Section 2

Management of Logged Forests

by

The Selective Cutting System

CONTENTS

1. Introduction

In the forests of East Kalimantan, the main commercial forests are tropical rain forests represented by Dipterocarpaceae among various kinds of vegetations as described in Section 1. In typical stands containing giant layers, the upper layer forms a coarse crown canopy composed of 40 to 60 m trees mainly of Shorea, Dipterocarp, etc. of Dipterocarpaceae, to offer full-bodied, straight and large timbers. In the middle layer, many kinds of 30 to 40 m trees stand a little densely, and the lower layer has many kinds of 15 to 30 m dense canopies. Therefore, the forest floor is dark, and undergrowth is small.

East Kalimantan is the largest source of timber supply in Indonesia, and the security of resources and the preservation of environment are important subjects. For this reason, various survey teams from many countries, have visited the area, and have been extending their cooperation in various studies of forestry. However, these studies were often short or too specialized. The present survey is not satisfactory enough either, but it can be said to be very significant in that many researchers, including those in the fundamental fields concerned with forestry, stayed for a long period, to study jointly with the special researchers of the local Mulawarman University.

In the Republic of Indonesia, virgin forests have been cut according to the Indonesian Selection Cutting System (TPI). It was set as the object of this study, to discuss the research method on the treatment to be made after cutting according to the selection cutting system. However, the discussion covered extensively also the silvicultural research of tropical rain forests.

2. Research Method

The research items and methods were as described below.

(1) Surveyed forests

To consider the rational method of management to be made for virgin forests after selection cutting, both virgin forests and selection forests were surveyed.

The surveyed locations are shown in Fig. 1. That is, Bukit Soeharto University Forest, Lempake University Forest of Mulawarman University, Kutai Timber Indonesia (K.T.I.) in Sebulu and Balikpapan Forestry Industry (B.F.I.) in Sotek were surveyed.

(2) Survey items

i. Stand climate

Investigation was made into the illuminance, temperature and humidity in each stand, ground temperature, etc. concerned with the regeneration and growth of saplings, for finding the proper treatment for selection forests.

In a virgin forest and a selection forest in Sebulu (at 4.5 km and 38 km points), winding hygrothermometer was used to measure the daylight temperature and humidity near the ground surface and the temperature at a depth of 30 cm in the ground. At the same points, sun stations and lux meters were used to measure the luminosity. As for light stations, three stations were set for each stand, and two light receiving sections were used in each station.

ii. Forest soils

Since soil depends on the site conditions and stand composition and may depend also on the treatment of the forest, it was pertinent to investigate the influence of selection cutting on forest soils and the relationship of soil with the regeneration of sapling, of planted forest, etc. For this purpose, one or two points were selected for survey in each location in typical locations of virgin forests and selection forests.

Soil profiles were surveyed by the forest soil survey or and also chemically analysed by a Yagi handly soil tester.

iii. Stand composition

The survey teams tried to know the number of trees, tree height, diameter, etc. of each species in each present standard area, for discussing the influence of selection cutting based on the actual situations such as forest density. The survey was made according to the quadrate method. That is, a survey area of 1 ha (100 m × 100 m) or 0.25 ha (50 m × 50 m) was set in a typical location of

each virgin forest or selection forest, and the stand composition of it was found. Then, the composition of commercial species and non-commercial species, and the breast height diameters, tree heights and volumes of the respective species were obtained. The area and the items were properly examined, depending on the conditions of the forest in each survey location.

iv. Damage to succeeding trees by logging

With regard to the succeeding trees which greatly affect the successive production of good trees, it was intended to study the actual situations of damage involved in selection cutting and to find the proper method of logging which minimizes the damages. For this purpose, investigation was conducted on stands selectively cut immediately before in Sebulu. The area was properly examined, depending on the conditions of each survey location.

v. Regeneration, flourishing and vanishing of saplings

For rational management of selection forests, it is important that commercial species be regenerated and tended as succeeding trees. For this purpose, it is required to know the regeneration, vanishing and flourishing conditions of respective commercial species. Ten plots of 2 m^2 (1 m × 2 m) were set for surveying in 1980, and a plot of 900 m^2 (30 m × 30 m) was set in 1981. Surveyed of ligneous plants were (1) 2 cm or less in their breast height diameter (saplings), (2) 2 to 4 cm and (3) 5 to 19 cm.

vi. Pest damage and growth disturbance to forest plants

If the forest environment is changed by cutting, etc., pest damage and growth disturbance occur in forest plants, and the decrease of useful insects may be observed. For further investigation of growth disturbance, the external symptoms of pole size trees were recorded in KTI, Sebulu, and the names of diseases were searched for in reference to the description of literature. For pest damage, the insect fauna and damage to forest plants were investigated in the agricultural land, virgin forests, secondary stands and planted forests in and around Lempake and Samarinda from the middle to the end of March, 1980.

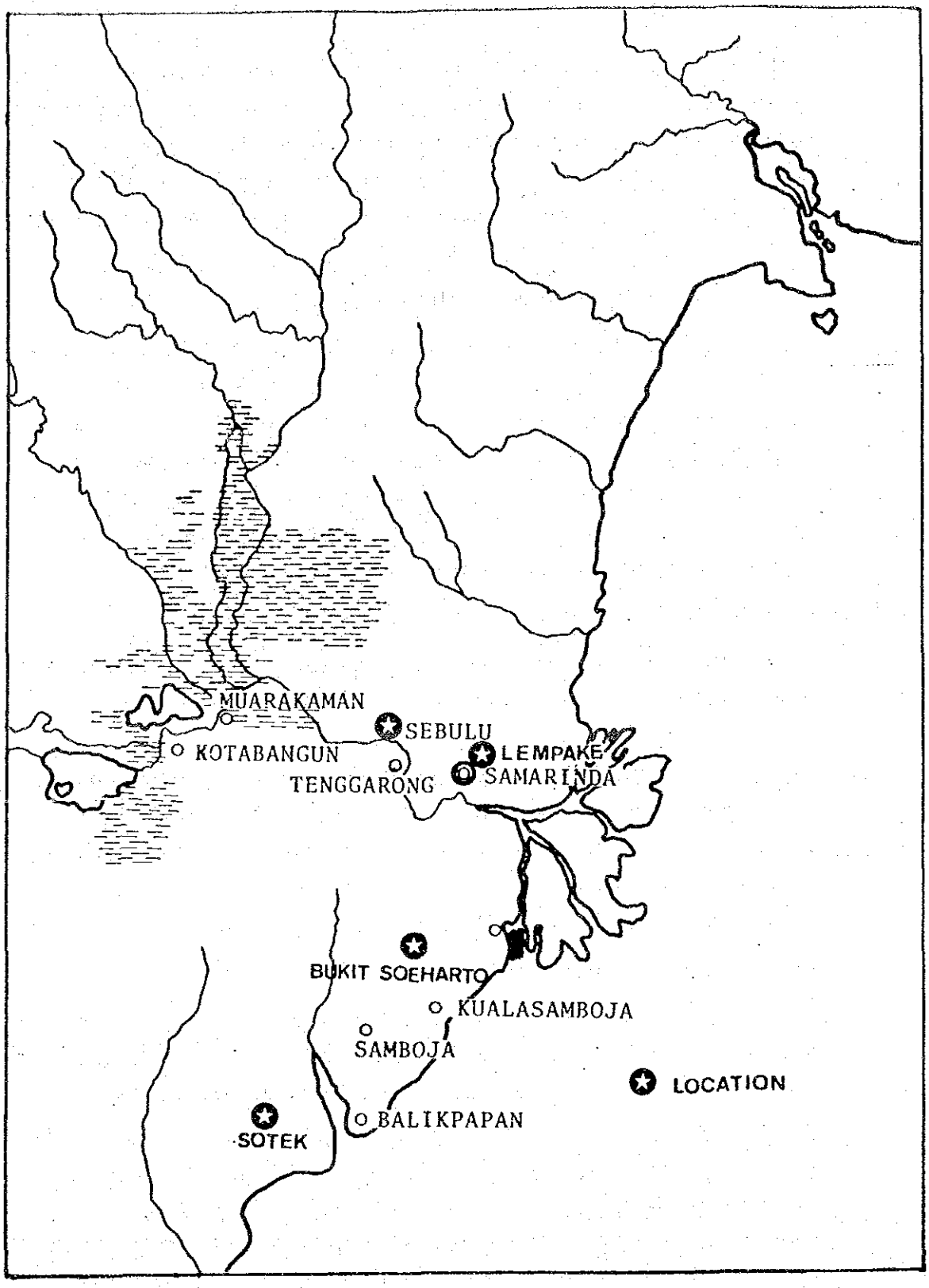


Fig. 1 Locations of surveyed districts

3. General Conditions of Surveyed Districts

(1) Sebulu

i. Location

Sebulu is located at about 30 km northwest from Samarinda along the Mahakam river, as shown in Fig. 1.

ii. Topographic and geologic features

Sebulu is topographically hilly in the stage of old age and is low in elevation, being lower than 100 m. It belongs geologically to the Tertiary.

iii. Climate

As for the climate of this district, the values observed in the camp of PT K.T.I. and arranged in order are shown in Tables 1 and 2.

The annual average precipitation is about 5,400 mm, but the precipitation changes relatively great from year to year. The highest precipitation of 5 years was 6,480 mm recorded in 1976, and the lowest precipitation was 2,258 mm in 1973. As for monthly precipitations, the months which recorded large precipitations were different from year to year, but generally, large precipitations were recorded in April and December.

Meanwhile, after completion of this survey, there was a large drought in 1982 to 1983, and it was reported that the concession of PT. K.T.I. had also suffered a large fire.

As for temperatures, monthly mean temperatures ranged from 27.0 to 28.8°C, and there was not much difference between the respective months. The annual mean temperature was 28.0°C. The annual mean maximum temperature was 34.5°C, and the annual mean minimum temperature was 21.4°C.

Table 1 Precipitation, days of precipitation and precipitation intensity in Sebulu

Year	1973		1975		1976		1978		1979		Average for 5 years		Mean of 3 years		Precipitation intensity (mm/day)	
Month	Precipitation mm	Days of precipitation	Precipitation mm	Days of precipitation	Precipitation mm	Days of precipitation	Precipitation mm	Days of precipitation	Precipitation mm	Days of precipitation	Precipitation mm	Days of precipitation	Precipitation mm	Days of precipitation	Mean of 5 years	Mean of 3 years
Jan	263	8	844	20	349	20	239	8	-	-	423.8*	14.0*	283.7	12.0	30.3	23.6
Feb	46	2	477	13	662	15	771	18	240	11	439.2	11.8	493.0	11.7	37.2	42.3
Mar	159	7	710	17	613	15	323	10	562	19	473.4	13.6	365.0	10.7	34.8	34.2
Apr	137	12	548	16	956	14	555	10	817	17	606.6	13.8	549.3	12.0	44.0	45.8
May	561	16	319	11	428	11	460	17	457	9	445.0	12.8	483.0	14.7	34.8	32.9
Jun	174	11	308	16	366	10	409	16	70	3	265.4	11.2	316.3	12.3	23.7	25.6
Jul	143	7	277	16	218	6	281	13	267	8	237.2	10.0	214.0	8.7	23.7	24.7
Aug	131	13	654	13	333	11	492	14	119	7	345.8	11.6	318.7	12.7	29.8	25.1
Sep	694	21	598	12	409	8	550	12	229	10	496.0	12.6	551.0	13.7	39.4	27.1
Oct	125	8	532	18	957	21	373	11	166	7	430.6	13.0	485.0	13.3	33.1	36.4
Nov	321	13	-	-	523	15	1073	19	288	8	551.3	13.8	639.0	14.7	40.1	43.6
Dec	670	15	-	-	666	14	736	15	1064	13	784.0*	14.3*	690.7	14.7	55.0*	47.1
ANN	2258	133	5267[1)]	152[1)]	6480	160	6262	163	4279[2)]	112[2)]	5498.3	142.5	5388.7	151.2	35.5	34.0

Note: A hyphen indicates no measurement made. 1) indicates a mean or total of 10 months. 2) indicates a mean or total of 11 months. * indicates a mean of 4 years.

The basic data was obtained from P.T. Kutai Timber Indonesia: Rencana Karya Tahunan Pengusahaan Hutan.

Table 2 Maximum, minimum and mean temperatures of Sebulu
(5-year mean values of 1973, 1975, 1976, 1978 and 1979)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANN
Maximum temperature	34.7	35.4	35.2	35.0	35.6	34.3	33.7	34.0	33.9	34.7	34.4	33.4	34.5
Minimum temperature	21.8	22.1	22.1	22.1	21.9	21.7	20.3	21.0	20.4	21.1	21.0	21.0	21.4
Mean temperature	28.3	28.8	28.7	28.5	28.8	28.0	27.0	27.5	27.2	27.9	27.7	27.2	28.0

Note: The basic data was obtained from P.T. Kutai Timber Indonesia: Rencana Karya Tahunan Pengusahaan Hutan.

iv. Soil

The soil of Sebulu belongs to reddish yellow podzolic according to Thorp J, et al.[2] The soil productivity is surmised to be relatively high in East Kalimantan which is generally low in soil productivity. The pH (KCl) was 4.0 to 4.5, being acidic, and the exchangeable acidity was large. The pH of soil was lower in sprout forests than in selection forests. Both nitrate nitrogen and ammonium nitrogen were small in content.

v. Vegetation

The virgin forests in low land areas are of Dipterocarpaceae and tropical heaths. The hills are covered with Dipterocarpaceae forests. Tropical heath forests exist like islands in Dipterocarpaceae forests in the low land.

(2) Bukit Soeharto

i. Location

Bukit Soeharto is a practical training forests of Mulawarman University, located at about 40 km north from Balikpapan along a highway, as shown in Fig. 1.

ii. Topographic and geologic features

Bukit Soeharto is topographically hilly in the stage of old age like Sebulu and is mostly lower than 100 m in elevation. It belongs geologically to the Tertiary.

iii. Climate

Since Bukit Soeharto district is located almost at the center of Samarinda and Balikpapan, the values observed in both the cities can be used for discussion (Tables 3 and 4). The annual mean precipitation in Balikpapan was 3,006 mm, and also in the dry season, the rain was relatively much.

The temperature difference between the districts was small. Maximum temperatures were about 30°C, but minimum temperatures were greatly different. Humidities were about 85%, not showing large difference.

Also in this district, a drought continued in the rainy season of 1982 to 1983, and in the large fire of 1983, many portions were burnt. The coal layer along the road smoked till December of 1983, about half a year after the fire.

iv. Soil

Also the soil in Bukit Soeharto generally belongs to reddish yellow podzol[2)] as in Sebulu.

v. Vegetation

Bukit Soeharto, is mostly a hilly land located between Balikpapan and Samarinda. Since the Balikpapan-Samarinda highway was completed with help from Japan, this district has been rapidly developed, in succession to the development made in the zone along the coast. Therefore, the forests along the highway were heavily destroyed by peasants, and virgin forests can be seen only deep inside. However, though they appear to be virgin forests, most of them have once been weakly selectively cut.

Table 3 Climate in Balikpapan

Item \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Precipitation (mm)	282	263	256	218	269	238	319	218	204	235	252	252	3,006
Mean temperature (°C)	26.5	26.5	26.2	26.7	26.9	26.8	27.0	27.0	27.4	27.8	27.4	27.4	27.0
Maximum temperature (°C)	30.2	30.1	30.0	30.0	30.2	30.0	29.5	29.7	29.9	30.0	30.1	30.3	30.0
Minimum temperature (°C)	23.9	23.7	23.7	24.0	24.2	24.1	23.7	24.0	24.3	24.5	24.1	23.3	24.0
Humidity (%)	85	86	87	88	86	88	85	85	84	84	85	85	85.7

Table 4 Climate of Samarinda (mean values of 1976 to 1978)

Item \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Precipitation (mm)	192	198	189	269	98	163	89	71	106	159	138	146	1,820
Mean temperature (°C)	25.3	25.3	25.3	25.7	26.3	26.0	26.0	26.0	26.3	25.3	26.0	26.3	25.9
Maximum temperature (°C)	30.0	30.3	31.0	30.7	31.0	30.7	30.7	31.0	32.0	30.3	31.0	31.0	30.8
Minimum temperature (°C)	18.3	19.0	19.3	19.0	18.3	19.0	19.3	18.7	19.0	19.0	19.0	18.7	18.9
Humidity (%)	86.3	84.3	85.3	85.6	85.3	86.0	83.0	83.0	80.0	87.3	86.0	85.3	84.8
Days of rainfall	12	12	10	12	9	8	5	6	3	8	9	9	102

(3) Sotek district

i. Location

Sotek is located at about 20 km northwest from Balikpapan along the Riko river, as shown in Fig. 1. The concession in which PT. B.F.I. has their office was selected as Sotek district.

ii. Topographic and geologic features

Sotek is generally hilly, low in elevation, and of low rolling hills of 40 to 50 m. It geologically belongs to the Tertiary period.

iii. Climate

Since observed values in Sotek could not be obtained, the values in Tables 3 and 5 were used for references.

In Balikpapan, the annual rainfall was more than 2,000 mm, and there was some rainfall in terms of mean values even in the dry season when the number of days of precipitation is small, as can be seen from Table 5. The mean temperature can be said to be about 27°C.

iv. Soil

Also the soil in this district mostly belongs to reddish yellow podzol as in Sebulu. In general, the soil is thin in layer A, being yellowish brown and clayey.

v. Vegetation

This is one of the districts most advanced in the utilization and development of forests in East Kalimantan, and has many burnt fields and secondary stands. Therefore, around the office in Sotek, there are few virgin forests, planted forests and selectively cut areas spread-over. The virgin forests are generally composed of trees of Dipterocarpaceae.

Table 5 Observed values of Balikpapan[3)]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean
Mean temperature (°C)	26.4	26.2	26.4	26.5	27.0	26.8	26.8	26.7	27.3	27.2	27.3	27.0	26.8
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall** (mm)	198	199	178	232	170	132	118	121	144	135	161	236	Total 2,024
Days of rainfall**	15	14	14	16	16	14	12	10	12	10	15	18	Total 166

* Temperatures show mean values of the data observed in Pertamina from 1971 to 1977.

** Rainfalls and days of rainfall are mean values of the data observed in ITCI from 1972 to 1979.

(4) Lempake

i. Location

Lempake is located at about 10 odd kilometers from Mulawarman University in the suburbs of Samarinda, as shown in Fig. 1.

ii. Topographic and geologic features

Lempake is topographically hilly in the stage of old age. The elevation is low, being about 50 m. It belongs geologically to the Tertiary period.

iii. Climate

Since there was no meteorological data for the practical training forests, discussion was made using the data of Samarinda in Table 4.

The annual rainfall was 1,820 mm, and the number of rainy days was 102. The mean temperature was about 26°C, and the mean humidity was about 85%, showing a high value.

iv. Soil

The soil of this district also belongs to reddish yellow podzol[2] as in Sebulu and Sotek, but partially contains red podzol. In general, layer A is thin and layer B is yellowish brown or reddish brown. The soil texture is mostly clayey or loamy.

v. Vegetation

This district contains practical training forests of the university and some villages and arable land of immigrants. The forest land of the villages and their peripheral areas is mostly secondary stands, and virgin forests can be seen only very deep inside from the road. The practical training forests are mostly of old secondary stands or of selection forests. They are of Shorea, Eusideroxylon, etc.

After the completion of this survey, a large area of the secondary stands and part of virgin forests were lost in the fire of 1983. After the fire, the forest floor become bright with grasses and saplings growing vigorously. Accordingly, many insects such as butterflies can be seen.

4. Surveyed Stands of Trees

(1) Sebulu

In Sebulu, a virgin forest, a forest selectively cut 10 years before, and a forest selectively cut immediately before (1980) were surveyed.

Sebulu is located as shown in Fig. 1. The surveyed virgin forest is located at about 28 km inside from the office of PT. K.T.I. along the Mahakam river. It is at an elevation of 40 m, and topographically almost flat (Fig. 2), facing slightly to the west.

The stand selectively cut immediately before is located at about 35 km inside from the office of K.T.I., and is at an elevation of 55 to 60 m, forming a gentle slope facing west (Fig. 3).

The stand selectively cut 10 years before is located about 45 km inside from the office of K.T.I., and is at an elevation of about 80 m, forming a gentle slope facing northwest (Fig. 4).

Sebulu district is generally hilly in the stage of old age, and these surveyed locations are lower than 80 m in elevation and form almost flat or gentle slopes.

(2) Bukit Soeharto

In Bukit Soeharto district, only virgin forest was surveyed. The surveyed location is as shown in Fig. 1 at about 300 m eastward from the 50 km point of Balikpapan-Samarinda highway, and is at an elevation of about 60 to 70 m, being topographically complicated, low at the center and high almost in the south and north (Fig. 5).

(3) Sotek

Sotek district is located as shown in Fig. 1, and (a) virgin forest and two stands selectively cut 10 years before were surveyed. The virgin forest is located at point A, 78 m west from the office of Sotek. The stands were selectively cut 10 years before are located at point B, 12 km west from the Sotek office, and point C, 4.5 km further west (Fig. 6), and are at an elevation of about 60 m, being topographically very undulated.

(4) Lempake

Lempake district is located as shown in Fig. 1. In this district, virgin forest was surveyed. The surveyed forest is located in the practical training forests of Mulawarman University, in which large diameter trees of Shorea smithiana grow.

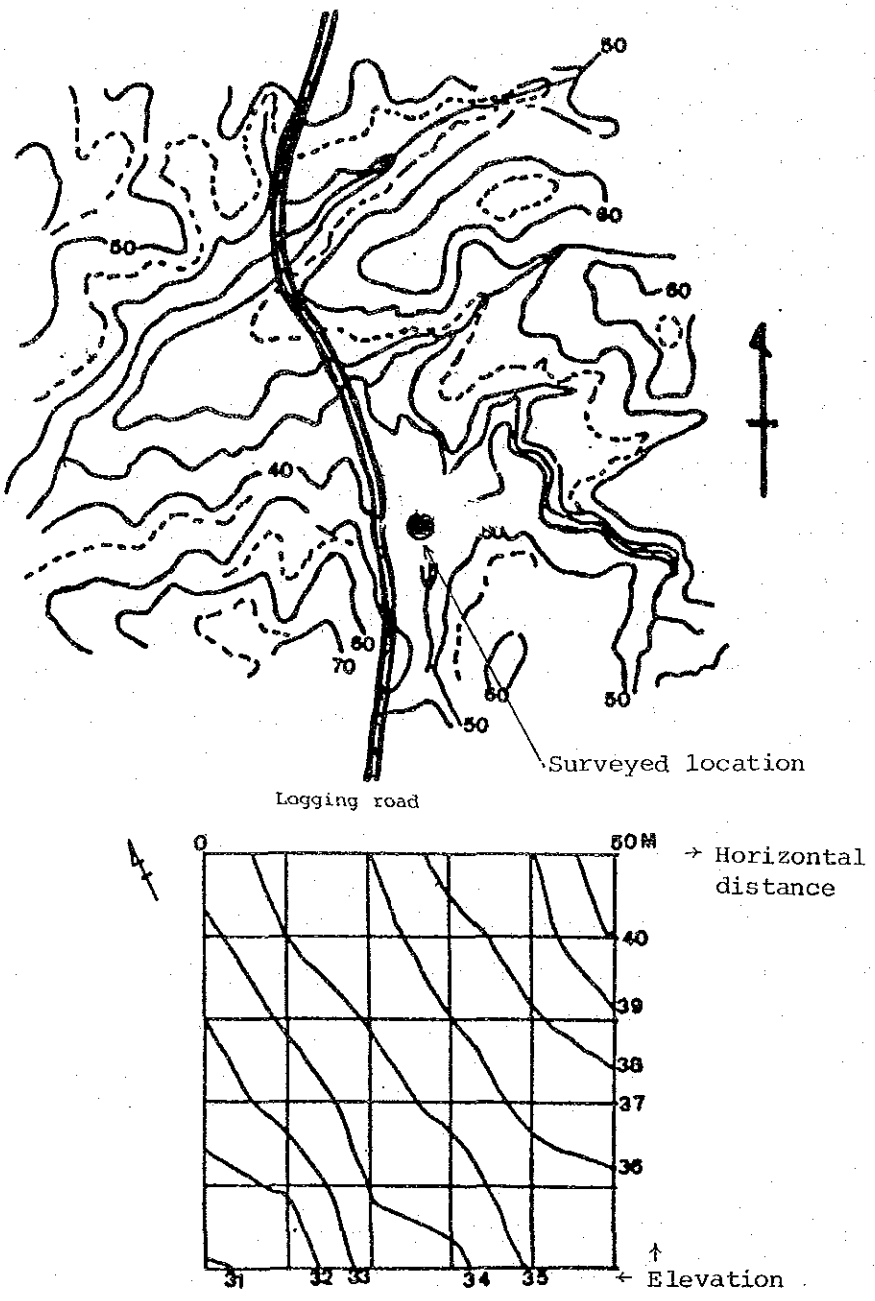


Fig. 2 Location and topography of surveyed Sebulu virgin forest

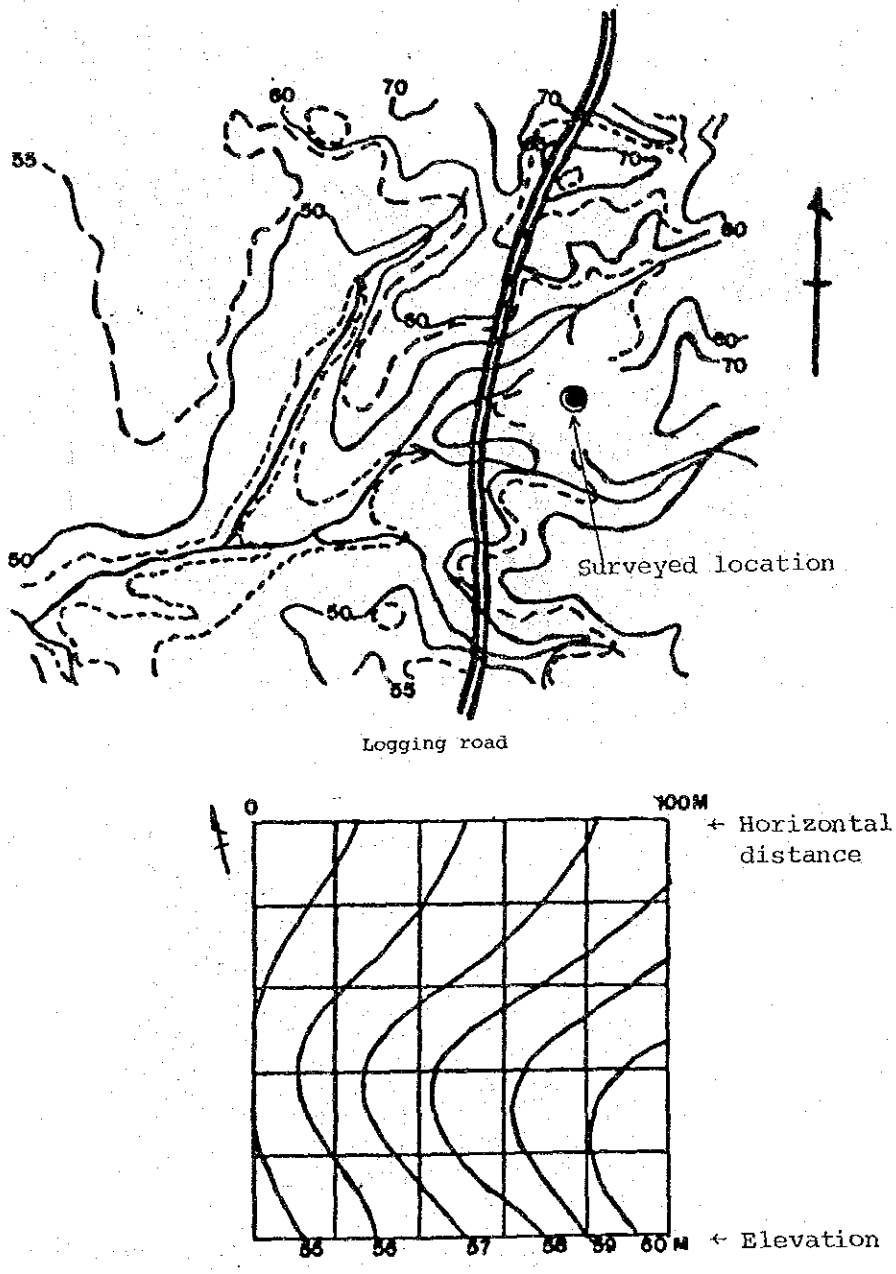


Fig. 3 Location and topography of the surveyed stand selectively cut immediately before

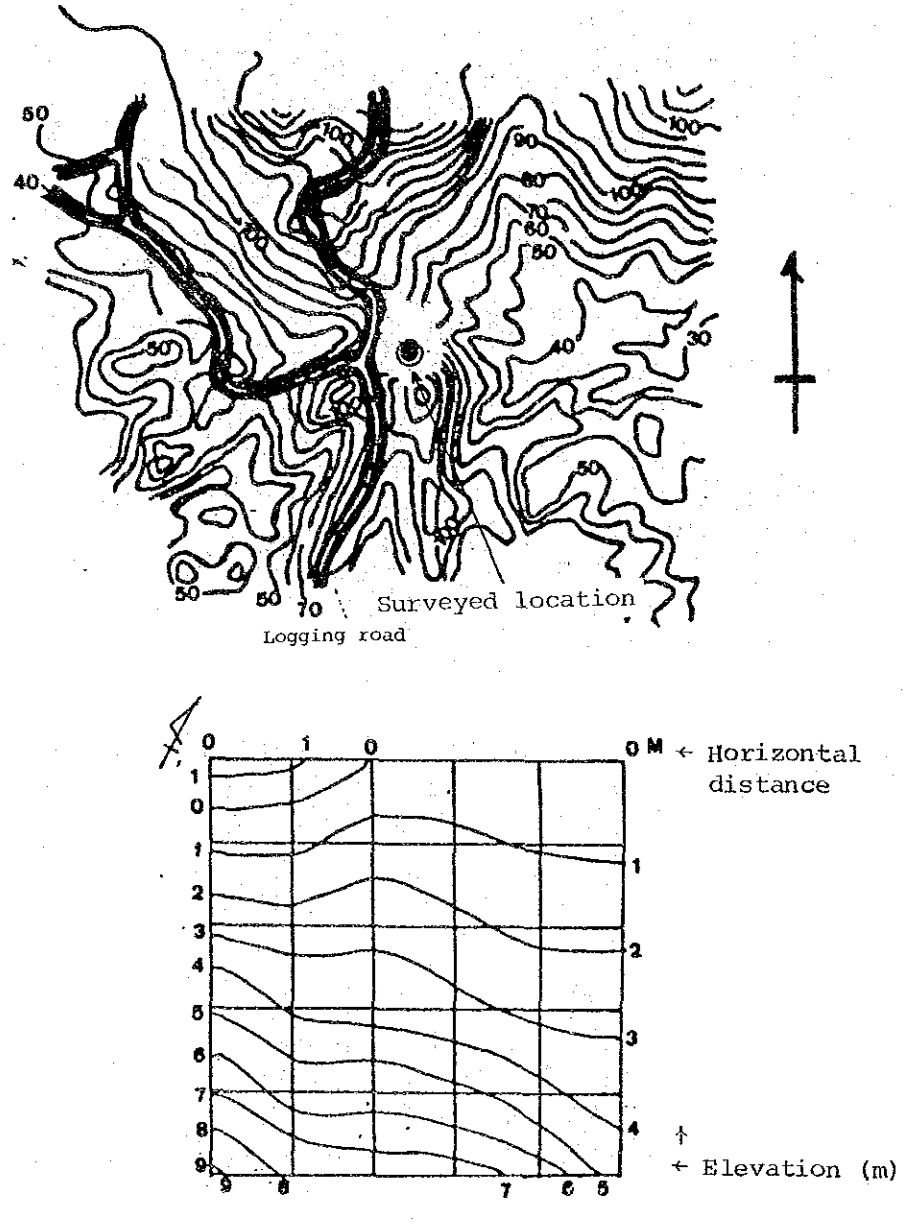


Fig. 4 Location and topography of the surveyed stand selectively cut 10 years before

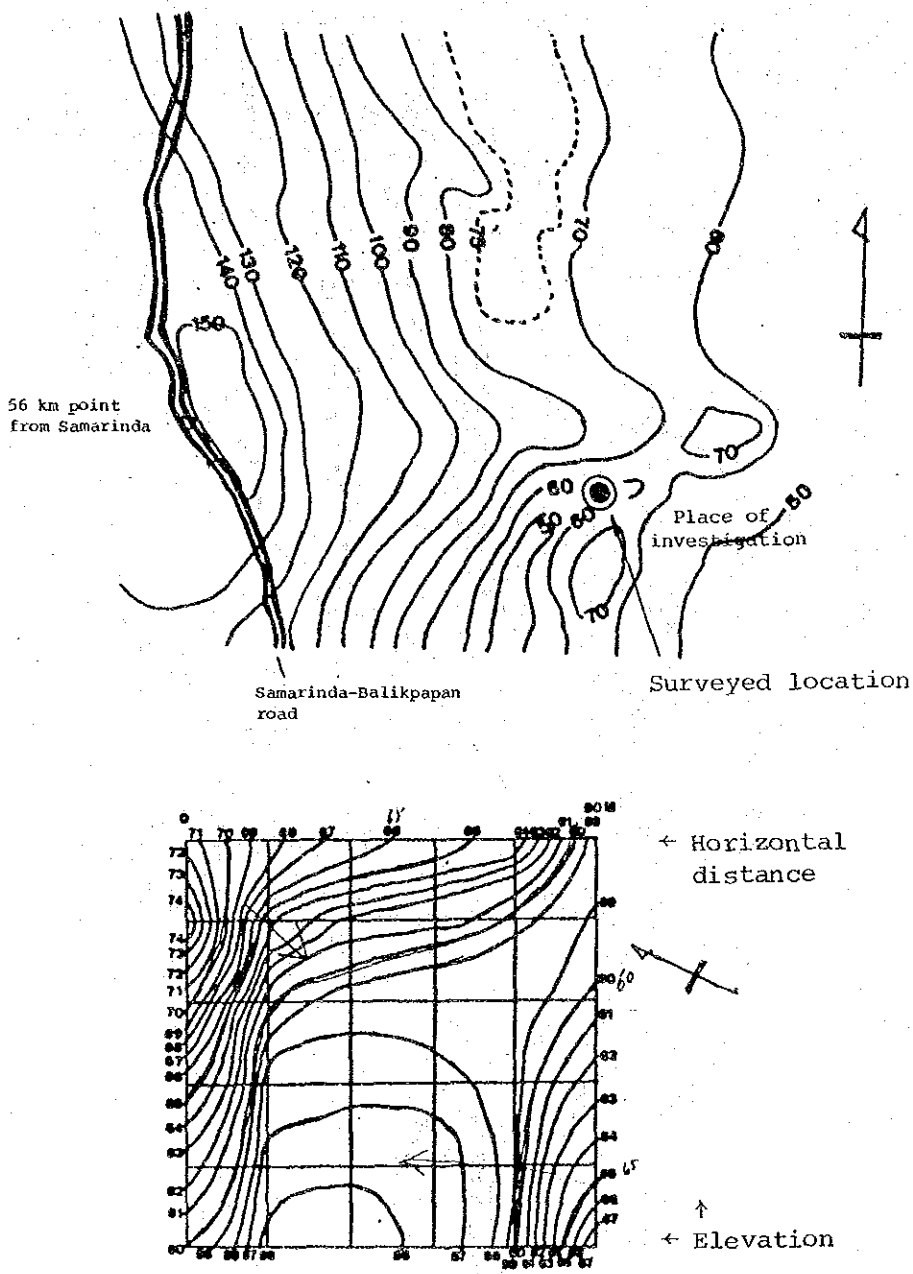


Fig. 5 Location and topography of the surveyed virgin forest of Bukit Soeharto

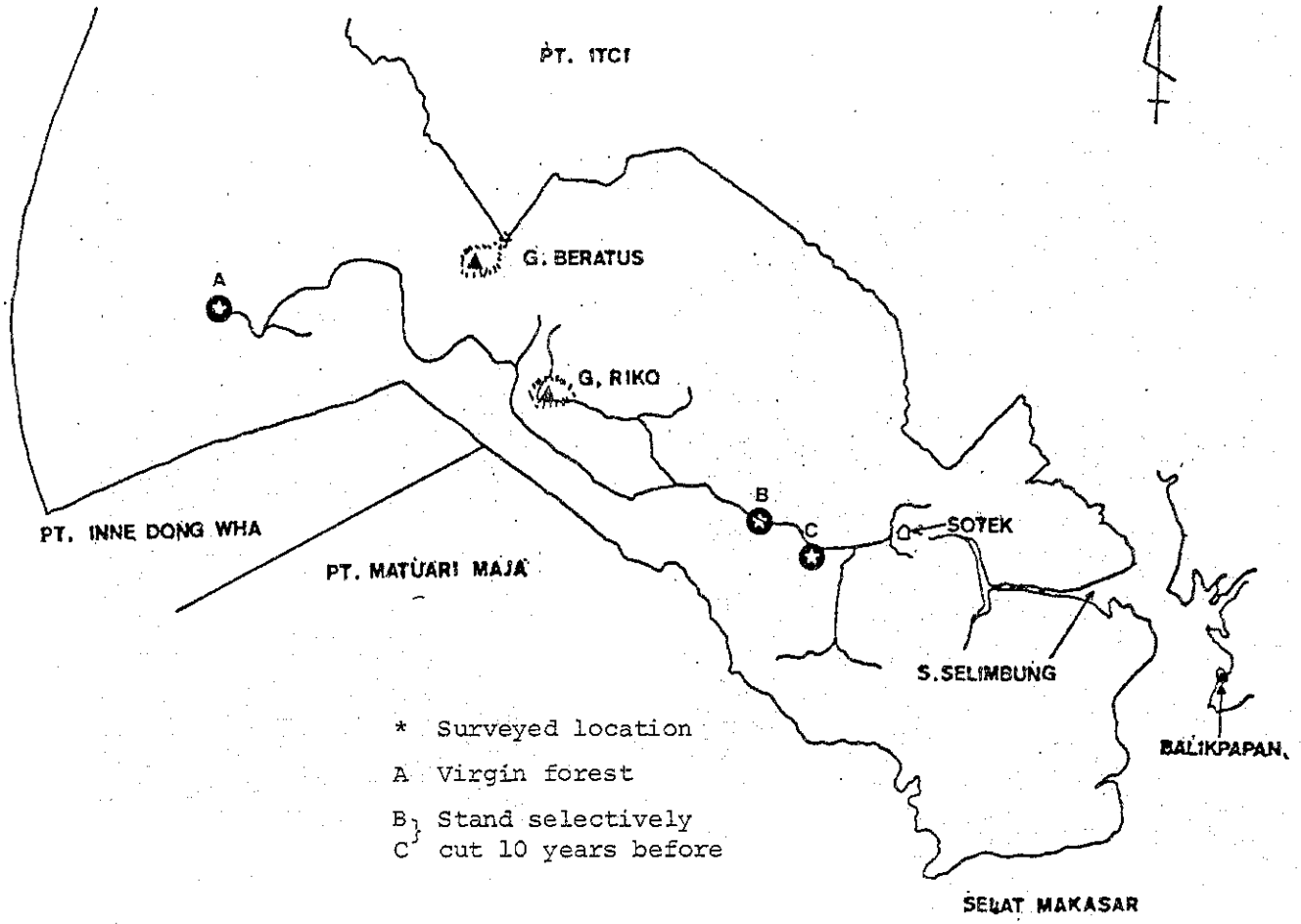


Fig. 6 Surveyed locations of P.T.B.F.I.

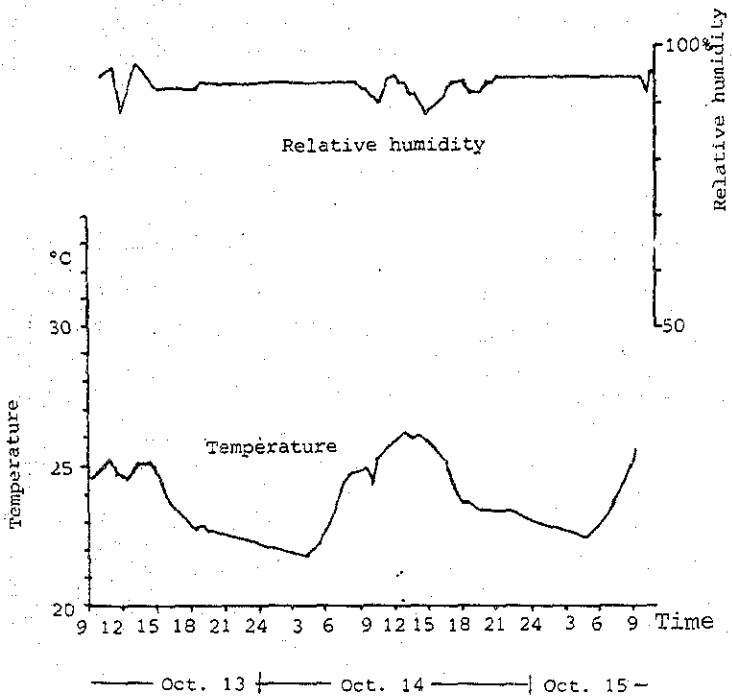


Fig. 7 Temperature and relative humidity of the virgin forest of Sebulu

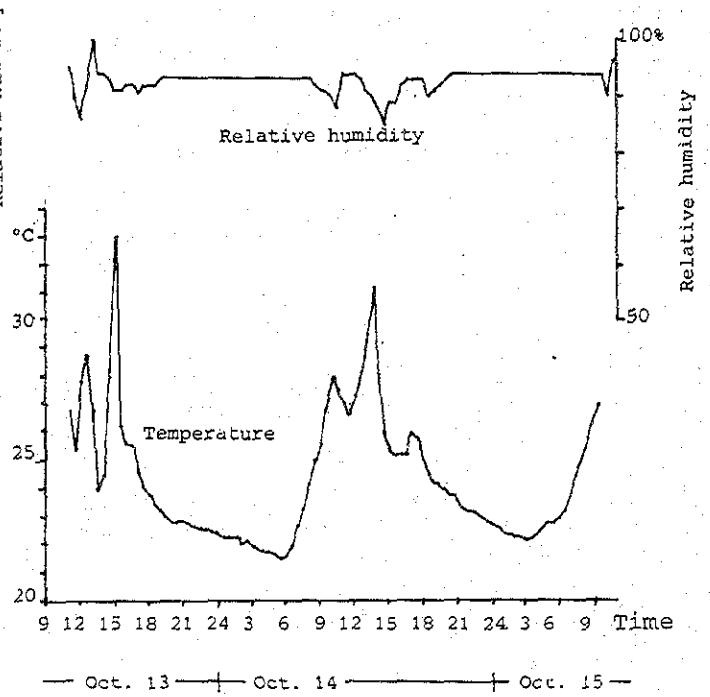


Fig. 8 Temperature and relative humidity of the stand selectively cut immediately before in Sebulu

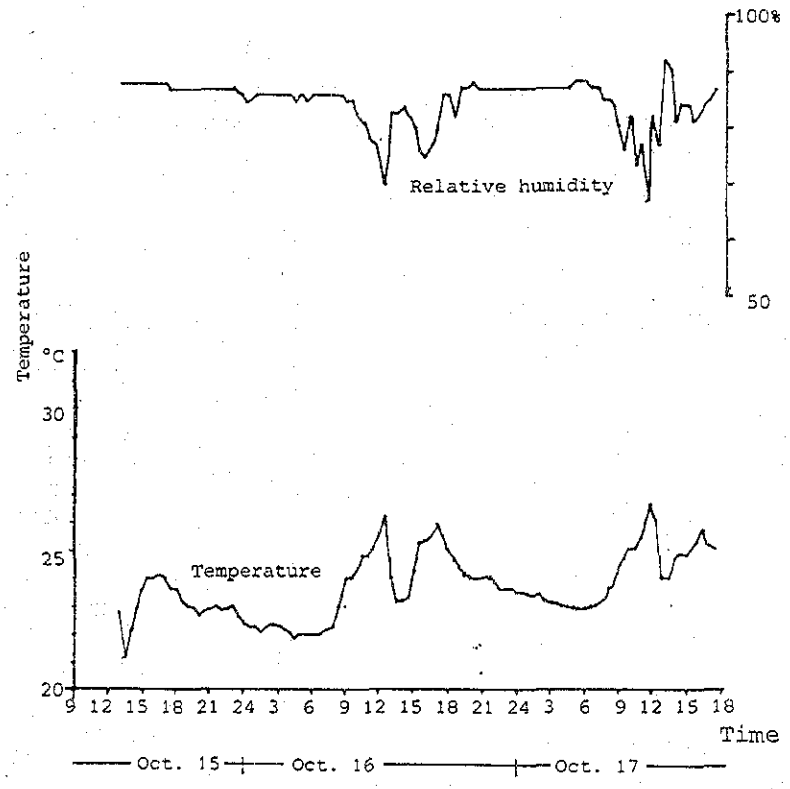


Fig. 9 Temperature and relative humidity of the stand selectively cut 10 years before in Sebulu

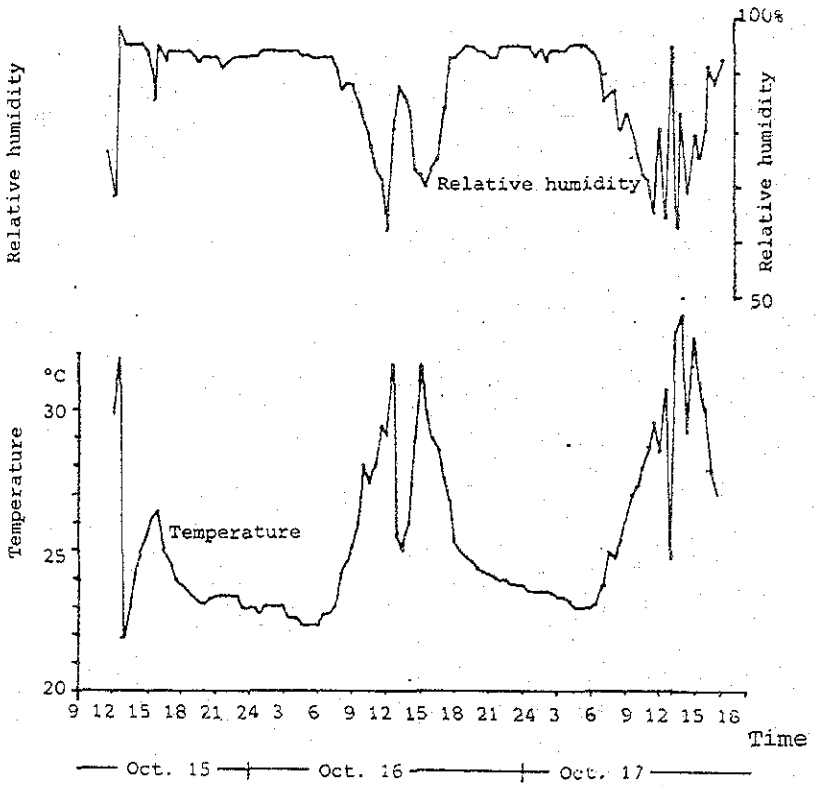


Fig. 10 Temperature and relative humidity of the stand (of Fig. 9) in Sebulu

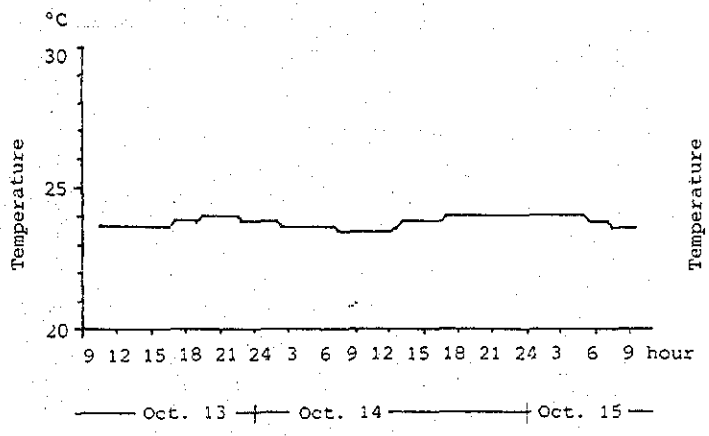


Fig. 11 Ground temperature of the virgin forest in Sebulu

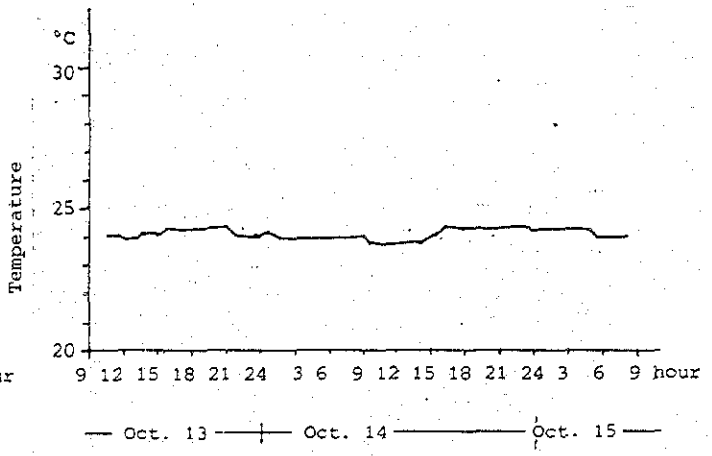


Fig. 12 Ground temperature of the stand selectively cut immediately before in Sebulu

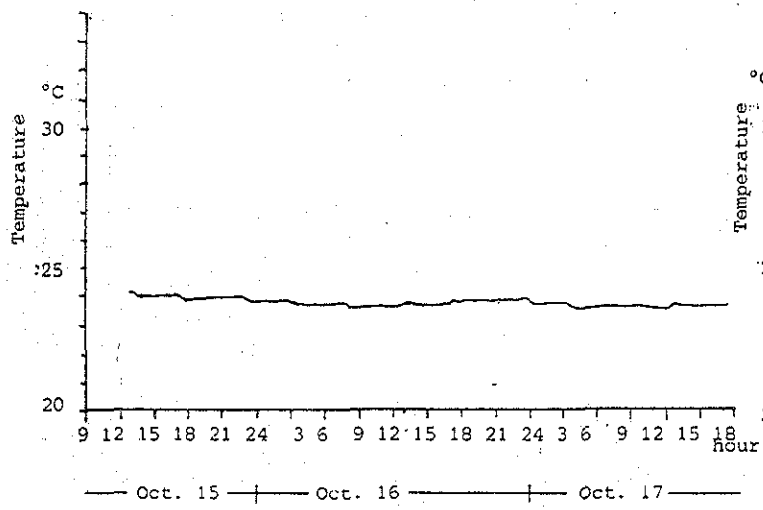


Fig. 13 Ground temperature of the stand selectively cut 10 years before in Sebulu

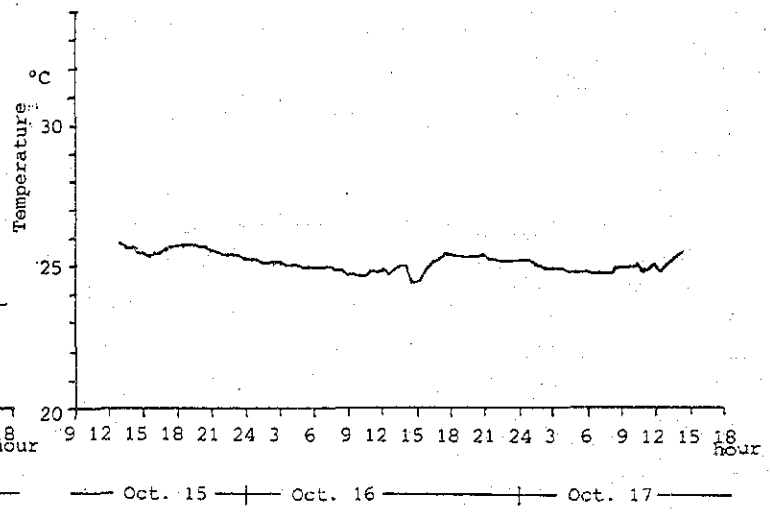


Fig. 14 Ground temperature of the stand (of Fig. 9) in Sebulu

5. Results and Discussion

As mentioned before, while how to study the treatment of cut forests was discussed, it became necessary to also, consider the regeneration including silviculture.

Thus, TPI (Indonesian Selection Cutting System) was presented, and the present situations were discussed. Furthermore, commercial species as succeeding trees were selected. In succession, based on the data obtained in the respective districts of Sebulu, Bukit Soeharto, Sotek and Lempake, the method of selection cutting, damage to succeeding trees involved in logging, regeneration, flourishing and vanishing of saplings, pest damage to timber, and afforestation of wilderness and clear cut areas were discussed.

(1) Indonesian Selection Cutting System

The government of the Republic of Indonesia has decided to adopt the Indonesian Selection Cutting System (T.P.I.) or Modified Malayan Uniform System for cutting virgin forests, in 1972.

The Indonesian Selection Cutting System is used for forests mixed in stand composition and poor in species useful for regeneration. As shown in Table 6, the minimum diameters of the commercial species to be cut are determined according to the lengths of cutting cycles, and the numbers of trees allowed to be cut out are limited.

The Modified Malayan Uniform System is adopted when there are abundant species useful for regeneration. Of the two systems, in general, the Indonesian Selection Cutting System is adopted.

The objective of the T.P.I. System established is to sustain the production of commercial species growing in selected and virgin forests. If a tree grows 1 cm in diameter per year on the average for a cutting cycle of 35 years, the breast height diameter becomes larger by 35 cm after 35 years. If this is added to the minimum diameter of the remaining tree, the breast height diameter of the remaining tree becomes only 70 cm in 35 years later.
If the largest diameter of remaining trees is 49 cm, and 35 cm is added to it, the sum is only 84 cm. Therefore, large diameter trees of more than the 1 m now available cannot be produced. However, if

Table 6 Indonesian Selection Cutting System (T.P.I. system)

Minimum diameter allowed to be cut (cm)	Cutting cycle (years)	Commercial species to be left	
		Number of trees per ha	Minimum diameter (cm)
50	35	25	35
40	45	25	35
30	55	40	20

Note 1: When the minimum diameter allowed to be cut is 50 cm, at least 25 trees of commercial species and of at least 35 cm in diameter must be left and preserved.

Note 2: Obligations to be performed before or after cutting include patrolling, setting of cutting border, tree marking, volume survey, plant refining and protection against erosion.

the growth of diameter is larger or if the number of medium diameter trees is small with 25 trees left per ha as specified for cutting cycles of 35 years and 45 years, or if trees of about 1 m in breast height diameter are left among the 25 trees by any special arrangement, then large diameter trees can be preserved and produced to some extent.

Forests of Dipterocarpaceae are characterized by the production of straight full-bodied large diameter trees, and in this regard, the production of large diameter trees of 1 m class in breast height diameter as produced now is surmised to be impossible except in special cases, where the diameter growth is more than 2 cm per year.

(2) Stand climate

i. Variations of temperature and humidity at daytime

A forest is known to raise the humidity in it and so lessen the temperature variations. The results measured in 1981 in Sebulu are shown in Figs. 7 to 10. A virgin forest and a stand selectively cut 10 years before show similar patterns, and a stand selectively

cut immediately before and bare land show similar patterns. On bare land, the range was as large as 12°C, but in a forest, it was as small as about 4°C. The minimum temperature in a forest was the same as that on bare land, but the maximum temperature in forests was low. This variation pattern can be said to be determined by weather or not by direct light and wind that enter the forest. The relative humidity varied between 85 and 90%, and the variation is small as far as there was neither direct sunlight nor rainfall. A forest eases meteorological conditions and makes variations small, and does not seem to be affected so sensitively by the quality and quantity of plant covering.

ii. Ground temperature

The temperatures at a depth of 30 cm in the ground are shown in Figs. 11 to 14. On bare land, the temperature rises by 1 or 2°C, but in forests, it remains constant at 24°C. This was lower by 2°C than the above mentioned mean stand ground surface temperature of 26°C, and lower by 1 to 1.5°C than the ground temperature in bare land.

iii. Stand illuminance

The brightness in a forest depends on the stand composition. The illuminance in the Bukit Soeharto virgin forest on the forest floor was about 900 to 1,000 luxes as shown in Table 7. The relative illuminance was 0.7 to 0.9%, being very low. On the contrary, the stand selectively cut immediately before in Sebulu gave 700 to 800 luxes at positions high in crown density and 3,000 to 7,000 luxes at positions low in crown density as shown in Table 8. The relative illuminance at the former was 5%, and that at the latter was from 10 to 40%.

Table 7 Relative illuminance
in the Bukit Soeharto virgin forest

(Measured on October 29, 1980)

Times / Position	1	2	3	4	5	6	7	8	Mean
Stand (LX)	1,073	1,000	1,050	1,160	1,150	890	990	1,080	1,049
Bare land (LX)	129,900	127,300	125,800	133,800	130,400	125,000	125,400	129,700	128,440
%	0.8	0.8	0.8	0.9	0.9	0.7	0.8	0.8	0.8

Table 8 Relative illuminance in the stand
selectively cut immediately before

(Measured on November 7, 1980)

No	In (Lx)	Out (Lx)	%	Crown density
1	690	14,400	4.8	6 - 9
2	780	14,730	5.3	"
3	7,000	15,900	44.0	2 - 4
4	3,200	10,270	31.2	3 - 4
5	4,490	34,200	13.1	"

Sun stations with two light receiving sections each were set at 3 locations in each stand of Sebulu in November, 1980, to measure the illuminance in January, 1981.

In the virgin forest and the stand selectively cut 10 years before, the illuminance was 5 to 9 kw/m^2 with some exceptions, showing no large difference. On the contrary, in the stand selectively cut immediately before, the illuminance at the respective stations was 20 to 50 kw/m^2, and the relative illuminance was 0.8 to 1.6%, and it can be said that the stand is a little brighter than the virgin

Table 9 Relative illuminance in the respective stands in Sebulu

Items / Stand	Measuring station	Measured values (kw/m^2) 1	2	Mean	Relative illuminance (%)	Remarks
Virgin forest	1	9.1	-	9.1	0.3	
	2	8.5	-	8.5	0.3	
	3	4.9*	105.6**	55.3	2.1	*0.2%,**3.4%
Stand selectively cut immediately before	1	23.6	19.2	21.4	0.8	
	2	51.6	33.9	42.5	1.6	
	3	30.0	31.0	30.5	1.2	
Stand selectively cut 10 years before	1	7.1	6.4	6.8	0.3	
	2	6.2	-	6.2	0.2	
Bare land	1	2,662	2,630.4	2,646.2	100.0	

Set on November 7, 1980

Measured on November 14, 1981.

forest and the stand selectively cut 10 years before. It can be considered that the stand selectively cut 10 years before was open and bright 10 years before but became closed again to almost the same extent as the virgin forest.

The meteorological conditions in a stand depend on the conditions of the forest, and the regeneration of saplings and the growth of succeeding trees depending on them. From the results of this survey, the brightness in a stand caused by selection cutting is not surmised to be sufficient for regeneration in many portions. In this regard, it can be said that the quantity of light after selection cutting and that sufficient light for the recovery from selection cutting and for the generation and growth of saplings must be measured with the lapse of time.

(3) Forest soils

i. Sebulu

1) Virgin forests

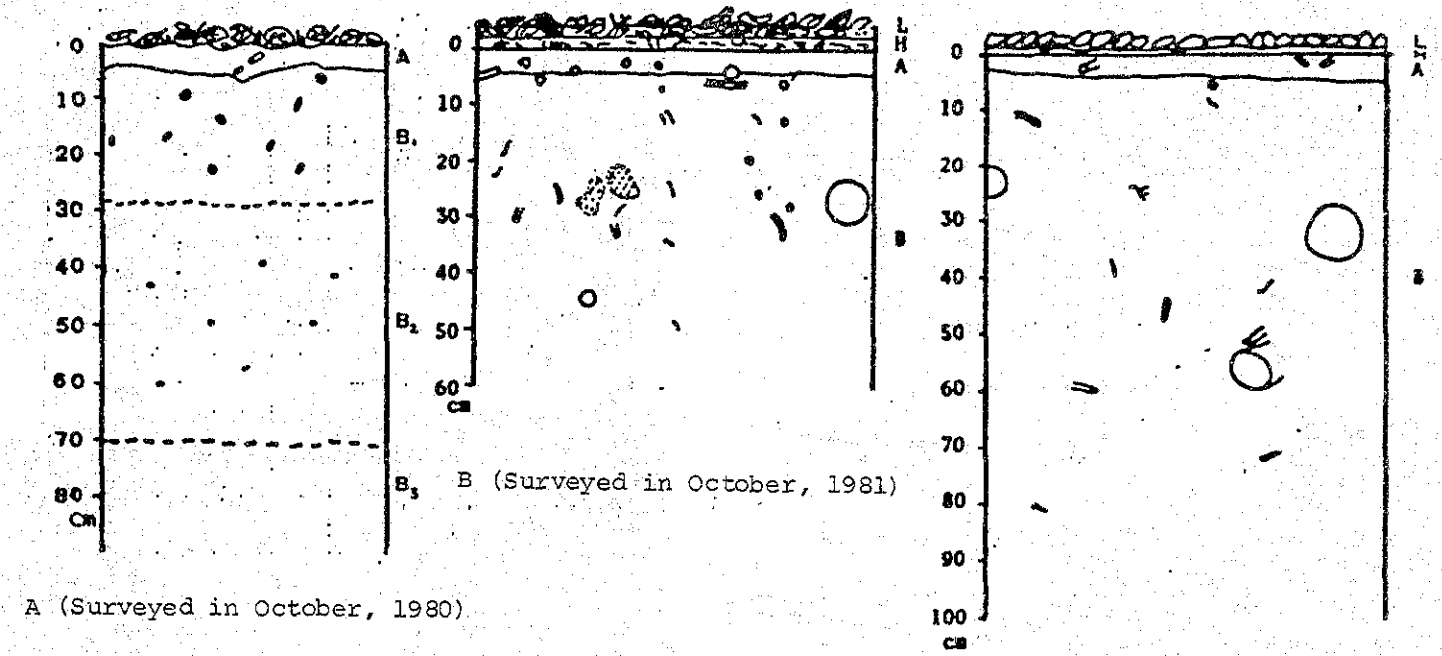
As for virgin forests, three locations of A, 28 km from the office of KTI, B, 25 km, and C, 37 km were selected. The soil profiles are shown in Fig. 15 (A, B and C), and Table 11. As tropical rain forests, the humus layer was relatively thick in some areas, but layer A was thin, being less than 5 cm. Layer A was dull brown or dark brown and contained less humus. Layer B was lightly yellowish orange or dull yellowish orange, being bright. The lower layer was very hard and low in organic content, air permeability, water permeability, etc., being defective structurally. Therefore the root system of trees can penetrate to only shallow depths of 1 m or less.

2) Selection forests

The soil of the stand selectively cut immediately before and the stand selectively cut 10 years before is shown in Fig. 16, Photos 1 and 2 and Tables 10 and 11. The soil profile of the stand selectively cut immediately before was not so different from that of the virgin forest, but in the stand selectively cut 10 years before, layer A was somewhat thick, at about 10 cm. As for the color of soil, the stand selectively cut immediately before was yellowish brown, but the stand selectively cut 10 years before was dull reddish brown, containing a relatively large amount of humus. The hardness of the surface layer was softer in the stand selectively cut 10 years before. These differences must have been caused by the differences in location rather than the differences in the treatment of the stand.

ii. Sotek

The stand surveyed in Sotek had been selectively cut 10 years before. The soil profile is shown in Fig. 16 and Table 10. In general, the humus layer was thin, and the color was greyish

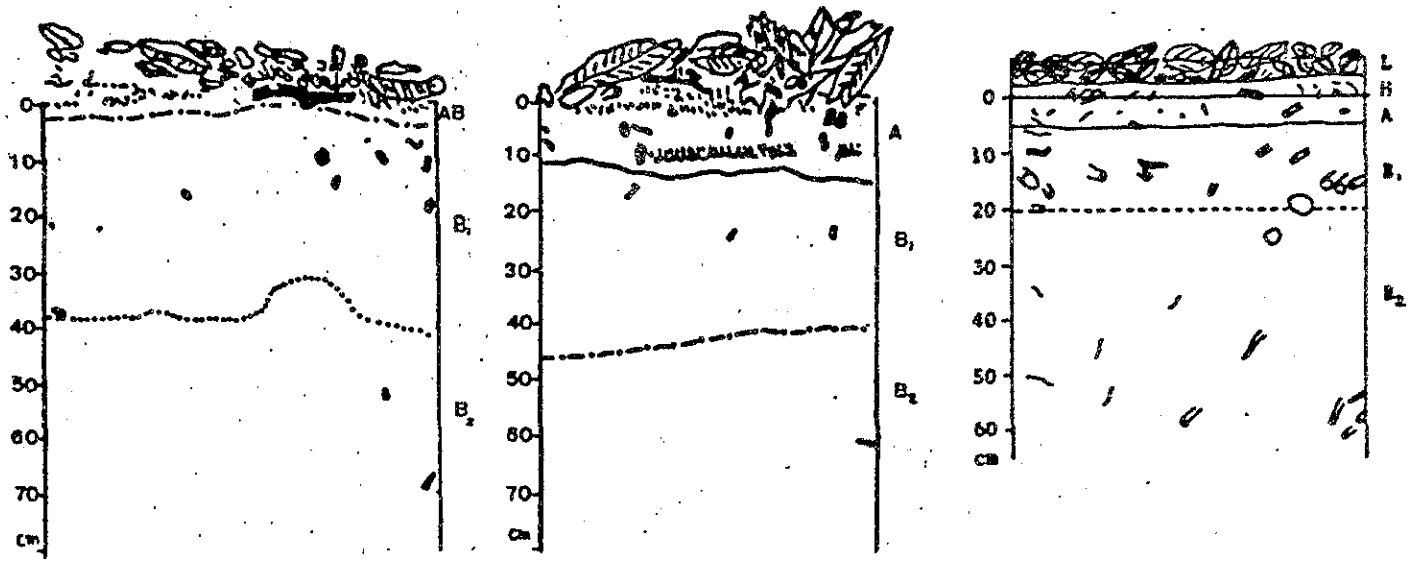


A (Surveyed in October, 1980)

B (Surveyed in October, 1981)

C (Surveyed in October, 1981)

Fig. 15 Soil profiles of virgin forests in Sebulu



Stand selectively cut immediately before in Sebulu (October, 1980)

Stand selectively cut 10 years :ting, before in Sebulu (October, 1980)

Stand selectively cut 10 years before in Sotek (October, 1981)

Fig. 16 Soil profiles of selection forests

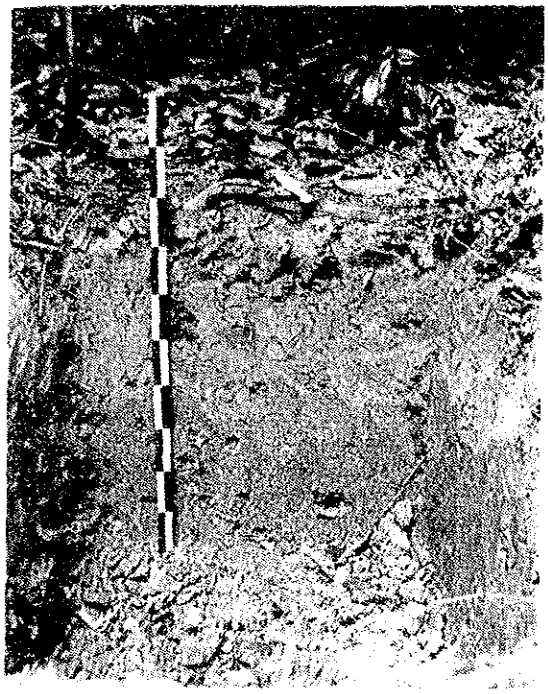


Photo 1 Soil profile of stand immediately after selective cutting, Sebulu

Photo 2 Soil profile of stand 10 years after selective cutting, Sebulu

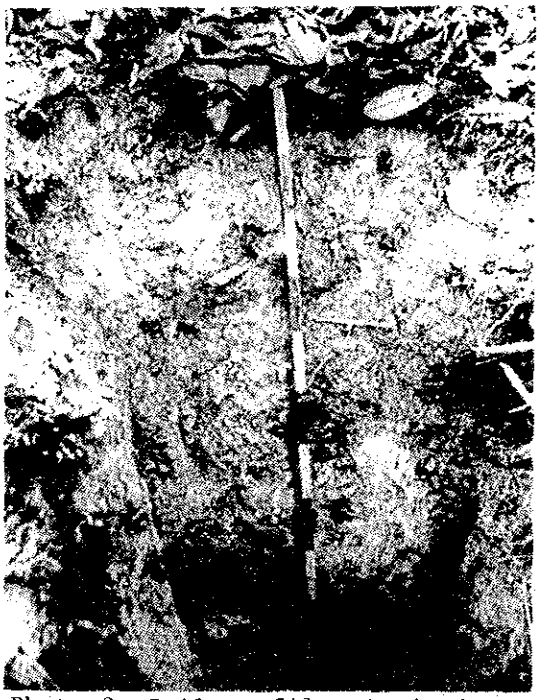


Photo 3 Soil profile of virgin forest, Bukit Soeharto

Photo 4 Soil profile of virgin forest, Lempake

Table 10 Surveyed soil profiles

Location	AO layer	Colour	Gravel rate (%)	Humus content	Structure	Texture	Average hardness by YAMANAKA soil hardness tester (kg/cm^2)	Porosity	Soil moisture	Mycorrhiza Mycelium	Root system	Undergrowth etc.
Virgin forest, in Sebulu (B)	L: 2-3 cm H: 2-3 cm	A: 7.5 yr 5/3 (dull brown) B: 10 yr 7/4 (dull yellow orange)			A: single grained B: massive	A: C B: Hc	3 - 5 cm deep: 4.04 13 - 15 cm deep: 5.03 23 - 25 cm deep: 4.35 33 - 35 cm deep: 5.03 43 - 45 cm deep: 4.04 53 - 55 cm deep: 5.03		A: moderate B: humid		A: much B: a little	
Virgin forest, in Sebulu (C)	L: 3-5 cm H: 1-2 cm	A: 7.5 yr 3/3 (dark brown) B: 7.5 yr 8/6 (light yellow orange)			A: massive B: massive	A: C B: C	3 - 5 cm deep: 2.24 13 - 15 cm deep: 4.04 22 - 25 cm deep: 5.42 35 cm deep: 6.29 45 cm deep: 7.32		A: humid B: humid		A: a little B: a little	
Stand selectively cut immediately before in Sebulu	L: 4-8 cm FH: 4 cm	AB: 10 yr 5/6 (yellowish brown) B_1: 10 yr 7/6 (yellowish brown) B_2: 2.5 yr 7/8 and 2.5 GY 8/1 (orange and light gray)	Almost nothing	AB: a little rich B: poor	AB: nutty B: very masene	AB: CL B_1: C B_2: C and partly CL	5 cm deep: 3.91 15 - 20 cm deep: 16.47 45 - 54 cm deep: 11.18 56 - 70 cm deep: 12.84	AB: a little rich B_1 and B_2: poor	AB: dry B_1 and B_2: a little moist	Partly ly found mycelium at the surface at soil profile	The roots in diameter are found	Plain 0.3-1.0 cm 56m above see level
Stand selectively cut 10 years before in Sebulu	AO: 5-20 cm	A: 5 yr 5/3 (dull reddish brown) B_1: 10 yr 6/6-5/8 (bright yellowish brown - yellowish brown) B_2: 7.5 yr 7/8 (yellow orange	A: less than 5 A_1 and B_2: 5-10	A: rich B_1 and B_2: poor	A: loose and granular	A: SL B_1 and B_2: L	5 - 8 cm deep: 1.37 15 - 25 cm deep: 21.21 35 - 45 cm deep: 26.04 65 - 75 cm deep: 35.65	A: rich B_1: poor B_2: very poor	A: dry B_1: dry - a little moist B_2: a little moist	Nothing	A layer is abundant with small roots of tree	
Stand selectively cut 10 years before in Sotek	L: 3-5 cm H: 2-3 cm	A: 7.5 yr 4/2 (grayish brown) B_1: 7.5 yr 6/3 (dull brown) B_2: 7.5 yr 6/4 (dull orange)			A: massive B_1: massive B_2: massive	A: C B_1: C B_2: C	5 cm deep: 2.24 15 cm deep: 6.29 25 cm deep: 7.32 32 - 35 cm deep: 5.42 43 - 45 cm deep: 5.03 55 cm deep: 6.78		A: humid B_1: humid B_2: humid		A: much B_1: much	
Virgin forest, in Lempake	L: 7-7 cm	B_1: 10 yr 6/6 (light yellowish brown) B_2: 7.5 yr 5/6 (light brown)			A: massive B_1: massive B_2: massive		1 cm deep: 1.18-1.93 10 cm deep: 11.79-24.45 30 cm deep: 8.54-16.68		A: dry B_1: moderate B_2: moderate		A: much B_1: a little B_2: few	
Virgin forest, in Bukit Soeharto	L: 5-6 cm F: 0.5-1 cm H: 1-2 cm		A: poor B_1: poor	A: rich B_1 and B_2: poor				A: rich B_1: poor B_2: very poor		Nothing		

Table 11 Chemical properties of soil

Soil sample	layer	PH		NO_2-N	NO_3-N	NH_4-N	Available K_2O	Ex-Ca	Ex-Mg	Ex-Mn	Al_2O_3	Available P_2O_3	Fe^{3+}	Fe^{3+}
		H_2O	KCl	mg/100g	mg/100g	mg/100g	mg/100g	%	mg/100g	PPm	mg/100g	mg/100g	mg/100g	mg/100g
Stand selectively cut immediately before in Sebulu	A_1	4.5	4.0	0.1	<1.0	10-25	0-3	0.07	5	> 10	15-20	10-25	150-250	25
	B_1	4.5-5.0	4.0	< 0.1	<1.0	1.0	0-3	0.07	5	> 10	15-20	1.0	<25- 75	< 25
	B_2	4.5-5.0	4.0-4.5	< 0.1	<1.0	1.0	0-3	0.07	5	> 10	15-20	0.1	< 25	< 25
Stand selectively cut 10 years before in Sebulu	A	5.0	4.0	0.1	<1.0	1.0	0	0.07	5	> 10	> 30	1.0	250	25
	B_1	5.0	4.5	<0.1	<1.0	<1.0	0	0.07	5	> 10	20	1.0	75	25
	B_2	5.0	4.0	<0.1	<1.0	<1.0	3	0.07	5	> 10	20	0.1	25	25
Virgin forest in Bukit Soeharto	A	5.0	4.0	4.0	<1.0	1.0	3	0.07	5	> 10	15	15.0	250	75
	B	4.5	4.0	<0.1	<1.0	<1.0	0	0.07	5	> 10	15	0.1	75	< 25

brown. On the contrary, layer B was thick, and the color was dull orange or dull brown, containing little organic matter, being hard and low in air permeability. The root system of trees can penetrate to depths of less than 60 cm.

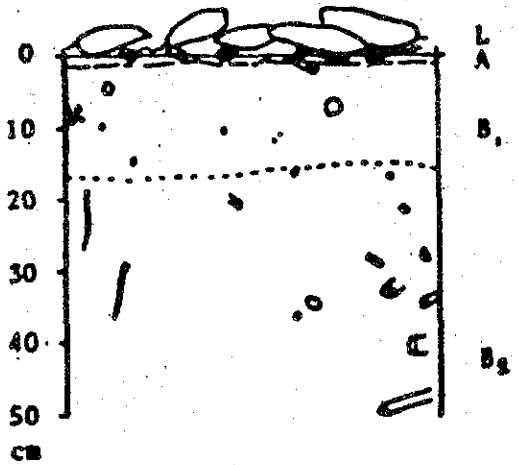
iii. Lempake and Bukit Soeharto

In both the districts, virgin forests were surveyed. The soil profiles are shown in Fig. 17, Photos 3 and 4 and Tables 10 and 11. The humus layer was thin as in other virgin forests, and the color was bright yellow. The soil was not so different from other soil in either hardness or air permeability, and the root systems of trees invaded at depths of less than 80 cm.

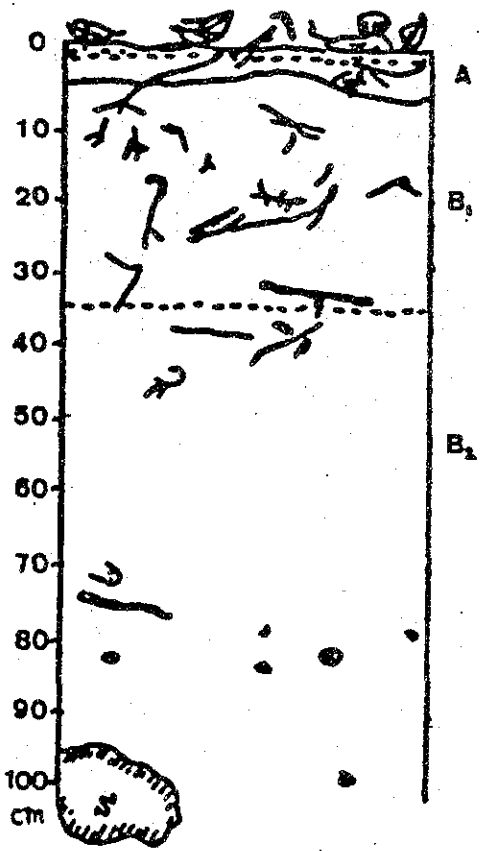
The soil in mountains and hills of East Kalimantan belong to reddish yellow podzol, according to Thorp, J. and Smith, GD[2)]. In general, it provides infertile forest land, but on recessed slopes and at medium and lower portions of gentle slopes, forests of Dipterocarpaceae are formed, showing many portions which can be regarded to be good in soil productivity.

The Luxurious growth of trees under such infertile soil conditions as in these districts is surmised to be brought about by the high temperatures, sufficient precipitation and sunlight peculiar to the tropical rainy zone. However, the large quantities of humus raises the decomposition rate, for efficient circulation of nutrients. Furthermore, though the quantity of nutrients in the soil is small, the volume of the crowns is large, and it must be borne in mind that nutrients may be stored in large quantities also on land.

The differences between virgin forests and selection forests observed in the survey of this time were observed only partially, and are surmised to be caused by the differences in location. In future, it is necessary to research and study the long time changes with the lapse of time by viogorously treating forests in reference to the soil parent material, topographic features, forest types, etc.



Lempake



Bukit Soeharto

Fig. 17 Soil profiles of virgin forests in Lempake and Bukit Soeharto

(4) Situations of stand composition

i. Sebulu

1) Virgin forest

A quadrate of 50 m × 50 m was set in a virgin forest, to investigate the stand composition. A crown projection of forest trees of 20 cm or more in breast height diameter is shown in Fig. 18, and its side view is shown in Fig. 19. The sizes of forest trees are shown in Table 12.

The number of living trees was 208 per ha, and the minimum breast height diameter was 20 cm, maximum breast height diameter, 180 cm, and mean value, 42.5 cm. The minimum tree height was 7 m, and the maximum tree height, 75 m. The number of upper layer trees of 50 m or higher was 16 per ha. The minimum clear length was 3 m, the maximum clear length, 40 m, and the mean value, 18.6 m. The sizes of crowns were large with investigated trees Nos. 2, 33, 47 and 51, being about 19 to 24 m in diameter. Therefore, the crown density was high, and the virgin forest is a so-called large virgin forest (Photo 5). In addition, there were three dead trees.

Out of the above living trees, the growing stages of trees of 35 cm or more in breast height diameter are shown in the crown projection (Fig. 20) and the side view (Fig. 21). The number of the trees is 88 per ha. The crown density is medium, being 120 trees less than that of trees of 20 to 30 cm in breast height diameter.

The trees in the surveyed stand were classified into commercial species and non-commercial species, and the numbers of trees, tree heights, volumes, etc. for the respective diameter classes are shown in Table 13.

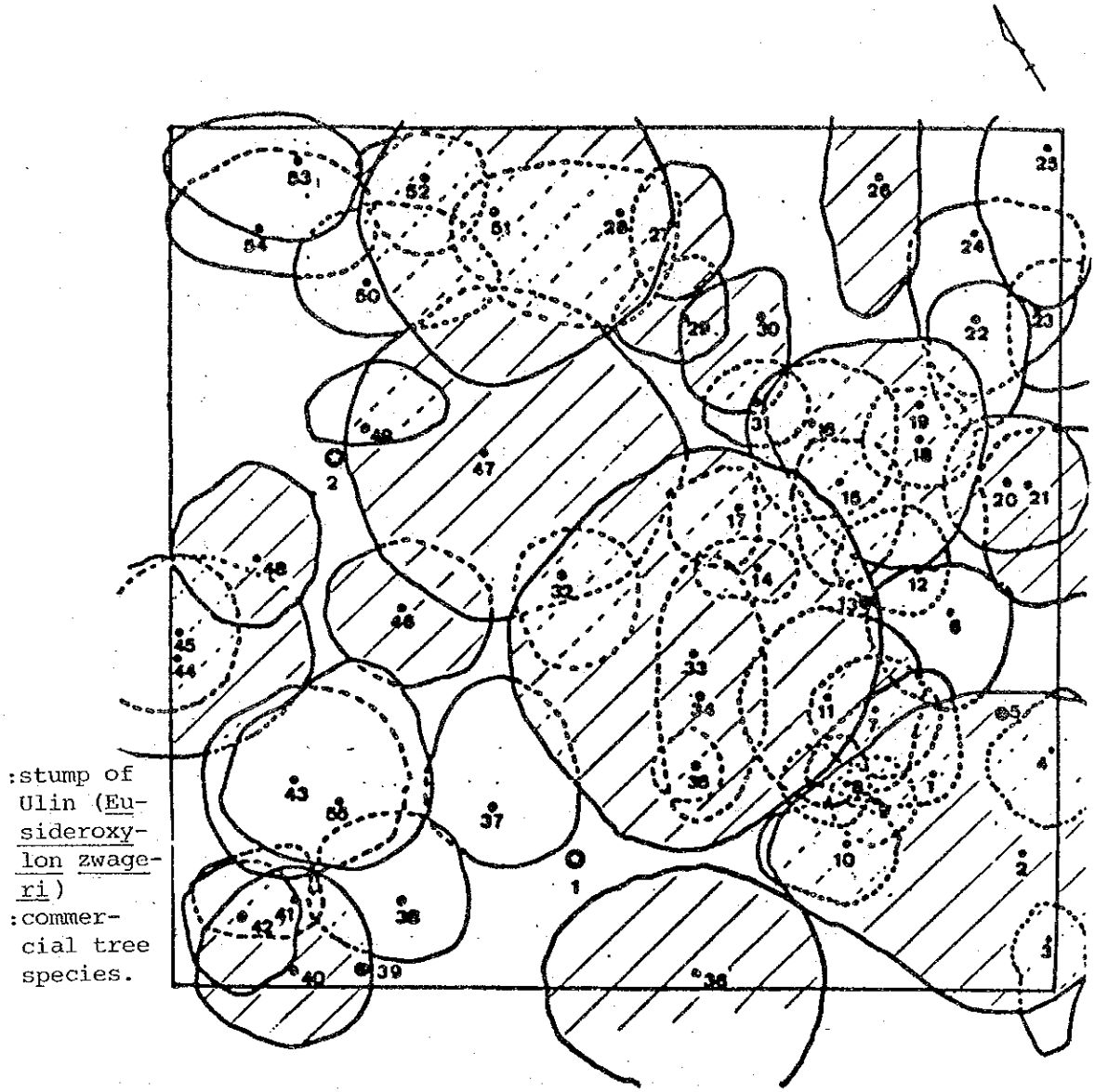


Fig. 18 Crown closer of virgin forest in Sebulu
DBH of 20 cm up

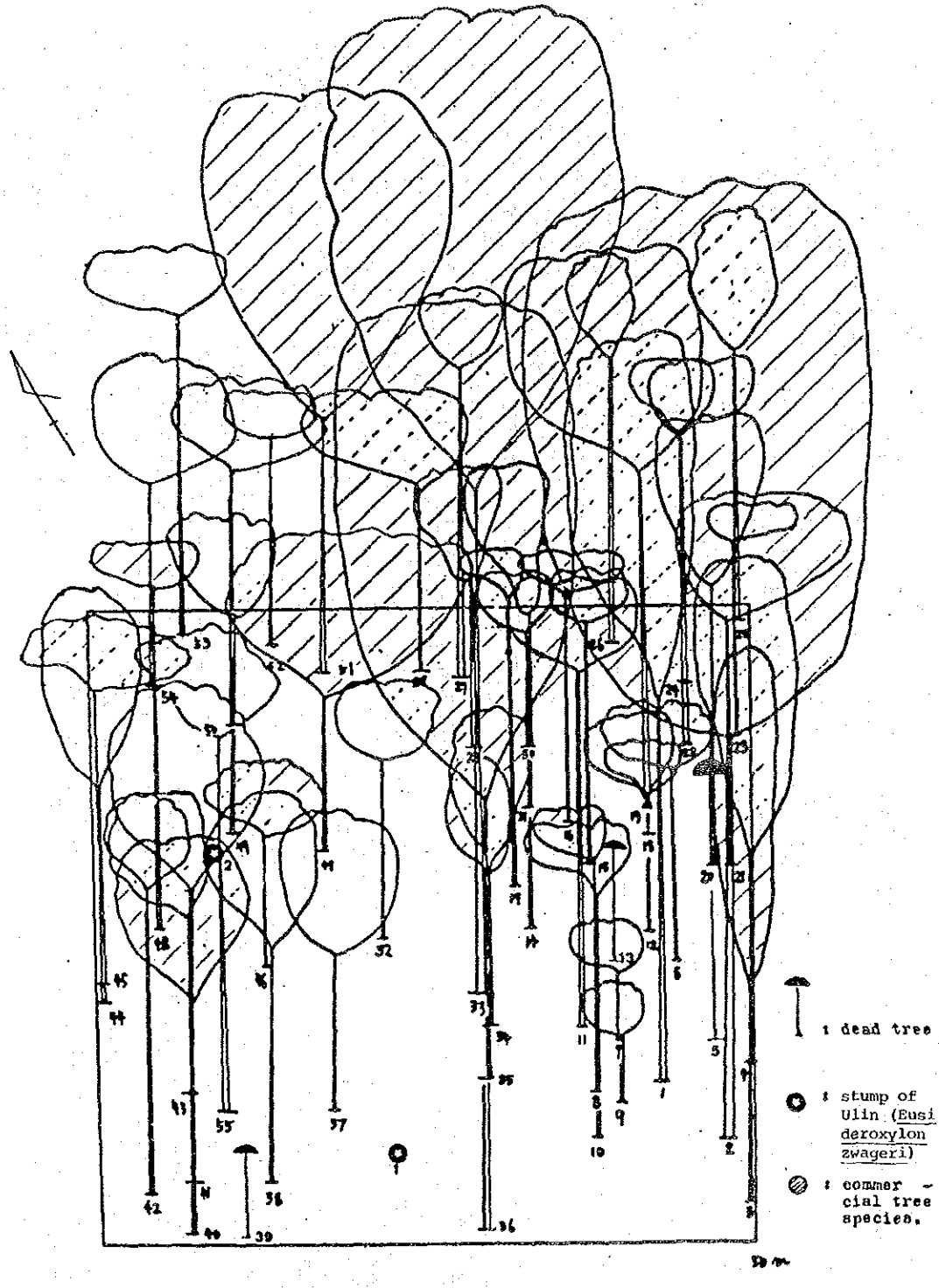


Fig. 19 Profile of virgin forest in Sebulu
DBH of 20 Cm up.

Table 12 Sizes of trees in a virgin forest in Sebulu

No.	Species.	H (m)	CH (m)	DBH (cm)	Size of crown				Note
					1	2	3	4	
1.	Litsea sp.	60	30	52	1.30	1.30	7.40	6.70	
2.	Shorea laevis.	75	31	220	9.90	9.50	14.50	9.40	
3.	Canarium littorale.	43	17	79	2.20	6.90	1.90	2.10	
4.	Parinary oblongifolia.	40	16	29	3.90	4.40	3.50	3.30	
5.	Eusideroxylon zwageri.	21	12	44	—	—	—	—	dead
6.	Gordonia sp.	20	15	29	3.40	5.60	4.80	2.70	
7.	Levistonia sp.	9	5	24	3.80	3.90	3.80	3.70	
8.	Shorea ovalis.	22	18	24	1.40	2.40	3.80	3.90	
9.	Levistonia sp.	9	5	21	2.50	2.50	2.70	2.60	
10.	Eugenia sp.	24	18	30	3.00	3.40	5.00	2.70	
11.	Parinary corymbosum.	35	27	44	5.50	6.40	4.90	5.30	
12.	Aporosa lunata.	17	10	20	1.80	2.50	4.70	3.40	
13.	Eusideroxylon zwageri.	9	—	25	0	—	—	—	dead
14.	Canarium sp.	28	23	43	2.10	2.00	3.50	1.90	
15.	Phobe sp.	23	19	20	3.60	6.00	2.70	2.60	
16.	Drypetes sp.	21	18	28	4.80	5.70	3.90	3.50	
17.	Cryptocaria sp.	26	22	24	1.00	3.70	4.20	2.20	
18.	Levistonia sp.	7	3	20	3.20	2.90	3.10	3.00	
19.	Pentace laxiflora sp.	44	26	110	3.50	9.50	8.70	3.90	
20.	Eusideroxylon zwageri.	35	22	71	4.50	4.00	3.50	4.00	
21.	Scorodocarpus borneensis.	29	19	50	10.20	6.60	2.50	3.00	
22.	Durio dullis sp.	30	24	26	3.20	6.50	2.50	2.10	
23.	Eugenia sibulanensis.	18	15	20	5.60	4.50	1.70	2.90	
24.	Strobosia javanica.	25	19	22	6.50	9.50	3.20	1.80	
25.	Glochidion sp.	32	21	39	3.50	9.50	3.60	2.50	
26.	Eusideroxylon zwageri.	30	22	47	2.60	7.80	3.00	7.50	
27.	Dyera costulata.	30	24	40	3.50	4.60	2.20	3.40	
28.	Scorodocarpus borneensis.	22	14	32	3.40	6.50	9.50	2.50	
29.	Durio sp.	22	13	25	2.10	2.50	4.20	3.50	
30.	Eusideroxylon zwageri.	22	10	39	1.50	5.50	4.50	3.00	
31.	Drypetes neglecta.	21	10	20	2.80	2.50	3.00	2.70	
32.	Litsea sp.	20	14	28	4.40	5.50	2.50	2.60	
33.	Shorea laevis.	75	40	180	10.50	11.40	10.30	11.50	
34.	Dialium sp.	24	12	36	3.50	7.20	2.40	8.40	
35.	Eugenia sibulanensis.	24	16	20	1.60	2.10	2.30	2.10	
36.	Shorea laevis.	74	32	129	6.90	10.50	8.50	6.10	
37.	Scorodocarpus borneensis.	23	12	27	5.00	3.50	3.70	7.20	
38.	Litsea sp.	30	18	39	3.50	3.40	5.20	5.20	
39.	Shorea sp.	7	—	47	—	—	—	—	dead
40.	Eusideroxylon zwageri.	31	18	47	4.40	3.80	5.60	5.90	
41.	Gironiera nervosa.	30	21	21	1.60	2.10	5.80	3.20	
42.	Polyalthia sumatrana.	31	24	23	3.60	4.20	3.40	3.30	
43.	Litsea sp.	32	16	30	6.30	5.90	5.10	5.40	
44.	Eusideroxylon zwageri.	30	24	65	7.70	5.70	5.50	6.30	
45.	Baccaurea macrophylla.	31	15	22	3.50	4.40	5.00	4.10	
46.	Eusideroxylon zwageri.	16	10	37	5.10	4.40	4.20	3.90	
47.	Scorodocarpus borneensis.	25	12	43	11.00	9.70	7.50	9.80	
48.	Dracontomelon costatum.	30	27	42	3.30	4.20	5.00	5.40	
49.	Aglaia sp.	25	17	21	4.50	1.00	3.50	4.00	
50.	Parinary sp.	27	20	25	7.20	3.20	4.00	4.50	
51.	Shorea ovalis.	45	20	59	11.50	10.70	7.40	8.60	
52.	Cryptocaria crosinervis.	20	17	20	3.50	4.50	4.00	2.50	
53.	Polyalthia sumatrana.	30	25	27	3.70	4.50	7.50	2.50	
54.	Mastixia rostrata.	26	16	29	6.50	2.50	5.20	4.70	
55.	Dialium sp.	35	23	34	4.90	3.50	6.50	8.60	

Note :
H : total height
CH : clear lenght
DBH : diameter breast height.

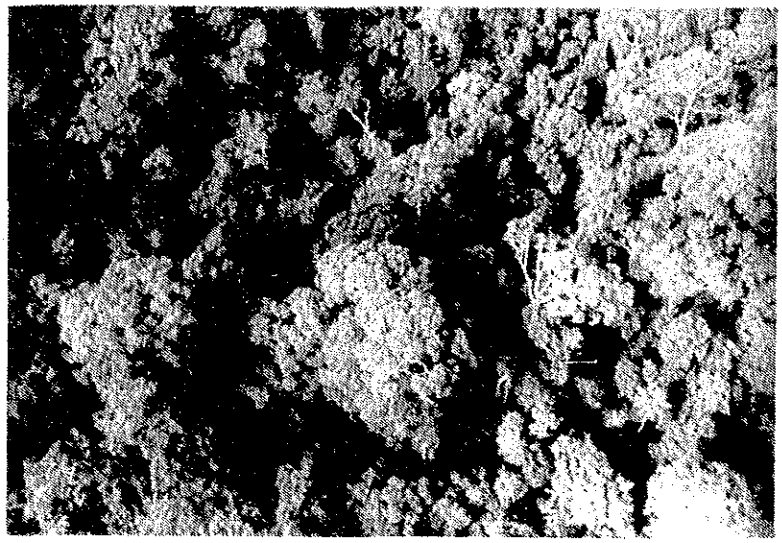
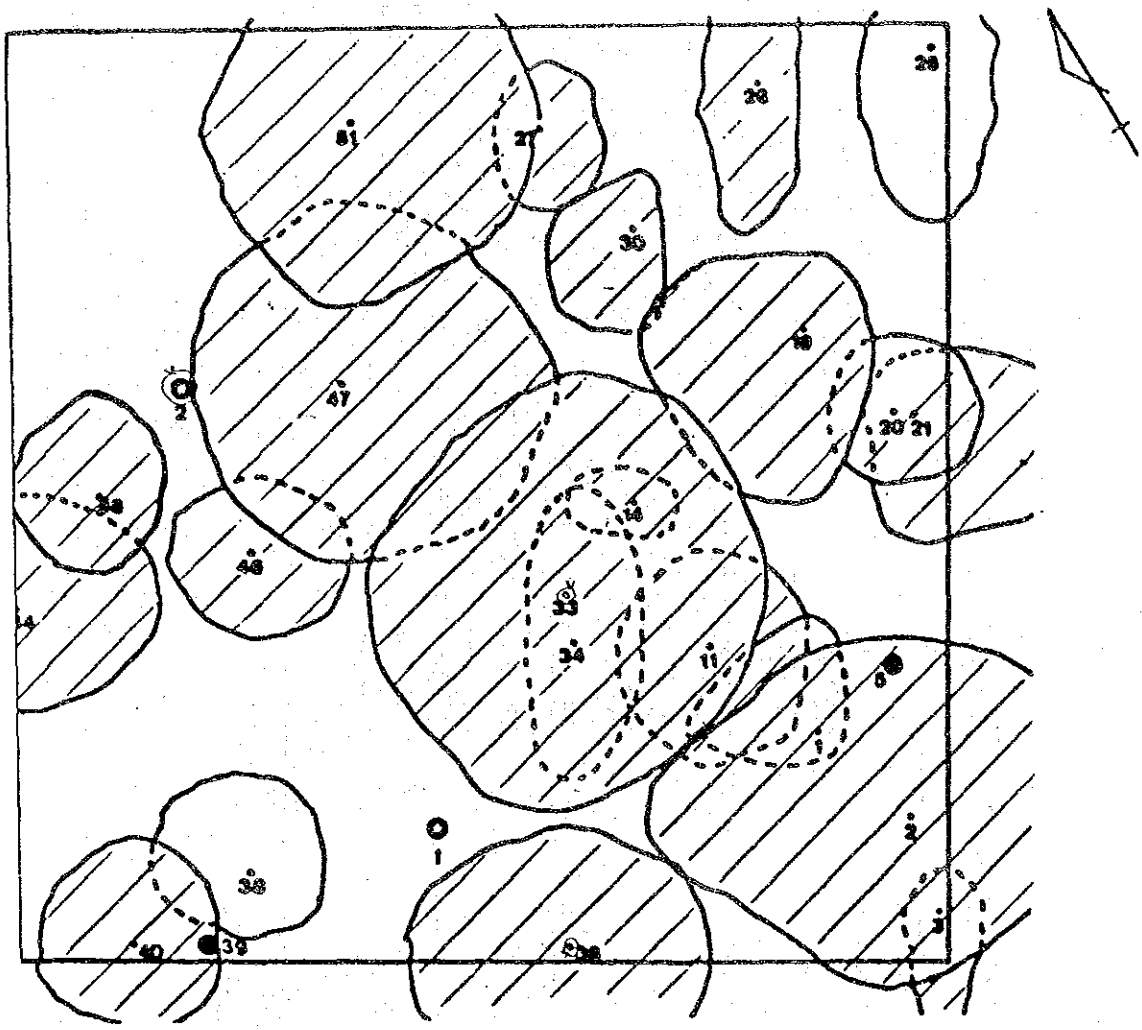


Photo 5
Virgin forest
in Sebulu

Photo 6
Stand selectively cut
immediately before in
Sebulu



● : dead tree

⊙ : stump of Ulin (Eusideroxylon zwageri)

⊘ : commercial tree species

Fig. 20 Crown closer of virgin forest in Sebulu, DBH 35 Cm up.

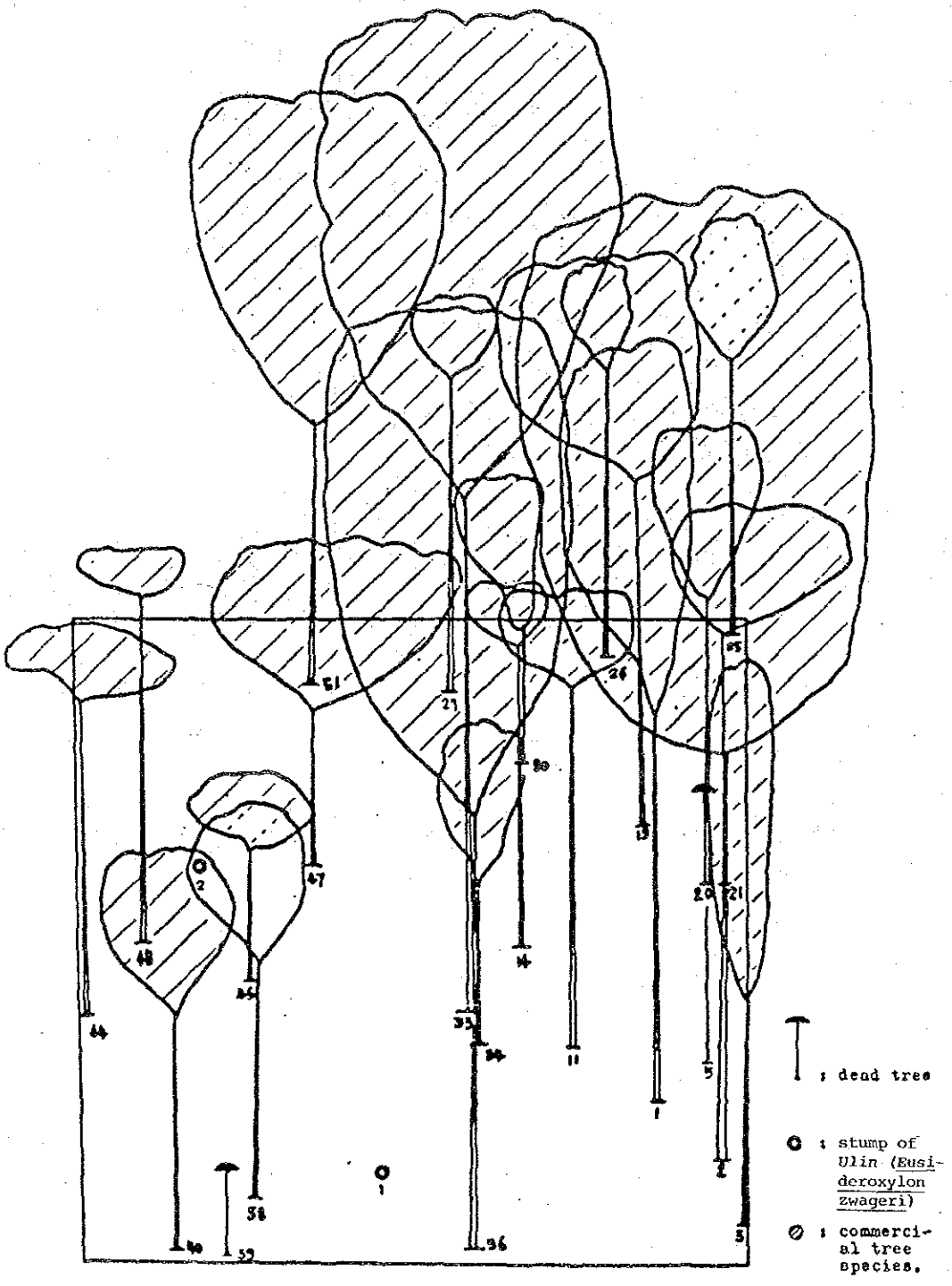


Fig. 21 Profile of virgin forest in Sebulu
DBH 35 Cm up

Table 13 Situations of stands

(per ha)

Location and stand		Item: Diameter class	Number of trees: Commercial species	Number of trees: Non-commercial species	Number of trees: Total	Breast height diameter: All species	Breast height diameter: Commercial species	Tree height: All species	Tree height: Commercial species	Volume (m^3)** : All species	Volume (m^3)** : Commercial species
Sebulu	Virgin forest	20-34 cm	8	112	120	24.9± 4.4	24.5± 0.5	23.6± 7.2	22.0± 0.0	63.3	3.8
		35-49	40	8	48	41.3± 3.4	41.8± 3.6	27.8± 5.0	27.4± 5.1	85.6	73.5
		50 or more	36	4	40	97.5+47.6	102.6 47.6	51.0+17.6	50.0+18.3	849.2	832.6
		Total	84	124	208					998.1	909.9
	Cut immediately before selective cutting	35-49			38	47.1±16.6		36.0± 8.1		68.3	
		50 or more			41	67.2±17.0		39.0± 8.3		244.7	
		Total			79					313.0	
	Cut 10 years selective cutting	20-34	48	44	92	25.8± 3.3	26.3± 3.2	25.4± 2.4	25.8± 2.4	82.2	32.4
		35-49	28	40	68	42.9± 4.3	43.9± 3.7	35.9± 2.2	36.4± 2.0	153.5	66.6
		50 or more	16	20	36	75.2+28.5	60.3± 8.0	47.5± 6.2	44.5± 3.8	358.4	85.4
		Total	92	104	196					594.1	184.4
Bukit Soeharto	Virgin forest	35-49	28	36	64	40.6± 4.4	42.5± 3.9	22.1± 6.7	22.6± 4.3	90.5	51.1
		50 or more	44	28	72	62.6±16.9	66.5±26.2	25.1± 4.0	26.4± 2.8	378.4	276.7
		Total	72	64	136					368.9	327.8

* The breast height diameter was measured at 1.3 m above the ground, but in case of a large diameter tree, it was measured at a position immediately above the buttress root.

** Calculated by breast height sectional area × clear length × 0.65.

Of the 120 trees of 20 to 34 cm in breast height diameter, the number of trees belonging to commercial species was only 8. The mean breast height diameter of them was 25 cm, the mean tree height, 22 m, and the volume, 3.8 m^3. The volume was only 6%.

The number of trees of 35 to 49 cm in breast height diameter was 48, and of them, the number of trees belonging to commercial species was 40, accounting for 83.3%. The mean breast height diameter of them was 42 m, and the tree height, 27 m. The volume was 73.5 m^3, accounting for 85.9%.

The number of trees of 50 cm or more in breast height diameter was 40, and the number of trees belonging to commercial species was 36, accounting for 90%. The mean breast height diameter was 103 cm, and the mean tree height, 50 m. The volume was large, 832.6 m^3, accounting for 98%.

2) Stand selectively cut immediately before

In a stand selectively cut immediately before (Photo 6), a quadrate of 100 m × 100 m was set, to investigate the stand composition. A crown projection of trees of 35 cm or more in breast height diameter is shown in Fig. 22, and its side view is shown in Fig. 23. The sizes of the forest trees are shown in Table 14.

The number of living trees was 79 per ha, and the minimum breast height diameter was 35 cm, the maximum value, 125 cm and the mean value, 54.8 cm. The minimum tree height was 24 m (that of damaged trees was 10 m), the maximum value, 57 m and the mean value, 36.8 m. The number of upper storey trees of 50 m or higher was 6. The minimum clear length was 11 m, the maximum value, 38 m, and the mean value, 22.1 m. The sizes of crowns were large with surveyed trees Nos. 29, 37, 45 and 76, and the diameter ranged from about 15 to 18 m. The crown density was medium.

One dead tree was also observed.

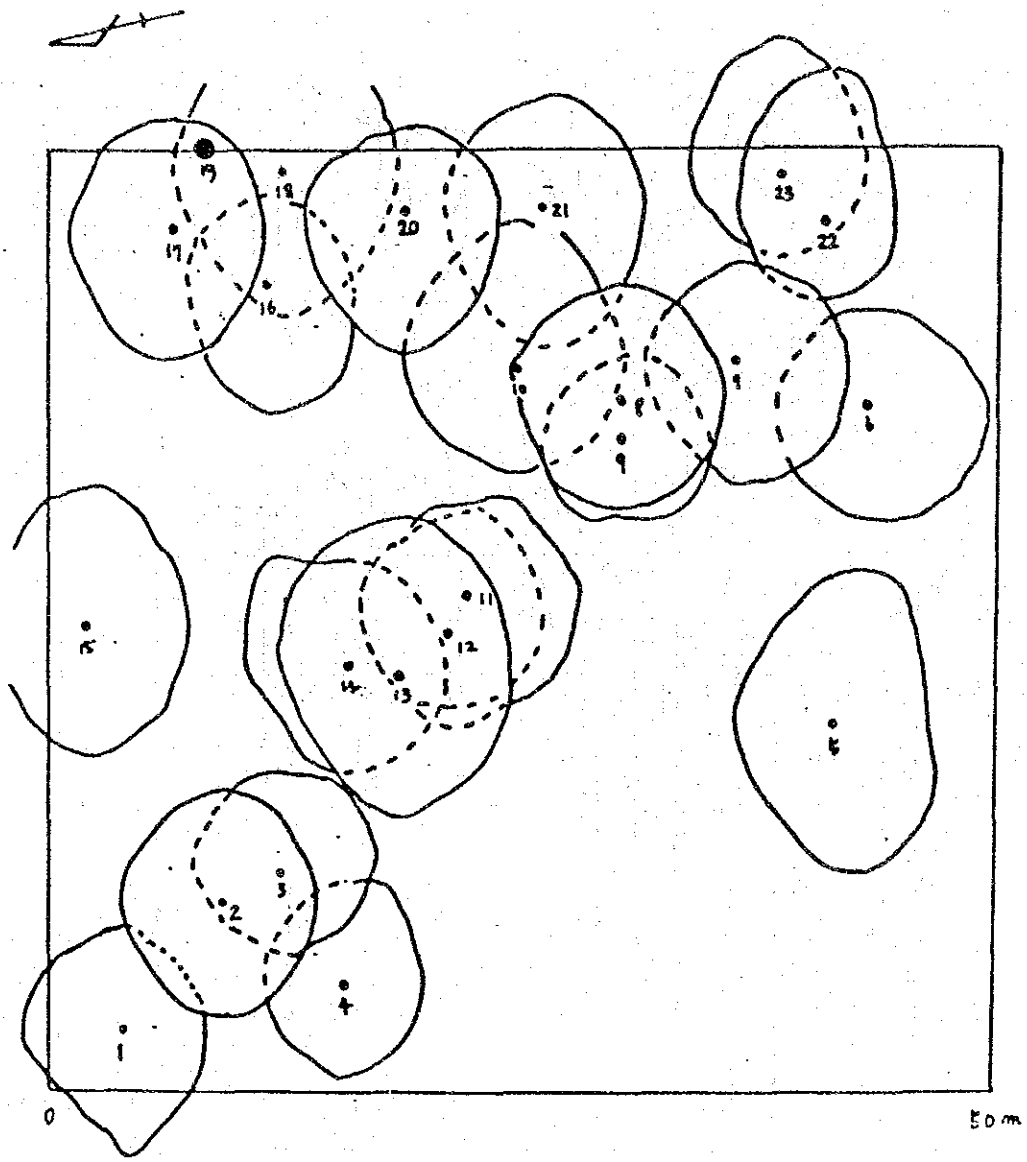


Fig. 22 Crown closer of one year logged over stand in Sebulu, DBH 35 Cm up

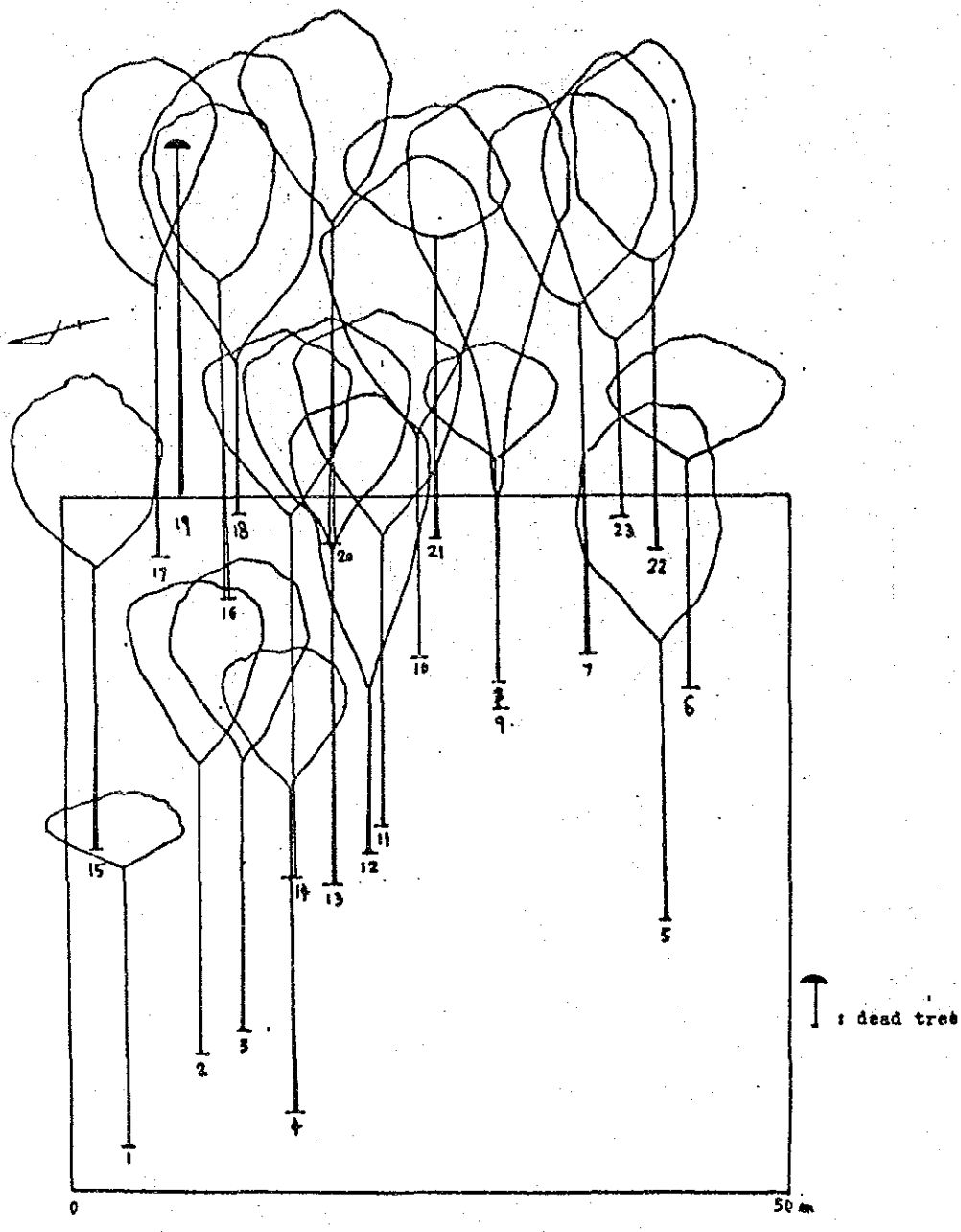


Fig. 23 Profile of one year logged over stand in Sebulu, DBH 35 Cm up

Table 14 Growth in a stand selectively cut immediately before in Sebulu

No	D.B.H.	H	C.L	Note	No	D.B.H.	H	C.L	Note	No	D.B.H.	H	C.L	Note
	(cm)	(m)	(m)			(cm)	(m)	(m)			(cm)	(m)	(m)	
1	38.0	25.0	20.0		28	69.0	44.0	27.0		55	44.0	20.3	—	Broken trunk
2	45.0	34.0	21.0		29	101.0	48.0	23.0		56	48.0	32.0	24.0	
3	44.0	33.5	19.5		30	72.0	53.0	26.0		57	46.0	36.0	26.0	
4	35.0	33.0	23.0		31	45.0	33.0	23.0		58	57.0	36.0	17.0	
5	49.0	37.0	20.0		32	45.0	36.0	27.0		59	37.0	28.5	16.5	
6	39.0	25.0	16.0		33	35.0	37.0	27.0		60	70.0	31.5	23.0	
7	59.0	40.0	25.0		34	37.0	25.0	14.0		61	56.0	49.0	30.0	
8	59.0	42.0	13.0	Forked tree	35	84.0	39.0	19.0	Forked tree	62	43.0	30.0	20.0	
9	39.0	26.0	18.0		36	46.0	39.0	25.0		63	71.0	34.0	16.0	
10	68.0	35.5	15.5		37	95.0	53.0	34.0	※	64	37.0	17.0	—	Stem broken
11	53.0	37.0	21.0		38	55.0	35.0	19.5		65	68.0	36.5	24.0	
12	46.0	33.0	11.0	Forked tree	39	42.5	37.0	23.0		66	52.0	33.0	14.0	Forked trunk
13	70.0	40.5	24.0		40	71.6	45.0	27.0		67	49.0	31.5	19.0	
14	51.0	39.0	26.0		41	43.0	31.5	13.0		68	38.0	39.0	24.0	
15	57.0	34.0	20.0		42	62.0	34.0	21.0		69	48.0	33.0	23.0	
16	36.0	35.0	23.0		43	61.0	10.0	—	Stem broken	70	95.0	44.0	30.0	
17	44.0	35.5	19.0		44	56.0	28.0	23.0		71	39.0	24.0	18.0	
18	75.0	33.0	11.0		45	111.0	57.0	33.0		72	36.0	41.0	32.0	
19	42.0	25.0	—	Dead tree	46	77.0	37.0	23.0		73	50.0	33.0	15.0	
20	56.0	38.0	23.0		47	52.0	33.0	24.0		74	77.0	54.0	30.0	
21	63.0	31.0	21.5		48	38.0	35.0	30.0	Forked tree	75	61.0	45.0	24.0	
22	35.0	36.0	20.5		49	58.0	37.0	26.0		76	45.0	54.0	32.0	
23	37.0	33.0	13.0		50	4 20	30.0	16.0		77	54.0	39.0	25.0	
24	36.0	31.0	14.0		51	51.0	40.0	18.0	Forked tree	78	125.0	52.0	38.0	
25	71.0	39.0	28.0		52	53.0	36.0	24.0		79	35.0	31.0	16.0	
26	51.0	38.0	17.0		53	35.0	31.0	21.0		80	58.0	34.0	19.0	
27	49.0	43.0	23.0		54	45.0	37.0	28.0						

※ Measured at a position immediately above the buttress root

3) Stand selectively cut 10 years before

In a stand selectively cut 10 years before, a quadrate of 50 m × 50 m was set, to investigate the stand composition. A crown projection of trees of 20 cm or more in breast height diameter is shown in Fig. 24, and its side view is shown in Fig. 25. The sizes of trees are shown in Table 15.

The number of living trees were 196 per ha, and the minimun breast height diameter was 21 cm, the maximum value, 143 cm, and the mean value, 40.8 cm. The minimum tree height was 22 m, the maximum value, 56 m, and the mean value, 40 m. The minimum clear length was 17 m, the maximum value, 32 m, and the mean value, 22 m. The sizes of crowns were large with surveyed trees Nos. 24, 39, 46 and 49, (being) ranging from about 12 to 17 m.

The growing stages of trees of 35 cm or more in breast height diameter are shown in the crown projection of Fig. 26 and the side view of Fig. 27. The number of living trees per ha was 104, and the crown density was medium. The number of trees of 20 cm or more in breast height diameter accounted for 53%.

The trees in the surveyed stand were classified into commercial species and non-commercial species, and the details of their respective diameter classes are shown in Table 15.

The number of trees of 20 to 34 cm in breast height diameter were 92, and of them, the number of trees belonging to commercial species were 48, accounting for 52%. The trees belonging to commercial species were 26 cm in breast height diameter and 26 m in tree height. The volume was 32.4 m^3, accounting for 39% of all the species.

The number of trees of 35 to 49 cm in breast height diameter were 68, and of them, the number of trees belonging to commercial species were 28, accounting for a small share of 41%. They were 44 cm in breast height diameter and 36 m in tree height. The volume was 66.6 m^3, accounting for 43% of all the species. The number of trees of 50 cm or more in breast height diameter were 36, and

of them, the number of trees belonging to commercial species were 16, accounting for 44%. They were 60 cm in breast height diameter and 45 m in tree height. The volume was 85.4 m^3, accounting for a small share of 24% of all the species.

In the commercial species, there was no tree of 1 m or more in breast height diameter, and the maximum diameter was 73 cm, the mean value being 60 cm. The number of trees of 50 cm or more in breast height diameter accounted for 18%, and that of those belonging to commercial species accounted for a small share of 8%.

ii. Bukit Soeharto

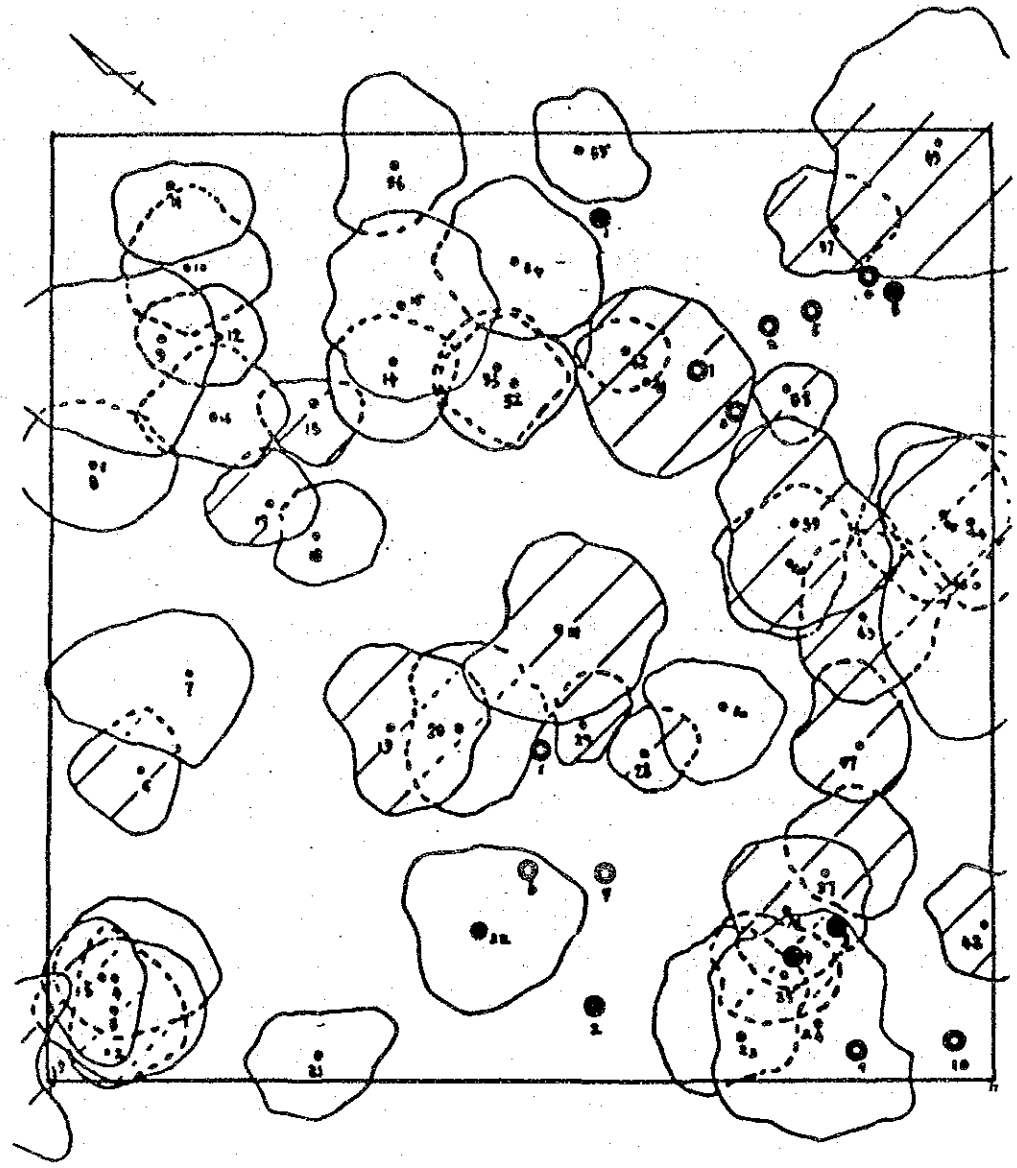
1) Virgin forest

In a virgin forest (Photos 7 and 8), a quadrate of 50 m × 50 m was set, to investigate the stand composition. A crown projection of trees of 35 cm or more in breast height diameter is shown in Fig. 28, and a side view of the stand is shown in Fig. 29. The sizes of the forest trees are shown in Table 16.

The number of living trees per ha. were 136, and the breast height diameter ranged from 35 cm to 129 cm, being 59.5 cm on the average. The minimum tree height was 12 m, the maximum value, 35 m, and the mean value, 23.8 m. The minimum clear length was 8 m, the maximum value 27 m, and the mean value, 16.1 m. The sizes of crowns were 14 to 17 with surveyed trees Nos. 2, 3, 13 and 32. The crown density was medium.

The trees in the surveyed stand were classified into commercial species and non-commercial species, and the numbers of trees, mean breast height diameters, mean tree heights and volumes for the respective diameter classes are shown in Table 13.

The number of trees of 35 to 49 cm in breast height diameter were 64, and of them, 28 trees accounting for 48% belonged to commercial species. The mean breast height diameter of the trees of commercial species were 43, and the mean tree height was 23 m. The volume was 51.1 m^3, accounting for 56.5% of all the species.

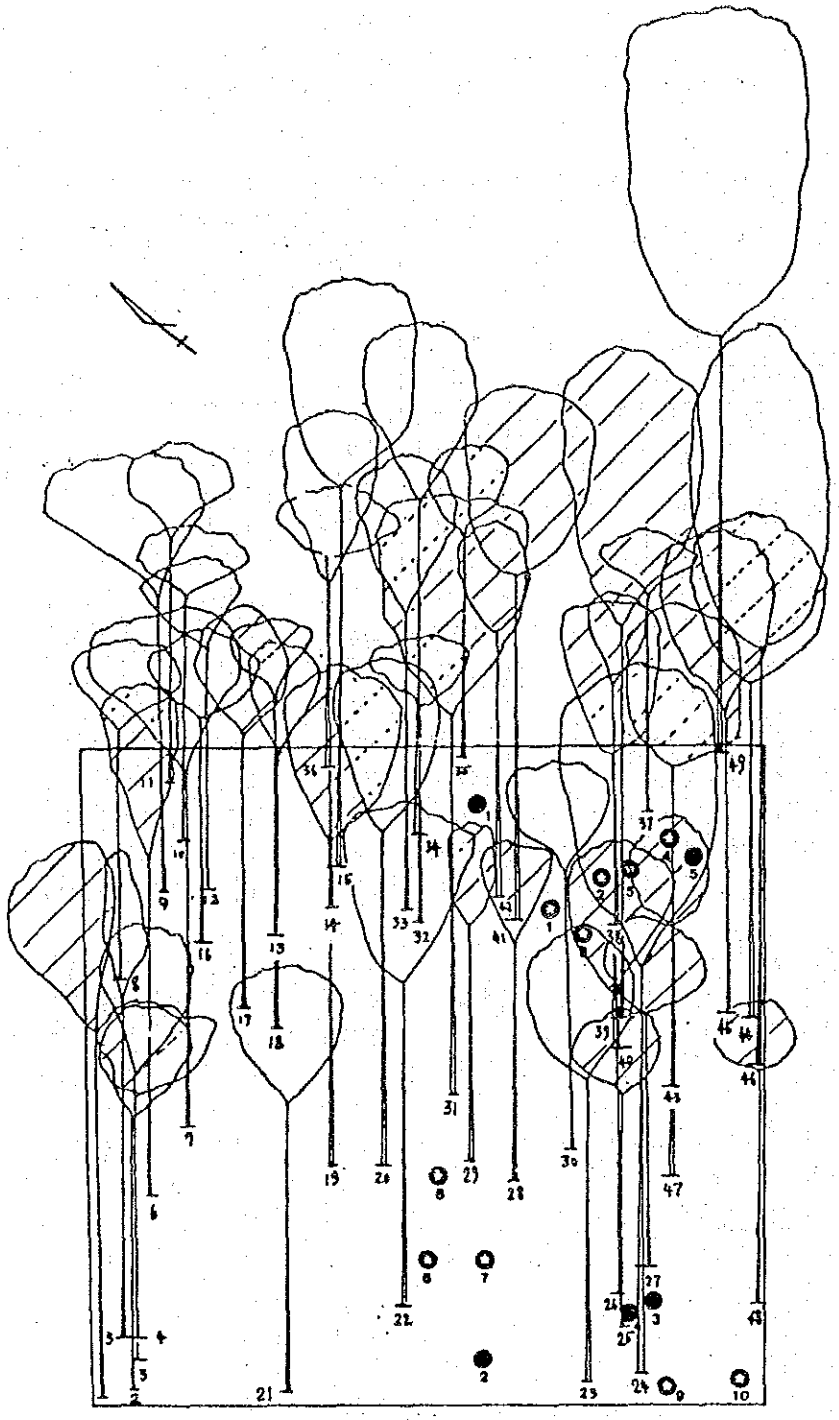


● : logging damaged tree

◎ : stump of cutting tree

○ : commercial tree species

Fig. 24 Crown closer of ten years logged over stand in Sebulu, DBH 20 Cm up



● : logging damaged tree

⊙ : stump of cutting tree

⊛ : commercial tree species

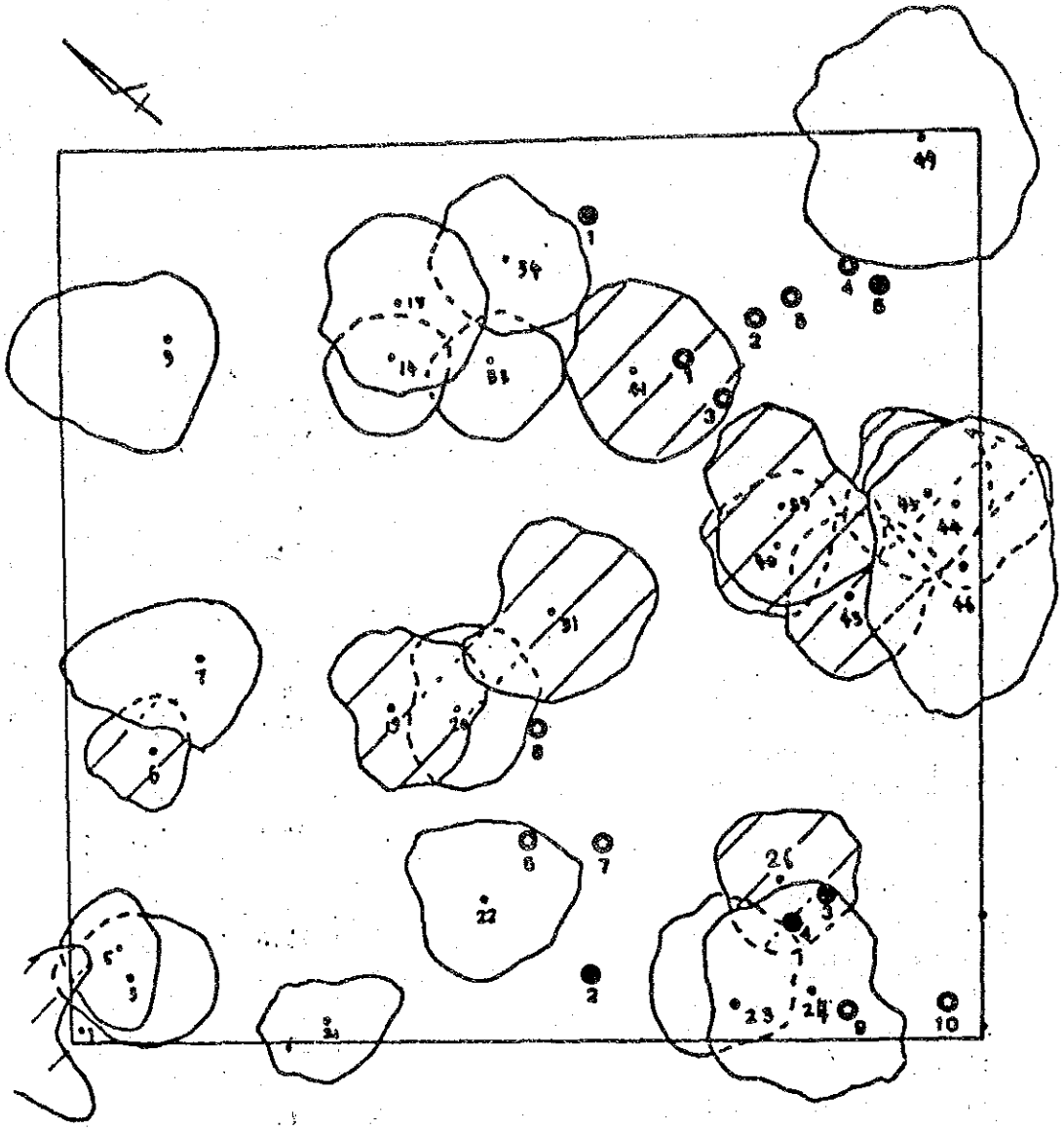
Fig. 25 Profile of ten years logged over stand in Sebulu, DBH 20 Cm up

Table 16 Tree species and it's size in ten years logged over stand in Sebulu (plot 50 m × 50 m)

No.	Species name	DBH (cm)	Total height (m)	Clear height (m)	Crown diameter (m)	Note
1	Shorea leprosula	55	42,0	27,5	10,2	o
2	Shorea laevis	31	29,0	20,5	8,3	o
3	Gironniera nervosa	37	33,5	21,5	8,8	
4	Daur sp	26	25,5	18,5	7,9	
5	Baccaurea sp	44	36,5	24,0	9,3	
6	Shorea laevis	48	38,5	25,0	9,6	o
7	baccaurea sp	50	39,5	26,0	9,8	
8	Baccaurea sp	26	25,5	18,5	7,9	
9	Quercus gemnel	38	33,0	22,0	8,8	
10	Smecarpus sp	25	24,0	18,5	7,8	
11	Eickocos sp	26	25,5	18,5	7,9	
12	Macaranga tricoka	25	25,0	18,0	7,8	
13	Shorea smithiana	24	24,0	17,5	7,7	o
14	(?)	46	37,5	24,5	9,5	
15	Endospermum sp	60	44,5	28,5	10,6	
16	Aporosa sp	23	23,5	17,0	7,6	
17	Palaquium sp	32	30,0	20,6	8,4	o
18	Rubiaceae	31	29,0	20,5	8,3	
19	Shorea laevis	46	37,5	24,5	9,5	o
20	Artocarpus elastica	48	38,5	25,0	9,6	
21	Eugenia sp	35	32,0	21,5	8,6	
22	Schima sp	46	37,5	24,5	9,5	
23	Ellipnathus beecarii	40	34,5	22,5	9,0	
24	Schima sp	83	53,5	30,5	12,4	
25	Shorea smithiana	24	24,0	17,5	7,7	o
26	Shorea laevis	39	34,0	22,5	8,9	o
27	Shorea laevis	27	26,5	19,0	8,0	o
28	Shorea smithiana	25	25,0	18,0	7,8	o
29	Diospyros sp	25	25,0	18,0	7,8	o
30	baccaurea sp	31	29,0	20,5	8,3	
31	Shorea laevis	61	45,0	28,5	10,7	o

No.	Species name	DbH (cm)	Total height (m)	Clear height (m)	Crown diameter (m)	Note
32	Litsea sp	21	21,5	16,5	7,8	
33	Sterculia sp	40	34,5	22,5	9,0	
34	Eugenia sp	48	38,5	25,0	9,6	
35	Nauclea sp	23	23,5	17,0	7,6	
36	Canarium sp	20	21,0	16,0	7,4	
37	Shorea smithiana	21	21,5	16,5	7,5	O
38	Shorea smithiana	25	25,0	18,0	7,8	O
39	Dipterocarpus cornatus	73	50,5	29,5	11,6	O
40	Shorea smithiana	38	33,0	22,0	8,8	O
41	Shorea laevis	52	40,5	26,5	10,0	O
42	Shorea smithiana	30	28,5	20,0	8,2	O
43	Shorea smithiana	44	36,5	24,0	9,3	O
44	Shorea smithiana	48	38,5	25,0	9,6	O
45	Shorea laevis	44	36,5	24,0	9,3	O
46	D u r i o sp	143	56,0	31,5	17,2	
47	Shorea laevis	28	27,0	19,0	8,0	O
48	Shorea laevis	24	24,0	17,5	7,7	O
49	Gironniera nervosa	100	56,0	31,5	13,8	

O: Commercial tree species

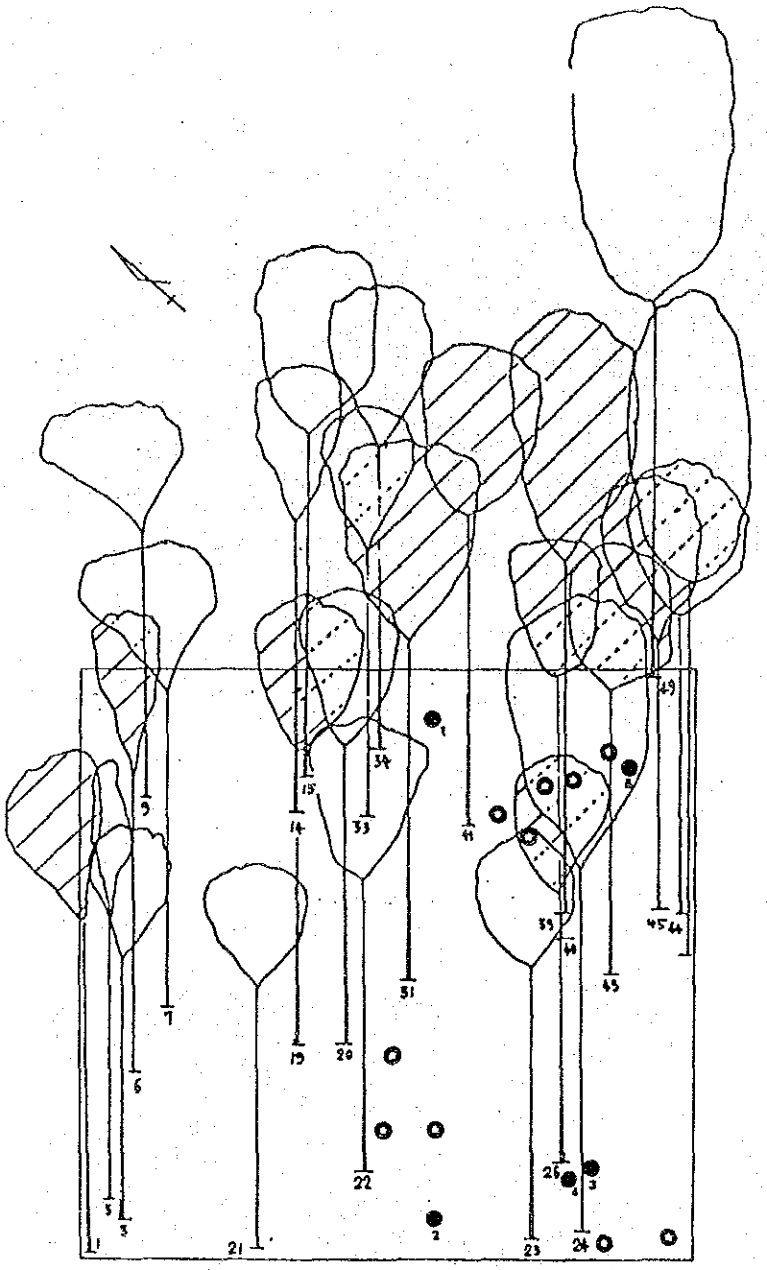


● : logging damaged tree

⊙ : stump of cutting tree

⊘ : commercial tree species

Fig. 26 Crown closer of ten years logged over stand in Sebulu, DBH 35 Cm up

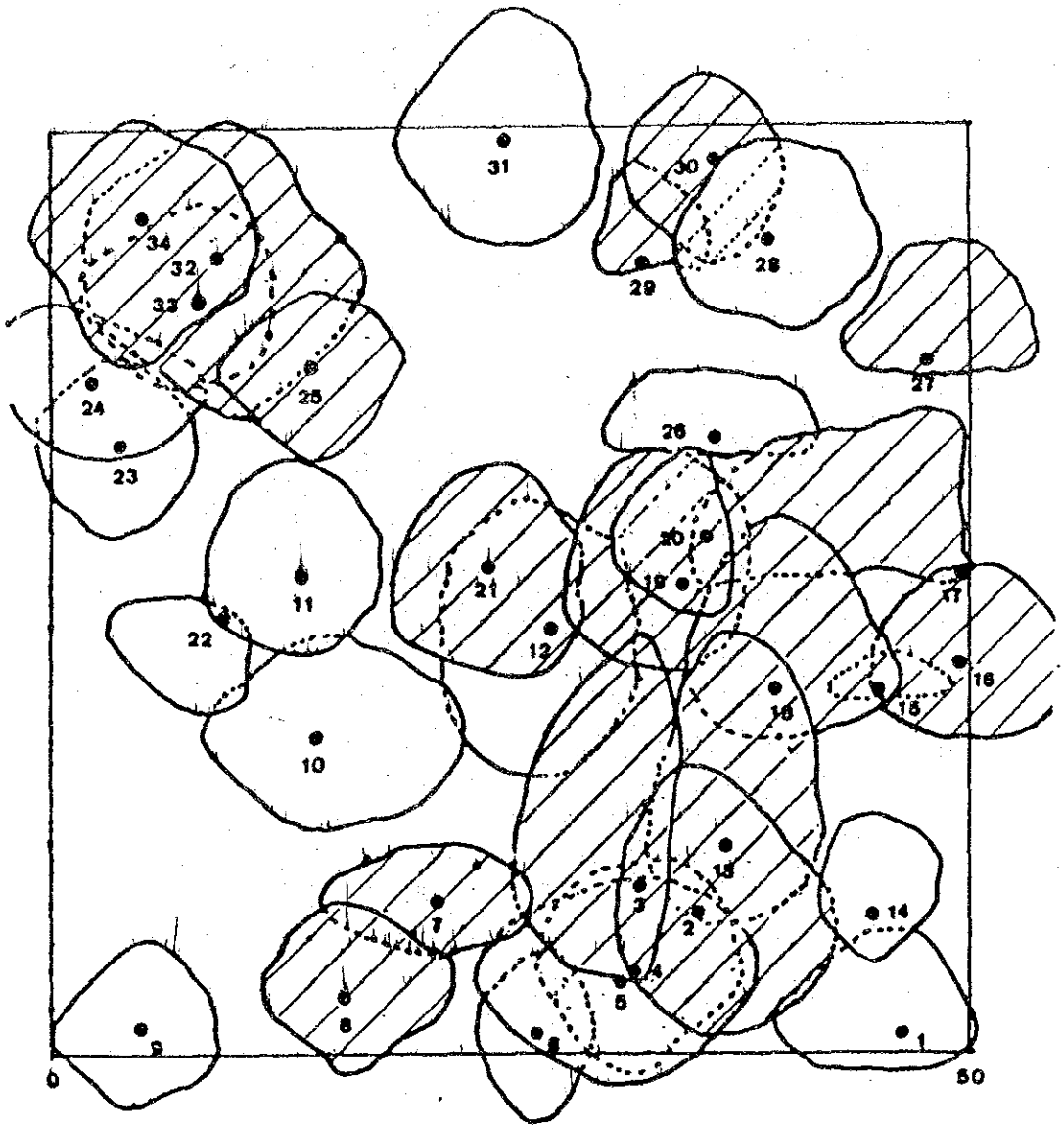


● : logging damaged tree

Fig. 27 Profile of ten years logged over stand in Sebulu, DBH 35 Cm up

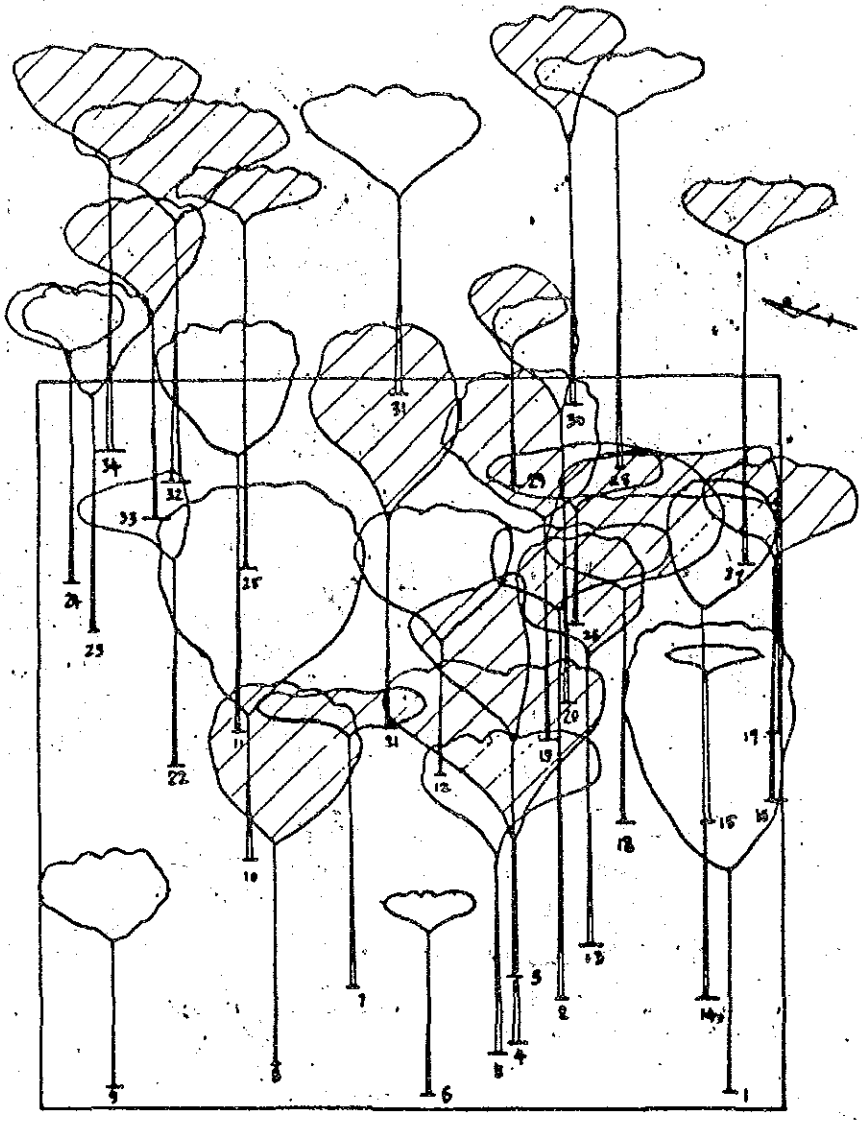
Photo 7 Virgin forest in Bukit Soeharto

Photo 8 Crowns of the above stand



: commercial tree species

Fig. 28 Crown closer of virgin forest stand in Bukit Soeharto University Forest of Mulawarman DBH 35 Cm up



⊘ : commercial tree species

Fig. 29 Profile of virgin forest stand in Bukit Soeharto University Forest of Mulawarman

Table 16 Sizes of forest trees in a virgin forest in Bukit Soeharto

No.	Species.	H (m)	CH (m)	DBH (cm)	Sise of crown 1	2	3	4	Note
1.	Eugenia spl	32	15	35	2. 10	6. 80	5. 80	4.0 0	
2.	Shorea laevifolia.	32	27	80	5. 90	4. 40	7. 80	7. 20	O
3.	Shorea laevifolia.	27	16	50	4. 30	6. 70	12. 80	—	CD O
4.	Shorea leprosula.	26	14	62	5. 40	8. 30	5. 30	6. 40	O
5.	Canarium sp.	22	13	35	4. 70	4. 70	7. 40	6. 40	
6.	Eugenia sp.	14	11	85	4. 50	3. 50	4. 50	2. 50	CD
7.	Shorea smithiana.	20	17	38	2. 30	6. 40	3. 30	5. 20	O
8.	Shorea laevis.	26	15	39	3. 40	4. 40	5. 30	5. 40	O
9.	Litsea sp.	16	10	48	3. 90	4. 80	4. 70	3. 70	
10.	Quercus sp.	26	10	95	4. 50	5. 30	5. 30	7. 50	
11.	Diromira sp.	28	19	45	3. 90	5. 20	6. 50	3. 60	
12.	Kranji.	18	9	39	7. 80	5. 60	6. 90	4. 60	
13.	Shorea sp.	28	20	95	3. 70	4. 80	12. 00	4. 40	O
14.	Quercus sp.	35	27	37	2. 40	2. 60	5. 10	5. 30	
15.	Litsea sp.	12	10	39	—	3. 20	1. 80	4. 00	
16.	Shorea sp.	23	17	65	4. 80	5. 60	5. 40	6. 20	O
17.	Shorea sp.	20	16	85	—	15. 20	8. 30	—	CD O
18.	Hopea sp.	25	16	49	2. 80	4. 70	9. 20	6. 30	O
19.	Shorea sp.	25	15	70	4. 40	6. 70	7. 60	2. 80	O
20.	Phoebe sp.	28	20	55	5. 70	4. 90	3. 40	—	
21.	Shorea sp.		14	59	5. 60	5. 30	5. 80	4. 60	O
22.	Drypetes sp.	20	14	36	4. 20	6. 90	—	—	
23.	Isigium sp.	24	16	50	4. 70	4. 50	4. 50	3. 80	
24.		20	16	54	3. 60	4. 50	5. 60	3. 40	
25.	Palaquium sp.	28	24	43	5. 30	4. 60	3. 70	5. 40	O
26.	Eugenia sp.	12	8	41	1. 00	6. 40	3. 40	5. 40	
27.	Shorea sp.	26	22	67	—	4. 40	6. 70	5. 40	HL O
28.	Litsea sp.	28	24	61	3. 50	5. 30	6. 80	5. 20	
29.	Palaquium sp.	15	9	46	—	2. 70	5. 60	3. 40	O
30.	Shorea sp.	27	18	66	5. 40	4. 70	4. 40	4. 30	O
31.	Isigium sp.	21	13	84	3. 40	6. 20	7. 80	4. 30	
32.	Shorea sp.	26	18	129	8. 30	7. 30	7. 20	8. 30	O
33.	Shorea sp.	22	14	40	4. 20	5. 40	5. 20	3. 90	O
34.	Dipterocarpus sp.	28	20	100	7. 20	5. 30	5. 40	5. 70	O

NOTE : H : height (m)
CH : clear height (m)
DBH : diameter breast height (cm)
CD : crown damage
HL : hole
O : Commercial tree speeies

The number of trees of 50 cm or more in breast height diameter were 72, accounting for 52.9% of the whole, and of them, 44 trees belonged to commercial species, accounting for 61.1% of all the species and 32.4% of the whole. The mean breast height diameter was 67 cm, and the mean tree height was 26 m. The volume was 276.7 m^3, accounting for 73% of all the species. Of them, the number of trees of 1 m or more in breast height diameter were 2, and their respective values were 1 m and 1.29 m. Their volumes were 10.2 m^3 and 15.3 m^3 respectively.

iii. Discussion

The stands surveyed in Sebulu and Bukit Soeharto will be discussed below.

Two virgin forests in Sebulu and Bukit Soeharto were investigated. As for the numbers of living trees in both the districts, there were 48 trees of 35 to 49 cm in breast height diameter in Sebulu, and 64 trees of the same class in Bukit Soeharto, and thus the number of Bukit Soeharto was larger. For 50 cm or more in breast height diameter, there were 40 trees in Sebulu and 72 trees in Bukit Soeharto, and thus the number of Bukit Soeharto was also larger. To be more specific, the number of trees of 35 to 49 cm in the virgin forest in Sebulu accounted for 75% of that in Bukit Soeharto, and that of 50 cm or more, 56%. On the contrary, the trees in Sebulu were larger in breast height diameter and tree height in all the diameter classes. As for the volume, there was not so much difference for 35 to 49 cm, in breast height diameter between both the surveyed districts, but for 50 cm or more in breast height diameter, the volume of Sebulu was 2.2 times that of Bukit Soeharto. That is, the stand containing large diameter trees of 50 cm or more in breast height diameter which were larger in diameter and tree height had a larger volume. As for commercial species, in Sebulu, there were 8 trees of 35 to 49 cm in breast height diameter and 4 trees of 50 cm or more, totalling 12 trees only, but in Bukit Soeharto, there were 36 trees of 35 to 49 cm in breast height diameter and 28 trees of 50 cm or more, totalling 64

trees. The volume was 73.5 m^3 for 35 to 49 cm in breast height diameter and 832.6 m^3 for 50 cm or more, totalling 906.1 m^3 in Sebulu, while it was 51.1 m^3 for 35 to 49 cm in breast height diameter and 276.7 m^3 for 50 cm or more, totalling 327.8 m^3 in Bukit Soeharto, accounting for about 36% of Sebulu's volume.

According to the survey by Noto, et al[5], the number of living trees per ha. in a K.T.I. virgin forest were 6 for 60 cm or more in breast height diameter, and the volume was 66.9 m^3. On the contrary, the number of forest trees of 60 cm or more in breast height diameter in the surveyed stand in Sebulu were 28. Such a difference in stand composition between surveyed locations may be caused by differences in site conditions, etc. Furthermore as for the forest type, even though recognized as a virgin forest, the stand surveyed this time was close to a residential area, being located in a place convenient for traffic, and it is recognized that cutting had been performed from long ago, and that stumps had decayed perfectly in some places.

In the stand selectively cut immediately before in Sebulu, there were 38 trees of 35 to 49 cm in breast height diameter and 41 trees of 50 cm or more. Compared with 40 trees and 36 trees in the virgin forest in Sebulu respectively, the total number in the stand selectively cut immediately before was smaller by 9, but the number of trees of 50 cm or more was rather larger. The trees of 50 cm or more in the virgin forest were larger both in breast height diameter and tree height, and the volume was also about three times. Considering that the volume of the cut trees in the virgin forest is about 10 m^3/tree, and considering that 4 or 5 trees of 70 to 80 cm or more in breast height diameter and of commercial species such as Meranti, Kapur and Keruing only, viz. 40 to 50 m^3 in volume are cut according to the present selection cutting system, then the difference in volume observed above is surmised to be caused by the difference of the stands in the age when they had not been cut yet.

In the stand selectively cut 10 years before, the number of living trees of 35 to 49 cm in breast height diameter per ha was large, 68,

but the number of trees of 50 cm or more were 36, being a little smaller than those of other stands. This stand contained 10 stumps and 5 dead trees as shown in Fig. 27. These are surmised to be the stumps and damaged trees caused by the cutting of 10 years before. Since the cutting cycle of selection cutting is 35 years, and selection cutting will be made 25 years later. The number of trees of 50 cm or more in breast height diameter and of commercial species were 16. If the growth in diameter which is said also to be 5 mm per year is assumed to be 1 cm, then the number of trees of 50 cm or more in breast height diameter and of commercial species per ha will be 76. If 10% of them is damaged by natural death, diseases and pests, then the number will be 68. The number of 76 trees includes 32 of 50 cm class, 16 of 60 cm class, 16 of 70 cm class, 8 of 80 cm class and 4 of 90 cm class. According to the T.P.I. system, at least 25 trees of commercial species and of 35 cm or more must be left per ha. The 76 trees of 50 cm or more in breast height diameter and of commercial species existing 25 years later will contain 43 trees which can be cut. However, in this case, the trees will include none of 1 m or more and only 12 of large diameter trees of 80 to 90 cm. They are smaller than the trees now being cut, and in case of 60 cm or more, out of 44 trees, it is surmised that about 20 trees will be able to be cut, considering the arrangement of the forest trees and the quality of stems. Even this situation is based on the assumption that the breast height diameter will grow 1 cm per year. In future, it is necessary to make continuous measurement at more locations.

As shown in Table 17, tree heights are very different from stand to stand, and the trees contain many trees of Shorea and other commercial species. However, except the virgin forest in Sebulu, there are few giant trees of commercial species exceeding 50 m, and it cannot be said that the present cut-over areas allow production in the rotation as intended.

Table 17 Tree heights in the respective surveyed stands

		Tree height (m)	>60	∿60	∿50	∿40	∿30	∿20	∿10	<10	Total
Sebulu	Virgin forest	Non-commercial species	0	1	0	6	17	6	1	4	
		Shorea	3	0	1	0	0	1	0	0	
		Other commercial species	0	1	1	4	7	1	0	0	
		Total	3	2	2	10	24	8	1	4	54
		%	5.6	3.7	3.7	18.5	44.4	14.8	1.9	7.4	100
	Stand selectively	Total		6	9	51	10	1	1		78
		%		7.7	11.5	65.4	12.8	1.3	1.3		100
	Stand selectively cut 10 years before	Non-commercial species		3	1	11	11				
		Shorea		0	3	7	10				
		Other commercial species		1	0	0	2				
		Total		4	4	18	23				49
		%		8.2	8.2	36.7	46.9				100
Bukit Soeharto	Virgin forest	Non-commercial species				2	7	6			
		Shorea				1	11	2			
		Other commercial species				0	3	1			
		Total				3	21	9			33
		%				9.1	63.6	27.3			100