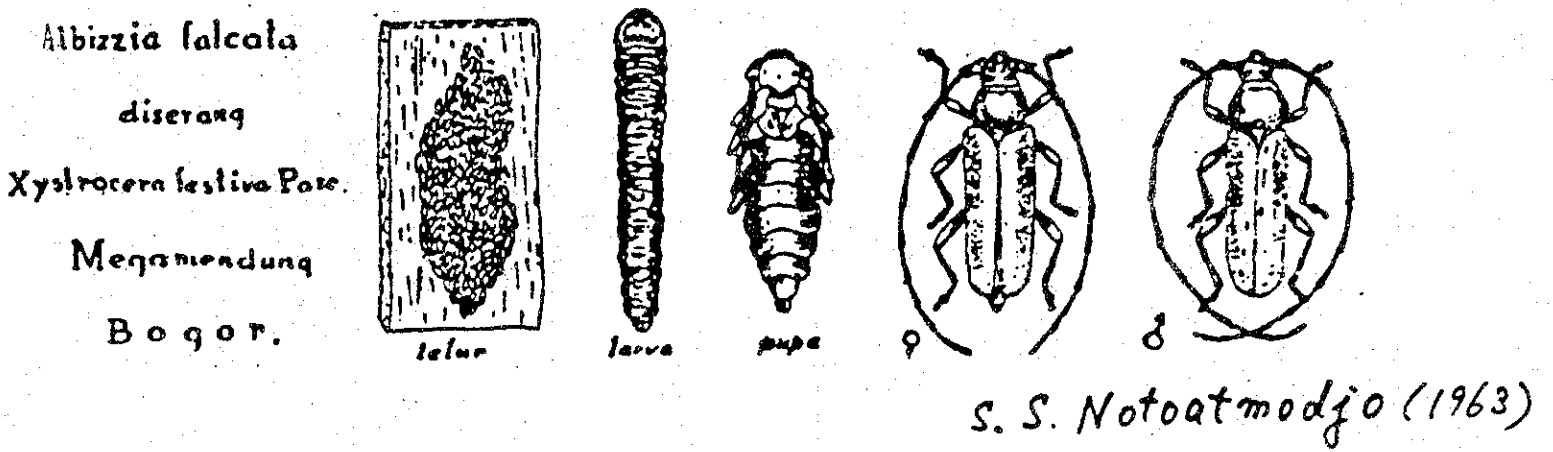


Fig. 48 A pest of Lauan (Cerambycidae)

treated, and that pests exist around the trees, and that the meteorological and other conditions are different. For spraying, usually 100 to 300 ml, or 150 ml on the average should be applied per squaremeter of the tree on the lower half surface in contact with the ground.

Table 37 Present pesticide for exterminating wood borers

Names of chemicals	Types	Effective ingredients and contents w/w%
Sumibarku oil conc	Oil	Sumithion 50%, EDB 15%, organic solvent 35%
Sumibarku Econc	Emulsion	Sumithion 50%, EDB 15%, infiltration promoting solvent 10%, spreader, solvent, emulsifier 25%
Sumibarku Econc	"	Sumithion 50%, EDB 15%, repellent 15%, spreader, solvent, emulsifier 20%
Baytex EDB emulsion	"	Bytex 50%, EDB 15%, infiltration promoting solvent 10%, spreader, solvent, emulsifier 25%
Diazinon EDB emulsion	"	Diazinon 50%, EDB 15%, infiltration promoting solvent 10%, spreader, solvent, emulsifier 25%
Surecide EDB emulsion	"	Surecide 25%, EDB 15%, infiltration promoting solvent 10%,spreader, solvent, emulsifier 25%
Dibtelex aqueous water solvent	Water soluble powder	Diptelex 97%

1) Sumithion: fenitrothion, 0, 0-dimethyl 4-nitro-m-tolyl phosphorothioate
2) Bytex: fenthion, 0, 0-dimethyl 0-((4-methylmercapto-3-methyl)phenyl) phosphorothioate.
3) Diazinon; 0, 0-diethyl o-(2-isopropyl-6 methyl-4-pyrimidinyl)phosphorothioate
4) Surecide, 0 -ethyl 0-(4-cyanophenyl)phenyl-phosphorothioate
5) Diptelex: trichlorofon, 0, 0-dimethyl 1-hydroxy-2, 2,2-trichloromethyl phosphorothioate
6) EDB: Ethylene dibromide, 1, 2-dibromoethene, CH_2BrCH_2Br

The pesticides used locally must satisfy the following conditions:

a. Resistance against heavy squalls must be considered.

b. Resistance against direct sunlight at high temperatures must be considered.

c. Since sap oozes out of the tree immediately after debarking, ingredients to provide high affinity and permeability are desirable.

d. For spraying immediately after debarking, the surface of the log in contact with the ground should be also coated by rolling the log by a bull-dozer.

Furthermore, Goda, et al.[2] present the following problems to be solved in chemical prevention and extermination.

i) Sprayers

In the field where logs are frequently carried in and out, rucksack type full automatic or manual sprayers of about 10 liters are suitable for field spraying rather than large spraying machines, and the use of many such sprayers are most effective.

ii) Coloring agents and color tones

When a pesticide is sprayed on the surface and cross section of a log debarked immediately before, the fresh log is wet with sap, and even if a usual pesticide (colorless and transparent) is sprayed, the coated portion cannot be clearly identified. Therefore, it is recommended to color the liquid for immediate identification of coated portions. At present, red is the best and makes the logs appear good. This allows not only the existence of the pesticide but also the density to be identified, to prevent omission of spraying and to be useful for confirming the proper amount of spraying.

For the present development of tropical rain forests in East Kalimantan, to prevent the damage caused by insects, the pest

control of virgin forests and planted forests must be discussed. For this purpose, the insect phase of virgin forests, secondary stands, etc. should be analyzed to clarify the ecological conditions, and to establish a general prevention and extermination means using chemicals auxiliary. On the other hand, for the felled trees being carried out, there is no other way than by applying chemical prevention and extermination, methods and the thorough execution of it is desirable.

6. Conclusion

In this research, the actual situations of virgin forests and selection forests in East Kalimantan were surveyed and discussed. Furthermore, how studies should be, is the proper treatment of cutover areas, viz. selectively cut over areas of forests was presented.

The forest in this area is characterized by the production of very excellent and useful logs which are large in length and diameter, straight, full-bodied and free from knots, mainly of Dipterocarpaceae in typical tropical rain forests. The quality of succession of such forests is problematic not only for Kalimantan but also for wood resource policies of the world. Problems based on the present situations will be indicated below for discussion.

(1) Method of selection cutting

As for the stand compositions in the virgin forests of Sebulu and Bukit Soeharto, the number of forest trees of 35 cm or more in breast height diameter ranged from about 90 to 140 (Table 11) per hectar. If cutting is assumed to be made with a cutting cycle of 35 years based on the Indonesian Selection Cutting System (T.P.I. system, Table 4), 25 standing trees of 35 cm or more in breast height diameter must be left per hectare, and therefore 65 to 115 trees can be cut. Furthermore, since the trees actually cut are of large diameter, being 70 or 80 cm or more in breast height diameter, the number of forest trees corresponding to the size is about 25.

If the virgin forest (Figs. 20 and 21) of Sebulu is assumed to be cut according to the T.P.I. system, the result is as shown in Fig. 30 and 31. That is, trees Nos. 2 (DBH: 180 cm), 33 (180 cm) and 36 (129) large in breast height diameter are cut. Since they are adjacent trees, a large space is formed at a position, and the damage to succeeding trees caused by cutting is surmised to be large. Furthermore since the stand becomes bright after cutting, twining plants may cover the remaining trees, to prevent their growth, it is desirable to kill them as shown in Photo 25. At the same time, the treading pressure of surface soil destruction by large machines and large diameter trees for timber haulage disturbs the soil, and this is a serious problem for tropical forest soil which stores less nutrient and is bad in physical properties. Therefore, the remaining trees may not always grow as intended, and therefore not suitable for cutting 35 years later at the next cutting.

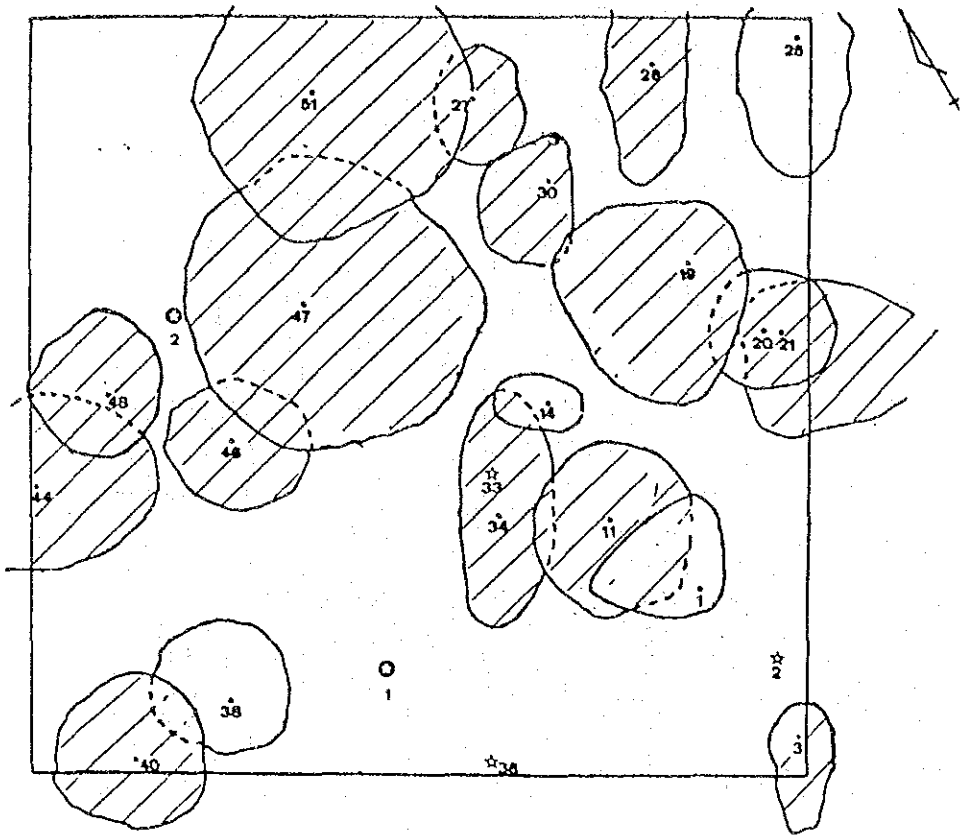
If the cutting standard is established to meet these problems in reference to the breast height diameter, the positions of remaining trees, viz. distribution of succeeding trees, prevention of damage, promotion of regeneration, spread of crowns, etc., the result of cutting according to the standard is shown in Figs. 32 and 33. That is, if trees Nos. 20 (61 cm), 33 (180 cm) and 51 (59 cm) are cut, they are positionally dispersed, and the remaining trees are positionally well balanced. Furthermore at the next time of cutting at 35 years later, the production of a large diameter tree of 1 m class can be expected. Moreover since the crown cover is not suddenly opened, this method is expected to be effective for maintaining the soil productivity of forest land and for generally preventing and exterminating pest damage.

In this case, it is necessary to conduct research into the problems yet to be solved, such as yield cost and to incorporate it into the detailed rules of TPI for working, etc., considering the volume and timber price. It is desirable to further widely analyse, them using the quadrate and transect methods, etc. as adopted in this survey.

Photo 25 Trees remaining in a selection forest, covered with twining plants

(2) Preservation of succeeding trees

To cultivate the succeeding trees by the selective cutting system, the damage to the succeeding trees by cutting must be minimized. If trees large in diameter only are selectively cut with emphasis placed on the efficiency of cutting and logging and economy, the succeeding trees are directly damaged and suppressed in growth, and in addition, a large hole is made in the canopy, which encourages twining plants to flourish and soil to be destroyed. It is said that especially a forest which is damaged by way of scratching and debarking at the stems and bases of trees is liable to be damaged by diseases and pests, which causes disturbances in growth and subsequence death. It is desirable to study the preservation of succeeding trees in selection forests, and to adopt a working method based on the results.

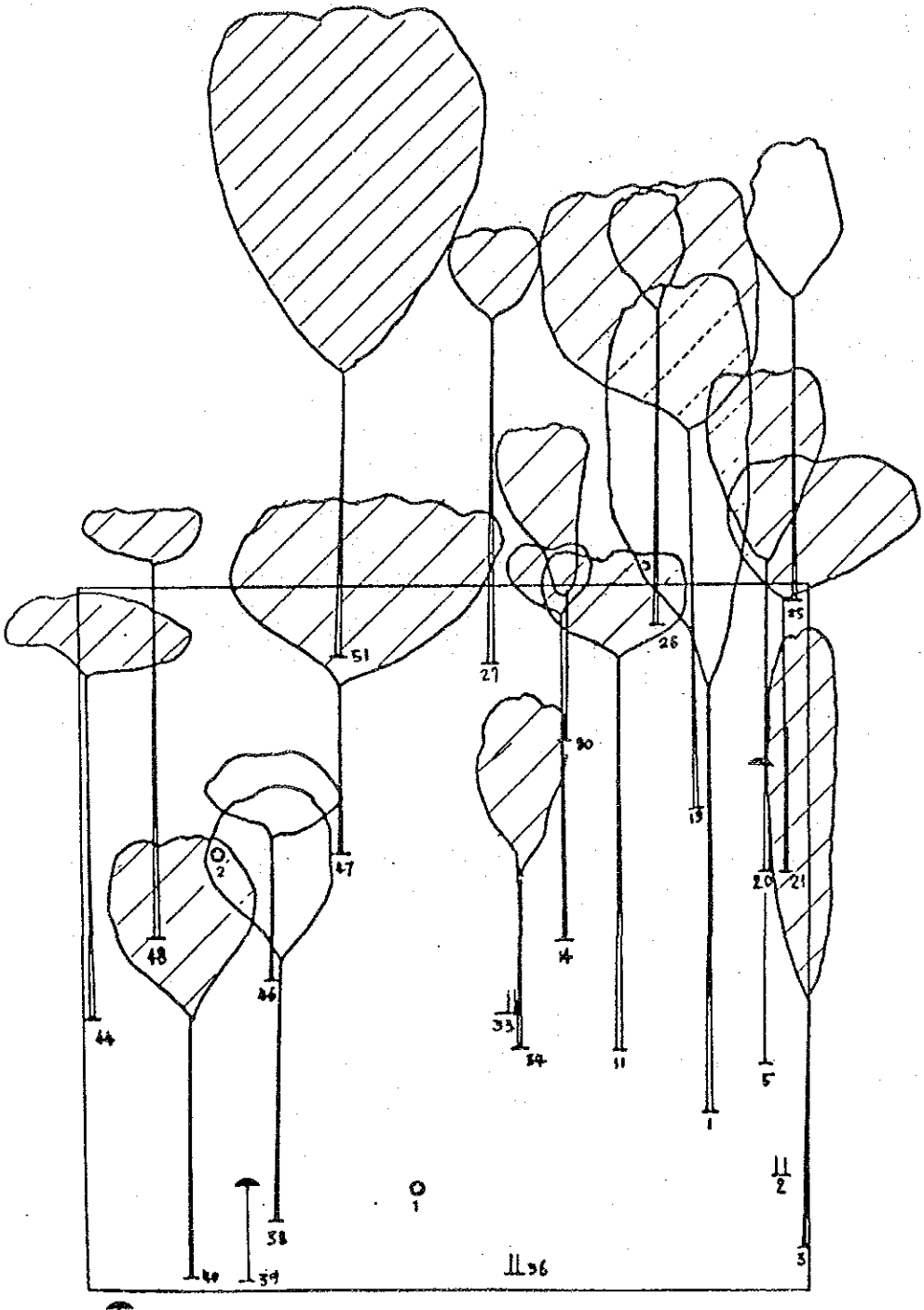


○ : stump of Ulin (Eusideroxylon zwageri)

⊘ : commercial tree species

☆ : stump of cutting tree

Fig. 49 Crown closer of logging over stand by T.P.I. system in Sebulu, DBH 35 Cm up

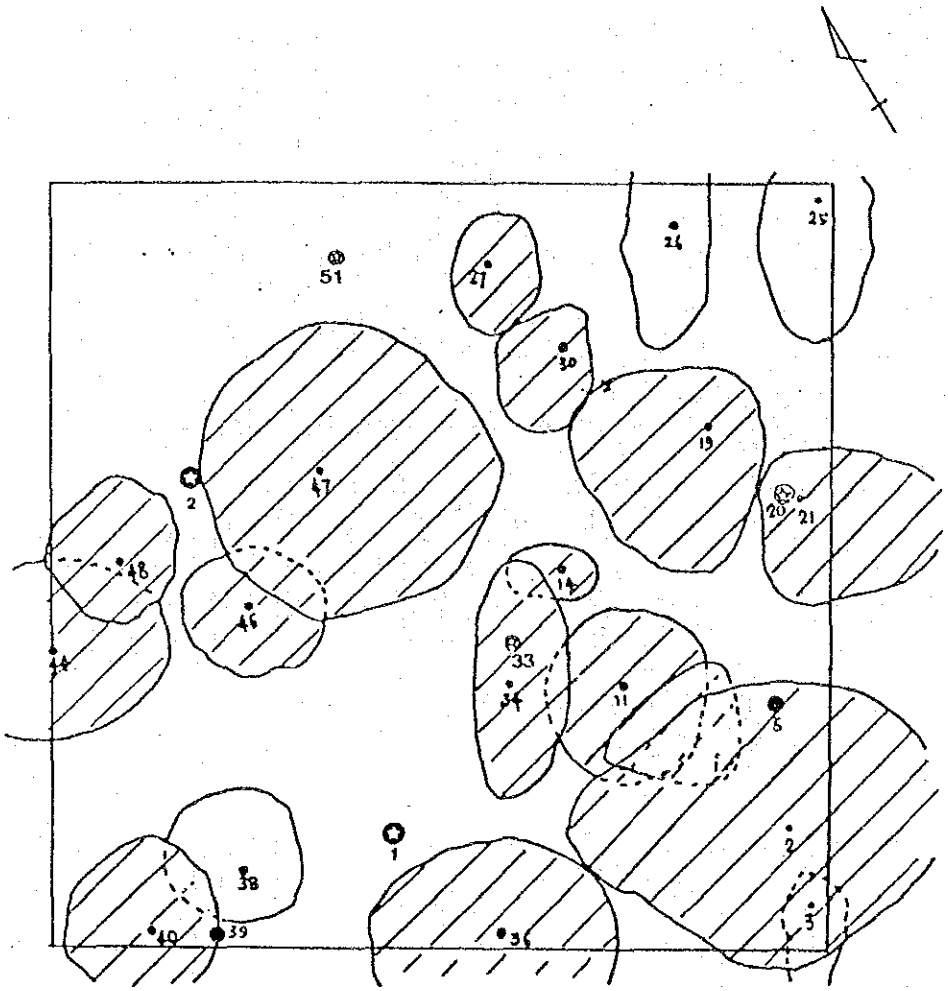


: dead tree

○ : stump of Ulin (Eusideroxylon zwageri)

Ø : commercial tree species

Fig. 50 Profile of logged over stand by T.P.I. system in Sebulu, DBH 35 Cm up



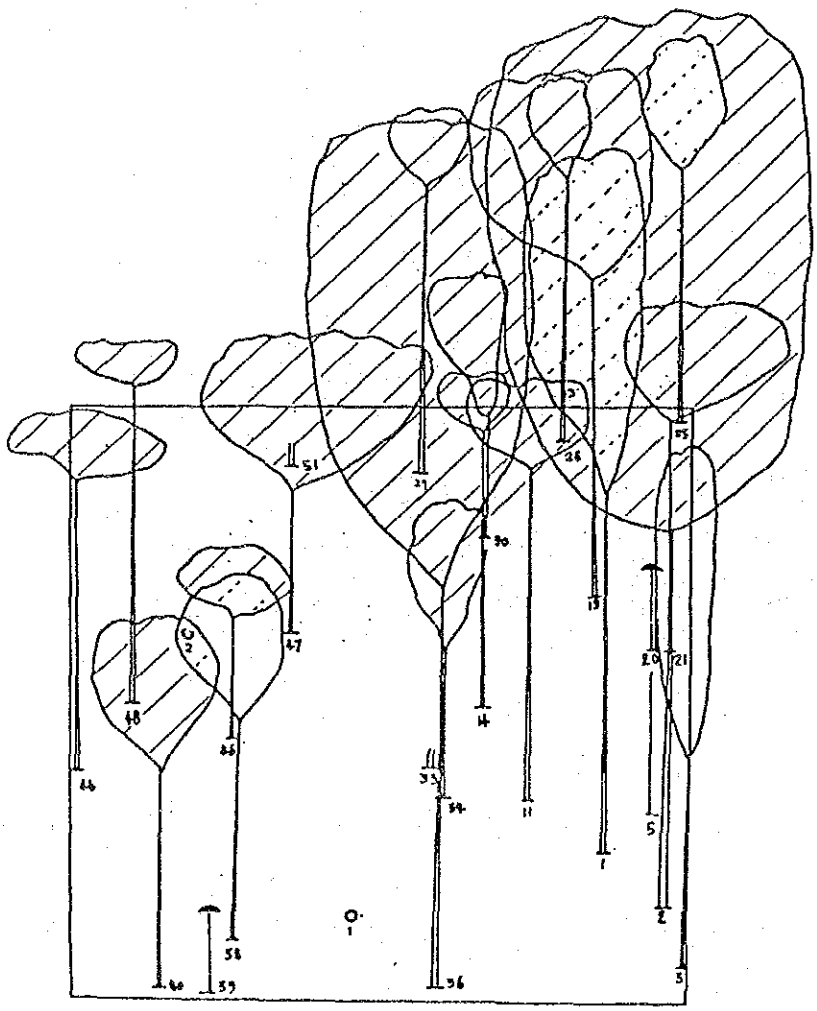
● : dead tree

O : stump of Ulin (Eusideroxylon zwageri)

▨ : commercial species

☆ : stump of cutting tree

Fig. 51 Crown closer of logged over stand by balance system (suggested) in Sebulu, DBH 35 Cm up



: dead tree

: stump of Ulin (Eusideroxylon zwageri)

: commercial tree species

Fig. 52 Profile of logged over stand by balance system (suggested) in Sebulu, DBH 35 Cm up.

(3) Regeneration and growth of saplings.

In general, saplings are regenerated in large quantities, and even in case of commercial species only, many saplings are regenerated around a cut tree. In most cases, the regeneration is quantitatively almost satisfactory. However, since the mortality rate of regenerated saplings is large, it is important to lessen the value for promoting their growth, and to cultivate good succeeding trees through competition. For this purpose, site conditions, present stand composition, density, etc. must be sufficiently examined. In order to cultivate the seedlings of commercial species such as Dipterocarpaceae, it is necessary to continue researches for a long period of time for clarification, so as not to cause adverse effects by the environmental changes of the stands.

(4) Prevention and extermination of pest and disease damage in forests

The forest environment at the time of survey was generally complicated, and the chances are that the pest damage to forest trees could cover a large area was surmised to be small. However, the chance may become large if human work is applied, to increase secondary stands, grass land and planted forests, or if the situation like the drought of 1982 to 1983 followed by a large fire increases.

Pests which should be noted now are Platypodidae, Scolytidae and other 4 families. Since most of these bore felled logs, they can be exterminated only by spraying pesticides on the felled or logged trees.

It is difficult to predict the situation which will occur with the change of environment, but against the pest and disease damage in forests, emphasis should be placed on the prevention of regeneration. For this purpose, the forest ecosystem should be seriously considered, and health of actual stands of virgin forests and selection forests must be surveyed, to establish a healthy ecosystem, for preservation, thereby preventing the regeneration of disease and pest damage, as a general prevention and extermination system using a pesticide spray as an auxiliary means. Study on this system is

required. As mixed planting is recommended in agriculture, a method for creating stands suitable for tropical forests and resistant to pest damage must be examined.

(5) Afforestation of wilderness and clear cut areas

With the forests cut continuously, the outlook for a successive supply of straight, full-bodied and knot-less timber as produced now is said to be bleak. Therefore, examination is required to be made urgently on the succession of selection cutting, and researches must be made on the artificial reproduction for destroyed grass land and wasteland.

The preparation of forests by selection cutting has a difficulty that tending must be made for a wide area for a long period of time. To find a reliable method for afforesting clear cut areas and wilderness in short periods of time, the study of artificial reproduction must be made simultaneously. For this purpose, it must be effective to afforest environment by using Macaranga (Photo 26), Kelempayan (Photo 27), Dillenia (Photo 28) and leguminous plants (Photo 29), etc. spontaneously growing on clear cut areas and on the roadside as intolerant trees or pioneer plants, and to introduce commercial species into the forests. Furthermore, Caribbean pine, Merkusi pine, Gmelina, Albizzia, Eucalyptus, and Giant Ipil ipil which are already adopted for securing income should be examined.

If forest land has been covered with these pioneer species, to preserve forest environment to some extent, then the seedlings of tolerant trees of commercial species such as Dipterocarpaceae (Photo 30, Tables 39 and 40) and natural seedlings (Photo 31) can be planted. With most species, if seeds are collected and sowed in optimum seasons, germination rates are high, but in forest land, many die after germination. The growth of seedlings of commercial species in forest land is generally good, and the number of leaves are also large. Especially Shorea leprosula has many leaves and is surmised to be high in shade bearing capability. Therefore, the results of physiological and ecological studies on these commercial species should be used in the studies for cultivation.

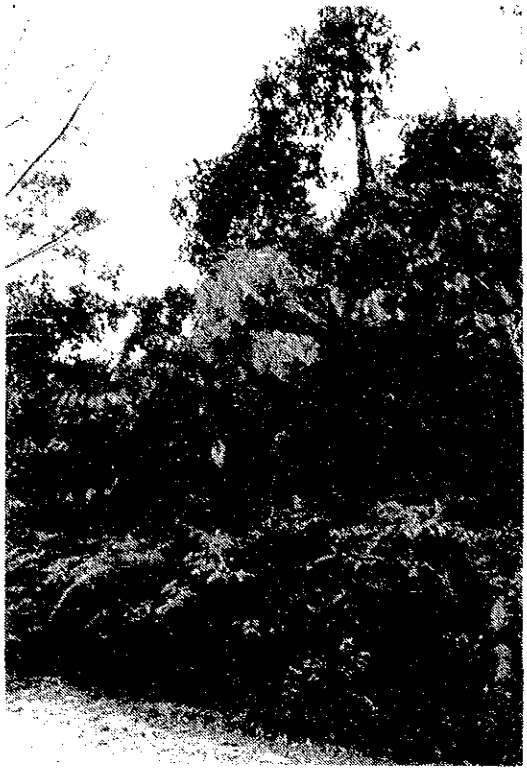


Photo 26 Macaranga

Table 38 Pioneer tree species

1. Macaranga spp
   a. Macaranga gigantea
   b. Macaranga triloba
   c. Macaranga hypoleuca
   d. Macaranga converta
2. Anthocephallus spp
3. Trema spp
4. Duabanga molucana
5. Ficus ribes
6. Vitex spp
7. Piper aduncum (Shrub)
8. Peronema sp

Photo 27 Kelempayan

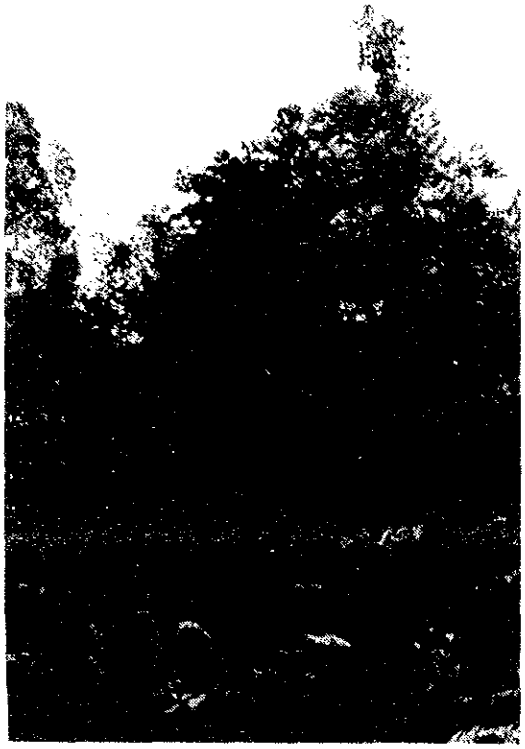


Photo 28 Dillenia

Photo 29 Planted forest of Albizzia

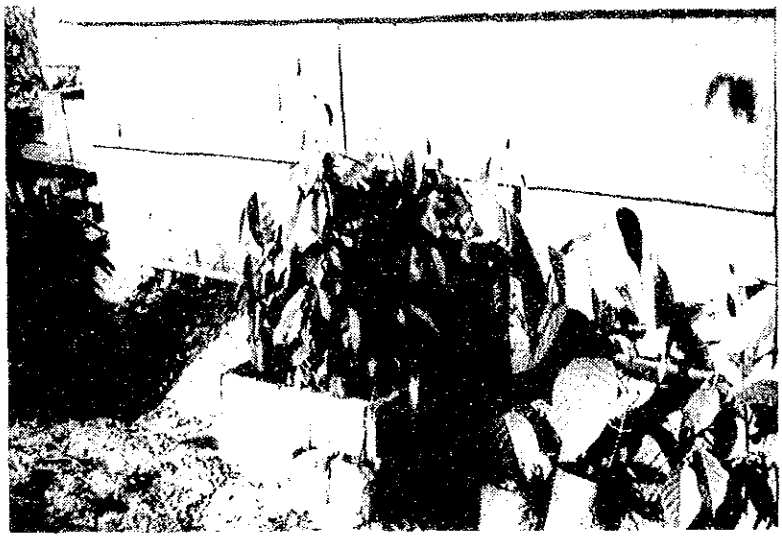


Photo 30 Pot nursery (6 months)
(practical training forest in Bukit Soeharto)

Photo 31 Natural seedling of Ulin

Table 39 Growth of pot seedlings in the nursery of Tenggarong Forest Bureau (6 months after seeding)

Shorea parvifolia				Shorea acuminatissima				Shorea smithiana				Shorea leprosula				Shorea ovalis			
No.	H cm	D mm	LN	No.	H	D	LN	No.	H	D	LN	No.	H	D	LN	No.	H	D	LN
1	26	3	6	1	39	4	6	1	24	5	6	1	38	3	14	1	23	3	7
2	27	3	8	2	19	2	5	2	29	5	5	2	45	3	12	2	22	4	7
3	26	3	7	3	29	3	4	3	28	4	7	3	49	5	18	3	22	3	7
4	25	3	7	4	34	3	5	4	26	5	6	4	36	3	15	4	20	3	6
5	25	2	6	5	40	3	5	5	34	6	8	5	39	3	13	5	19	3	8
6	22	3	6	6	44	3	5	6	30	5	6	6	33	2	9	6	27	4	8
7	29	3	8	7	42	3	6	7	29	5	4	7	35	3	9	7	22	3	7
8	25	3	6	8	49	3	7	8	25	5	4	8	32	3	9	8	29	4	9
9	28	3	8	9	29	2	5	9	17	5	2	9	52	3	10	9	22	3	7
10	24	3	3	10	42	3	5	10	23	5	3	10	39	4	12	10	25	4	10
11	12	2	3	11	39	3	6	11	13	4	2	11	39	3	16	11	17	2	6
12	29	3	7	12	57	5	8	12	24	4	5	12	32	3	10	12	21	2	7
13	23	3	5	13	39	4	5	13	21	4	6	13	19	2	6	13	35	3	8
14	15	2	4	14	43	4	6	14	25	5	3	14	45	3	23	14	18	3	6
15	19	2	3	15	43	4	7	15	22	4	3	15	44	3	7	15	20	3	7
16	15	3	4	16	53	5	6	16	24	5	4	16	30	3	15	16	18	3	8
17	29	4	6	17	52	4	6	17	26	6	5	17	29	3	7	17	21	3	9
18	41	5	7	18	44	3	6	18	24	4	6	mean	37.4	3.1	12	18	23	3	8
19	38	4	6	19	40	3	6	19	35	5	6					19	17	3	9
20	30	3	6	20	46	3	7	20	37	5	6					20	21	3	8
mean	25.4	3	6	mean	41.2	3.4	5.8	mean	25.8	4.8	4.9					mean	22.1	3.1	7

H: Seedling height D: Basal diameter LN: Number of leaves

Table 40 Growth of pot seedlings of Shorea smithiana in the nursery of Sei Gulas Forest Bureau

No.	Height (cm)	Leaves No.	Estimated leaf area (cm^2)
1	25	4	356
2	18	5	445
3	24	6	534
4	28	5	445
5	20	6	534
6	42	7	623
7	36	8	712
8	41	8	712
9	36	6	534
10	30	6	534
11	35	9	801
12	37	7	623
13	34	5	445
14	27	5	445
15	25	5	445
16	19	5	445
17	31	6	534
18	24	5	445
19	39	7	623
mean	30.1	6.1	538

In Indonesia, there are techniques such as mix cropping and tumpang sari, and it is desirable that the conventional techniques are utilized for afforesting grass land as far as possible. Furthermore, it is required to classify wilderness in terms of land use capability for selecting general land for afforestation, and to classify the planted land in terms of land use, and to study the development of the techniques for deciding the right side of each species.

In the large fire that was involved in the drought of this time, it was found that corridor planting seemed to be improper. In this regard, studies on the prevention of danger to various pure forests including the setting of fire zones are required.

Furthermore based on these studies, it is required to set multiple model stands.

(6) The future of commercial species.

The commercial species in the Republic of Indonesia are classified into those for export and those for non-export. This is decided by considering the present situation of resources and the balance of demand and supply, and may be changed yearly. Table 41 shows the commercial species in 1982.

Table 41 Commercial tree species (as of 1982)

For export	1. Meranti group spp (yellow, white and red meranti) (Shorea spp) 2. Kapur (Dryobalanops spp) 3. Agathis (Agathis borneensis) 4. Keruing (Dipterocarpus spp) 5. Benuang (Octomeles duabanga) 6. Medang (Dehassia spp) 7. Kayu kuku (Pericopsis sp) 8. Nyatoh (Palaquium spp)
For non-export	1. Ulin (Eusideroxylon zwageri) 2. Bangkirai (Shorea spp) 3. Rengas (Gluta renghas) 4. Kayu bawang (Scorodocarpus borneensis)

To examine the cultivation of succeeding trees, it is necessary to discuss the data to be used for selecting the species surmised to be economically advantageous in long periods of time, and to consider the growth and wood quality.

Before beginning the present research, it was deemed necessary to discuss the treatment to be made after selection cutting, for the reason that the studies on the methods of afforestation and selection cutting had progressed substantially. However the discussion was made based on the basic survey in the process of joint research developed as mentioned above, and it was considered to be necessary to make recommendations on the way of studying. With this, the first step to the ecological approach and to the land use capability classification is surmised to have been taken.

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8. Summary

The forests of East Kalimantan are mostly typical tropical rain forests based on Dipterocarpaceae. Though different from stand to stand, in general, the upper storey has a coarse crown canopy composed of 40 to 60 m forest trees mainly of Shorea, Dipterocarpus, etc. of Dipterocarpaceae, and supplies full-bodied, straight and giant timber. The middle storey has many kinds of 30 to 40 m forest trees slightly densely, and the lower storey has a dense crown canopy of many kinds of 15 to 30 m trees. Therefore, the forest floor is dark, and undergrowth is small.

The present research has been made for virgin forests and selection forests in this area, and has covered recommendations as to how to pursue studies on the proper treatment of selectively cut areas and how to pursue the silvicultural researches on tropical rain forests.

(1) Method of selection cutting

From the stand compositions of virgin forests and selection forests in Sebulu and Bukit Soeharto, ecological consideration was found to be required in adopting the TPI system (Indonesian Selection Cutting System), in order to continue the production of large diameter timber. That is, it was suggested that considering the balance of crown canopy composition, the quantity and arrangement of upper storey trees according to the rotation must be specified in the detailed rules for working. For this purpose, it was indicated that researches must be urgently made on the preparation of site index concerned with species composition, tree height and breast height

diameter, the estimation of diameter growth of forest trees constituting the upper storey and middle storey crowns after selection cutting.

(2) Preservation of succeeding trees

The damage to the forest trees constituting the upper and middle crowns by selection cutting was investigated, and it was pointed out that the actual unbalanced selection cutting could cause various kinds of damages. It was pointed out too that studies are required on the detailed rules for working, to maintain balanced crown compositions, for minimizing damages.

(3) Existence of saplings and filling up by planting

The numbers of saplings are generally very large, though the regeneration of saplings is different to some extent from stand to stand because of the differences in the arrangement of mother trees, conditions of forest floor, etc. However, many vanish, and to secure their growth, studies on the control of light conditions, etc. are required. Therefore it was pointed out that in order to cultivate saplings as succeeding trees, studies are required on the salvage cutting times, intensity, etc. for the forest trees constituting the lower storey crowns within the rotation, for ecological control to be specified in the detailed rules for working, of TPI.

(4) Prevention and extermination of pest and disease damage in forests

In the complicatedly composed tropical rain forests, as far as ecological balance can be kept, the problem of pest and disease damage will be minimised. However, for the pest damage to felled trees, it is surmised to be safe, to obligate the chemical prevention and extermination so far partially executed. Furthermore, if the forest balance is lost based on large-scale cutting and logging of forest, abnormal climate, etc., may be set in, which is ecologically disastrous. Thus, it was pointed out that studies on the prediction of the danger and early prevention and extermination including the use of chemicals are required.

With regard to the foxtail of pine saplings, there is no established theory. However, since it was suggested that the disease occurred more in places with humus or fertile places, attention should therefore be paid to the balance of nutrition, etc.

Not only when damage related to selection cutting is involved but also in the other cases, the decay of sapwood and corestock often comes into question. This becomes a problem especially with the trees left after selection cutting. This should be considered, when considering the security of future yield.

(5) Afforestation of wilderness and clear cut areas

Since a road for guiding people into the stand is constructed after cutting by TPI, unplanned or non-conforming reclamation may destroy the forest or bring about a wilderness. Since there are techniques such as mix cropping and tumpang sari in Indonesia, the conventional techniques should be used for afforestation of wilderness as far as possible, and it is necessary to classify wilderness in terms of land use capability for selecting general land for afforestation, to classify planted land in terms of land use, and to study the development of techniques for deciding the optimum land for each species. For afforestation, studies must be made also on the pioneer species, viz. species capable of forming forests and yielding in short periods of time as adopted in various countries and as spread also in Indonesia, and also on the selection of pioneer species from natural species. Since it was found that the corridor planting said to be good for fire prevention in Alang-Alang Grassland, was weak in abnormal drying, studies must be made on the prevention of danger to various pure forests, including the setting up of fire zones. In the afforestation by these pioneer species, it is desirable to select future commercial species for the lower storey, for making two-storied forests.

For this purpose, it is required to develop and spread economical and ecological techniques for securing seeds of Ulin, Shorea,

Dipterocarpus, etc., producing seedlings, undergrowth, control of upper storey trees for tending, etc., and also to set plural model forests for the purpose.

(6) When the research for this section was started, it was demanded from Indonesia to study on the treatment to be made after selection cutting for the reason that the studies on the methods of afforestation and selection cutting had advanced substantially. However, in the discussion involved in the basic survey in the process of the research, it was found necessary to recommend the studies as described in (1) to (5) including the improvement of working made so far, from a basic viewpoint. Thus, the first step to ecological researches and land use capability classification researches can be said to have been taken.