2-2-3 Characteristics of Forest Type

The forests in the study area are all subtropical broadleaved forests. There are no artificial forest or coniferous trees.

Between 1965 and 1979, when the forests had been in the possession of FINAP, its excellent large diameter trees were selectively felled. Even after FINAP's bankruptcy, unlawful felling continued so that what remains now is a tract of forest land barren of excellent large diameter trees.

While the dominant tree in northwestern forests in Paraguay is Peroba of the Apocynaceae family, Peroba is not seen in Capiibary. It seem that the dominant tree in Capiibary was Lapacho of the Bignonlaceae family before selectively felled.

Infant successor trees, bushes and liana make up the undergrowth vegetation which are seen distributed over the entire area, while bamboos, palms, Karawata, etc. are also seen locally. The thickness of the undergrowth makes it impossible to see anywhere inside the forests.

The forest type is clearly divided into high, medium forest and low forest. The area of low forest runs along the river and is of poor drainage. Soils are gleizated to a great extent. In the area of high, medium forest, trees are extracted because of a less change in topography. Such a trend is observed the entire area.

As mentioned above, high, medium forest and low forest are clearly identified. The average tree height in the upper layer is divided at the height of about 15 m. The division of high forest and medium forest are not clear due to the human influence.

a. Characteristics of forest type from the viewpoint of the number of standing trees

In the 32 sample plots (12.8 ha) surveyed, a total number of trees of a diameter breast height of 10 cm or more was 3,333. A total number of trees of a diameter breast height of 41 cm or more was 387.

A total of 3,333 trees are divided into 74 species counting the non-identified trees as one species. The number of emerging species for each class was as follows: 9 for class A; 9 for class B; 15 for class C; 22 for class D; and 19 for class E.

Among them trees of a diameter breast height of 41 cm or more, there were 49 emerging species, which are classified as follows: 8 for class A; 8 for class B; 13 for class C; 11 for class D; and 9 for class E.

The species classes are those five (5) classes divided according to utility value in Paraguay. They are as shown in Table III-2-6.

Table III-2-6 Species class classified by utility value

Species class	Description
A	Species useful both at home and abroad
B	Species slightly inferior to class A both in quantity and price
C	Species whose demand in domestic and foreign markets is expected to increase in future
D	Species whose demand is expected to increase in the domestic market
E	Species whose market prices are difficult to set

As described before in this report, the forest types were classified into high forest, medium forest, and low forest. According to these forest type, the number of trees per ha and volume were classified by species classes and by diameter breast height 10 cm or more (total measured trees) and 41 cm or more. These results are shown in Table III-2-7.

Table III-2-8 shows the number of standing trees per hectare of top 10 emerging species classified by forest type and species.

As seen from Table III-2-8, the number of trees of a diameter breast height of 10 cm or more per hectare is as follows: 245.8 for high forest; 266.5 for medium forest; and 323.8 for low forest. The number of trees increases for a forest of lower trees. To the contrary, however, the number of trees of a diameter breast height of 41 cm or more increases for a forest of higher trees as follows: 35.0 for high forest; 28.7 for medium forest; and 6.3 for low forest. In the low forest, the standing tree density is high, and the number of large trees is small. The high forest is to the contrary. In high forest and medium forest trees of a diameter breast height of 41 cm or more of Classes A and B account for about 40%. In low forest, trees of Classes A and B do not emerge. In high forest, the number of trees of Classes A and B is 14.0 and in medium forest is 11.5.

Table III-2-7 (1) Distribution of the number of trees and volume without bark (m^3) per hectare by species class by forest type

High Forest Type (A)

Diameter	Total surveyed trees		More than medium-sized trees	
Species class	Number of trees	%	Number of trees	%
A	38.2	15.5	10.0	28.6
B	14.5	5.9	4.0	11.4
C	37.2	15.1	9.5	27.1
D	92.6	37.7	5.7	16.2
E	57.0	23.2	4.5	12.9
Defective trees	6.3	2.6	1.3	3.8
Total	245.8	100.00	35.0	100.0

Diameter	Total surveyed trees		More than medium-sized trees	
Species class	Volume	%	Volume	%
A	19.88	25.9	12.65	29.7
B	10.17	13.2	7.46	17.5
C	16.74	21.8	11.18	26.2
D	17.40	22.6	5.83	13.7
E	10.84	14.1	4.57	10.7
Defective trees	1.8	2.4	0.94	2.2
Total	76.84	100.0	42.63	100.0

Table III-2-7 (2)

Medium Forest Type (M)

Diameter	Total surveyed trees		More than medium-sized trees	
Species class	Number of trees	%	Number of trees	%
A	29.8	11.2	7.5	26.1
B	13.0	4.9	4.0	13.9
C	43.8	16.4	9.2	32.1
D	128.7	48.3	4.4	15.3
E	44.0	16.5	2.8	9.8
Defective trees	7.2	2.7	0.8	2.8
Total	266.5	100.0	28.7	100.0

Diameter	Total surveyed trees		More than medium-sized trees	
Species class	Volume	%	Volume	%
A	14.17	20.5	8.55	26.3
B	6.67	9.7	4.94	15.2
C	18.04	26.1	10.87	33.4
D	21.23	30.7	4.81	14.8
E	7.31	10.6	2.57	7.9
Defective trees	1.67	2.4	0.80	2.4
Total	69.09	100.0	32.54	100.0

Table III-2-7 (3)

Low Forest Type (B)

Diameter	Total surveyed trees		More than medium-sized trees		Diameter	Total surveyed trees		More than medium-sized trees	
Species class	Number of trees	%	Number of trees	%	Species class	Volume	%	Volume	%
A	17.5	5.4	0	0	A	2.71	7.1	0	0
B	3.7	1.1	0	0	B	0.49	1.3	0	0
C	28.8	8.9	1.3	20.6	C	6.75	17.7	0.60	15.7
D	182.5	56.4	5.0	79.4	D	21.74	57.2	3.22	84.3
E	86.3	26.7	0	0	E	5.82	15.3	0	0
Defective trees	5.0	1.5	0	0	Defective trees	0.54	1.4	0	0
Total	323.8	100.0	6.3	100.0	Total	38.05	100.0	3.82	100.0

Table III-2-8 (1) Number of tress per hectare of top 10 species classified by forest type

High forest

Total surveyed trees					More than medium trees				
Order	Local name	Class	Number of trees	%	Order	Local name	Class	Number of trees	%
1	Aguaí	D	34.5	14.0	1	Cedro	A	5.2	14.8
2	Mborevi ka à	E	21.3	8.7	2	Kurupáy	A	2.8	8.0
3	Guatambú	B	20.3	8.3	3	Urunde y pará	C	2.8	8.0
4	Yvá poroitý	D	16.8	6.8	4	Yvyrá piú	D	2.2	6.3
5	Laurel hú	C	14.2	5.8	5	Laurel hú	C	2.0	5.7
6	Cancharana	B	9.2	3.7	6	Guapo ý	E	1.7	4.9
7	Ysapy ý morotí	D	7.8	3.2	7	Cancharana	B	1.5	4.3
8	Guavi rá	E	7.5	3.1	8	Gua ja y ví	C	1.3	3.7
9	Yvyrá pepé	C	6.8	2.8	9	Yvyrá pepé	D	1.3	3.7
10	Kurupay	A	6.5	2.7	10	Yvyrá pytá	D	1.2	3.4
Total			245.8	59.1	Total			35.0	62.8

Table III-2-8 (2)

Medium forest

Total surveyed trees					More than medium trees				
Order	Local name	Class	Number of trees	%	Order	Local name	Class	Number of trees	%
1	Yvá poroitý	D	55.5	20.8	1	Guatambú	A	5.0	17.4
2	Aguaí	D	32.0	12.0	2	Gua ja y ví	C	2.2	7.7
3	Guatambú	A	18.8	7.1	3	Urunde y pará	C	2.2	7.7
4	Laurel hú	C	11.8	4.4	4	Yvyrá piú	D	2.2	7.7
5	Yvyrá pepé	C	11.3	4.2	5	Yvyrá pepé	D	2.0	7.0
6	Katigua	E	9.5	3.6	6	Cancharana	B	1.8	6.3
7	Yvyrá piú	D	9.0	3.4	7	Robo itá	E	1.5	5.2
8	Cancharana	B	8.3	3.1	8	Kurupay	A	1.2	4.2
9	Guavi rá	E	6.8	2.6	9	Laurel hú	C	1.2	4.2
10	Ñuati arroyo	E	6.2	2.3	10	Loro blanco	D	0.8	2.8
Total			266.5	63.5	Total			28.7	70.2

Table III-2-8 (3)

Low forest

Total surveyed trees					More than medium trees				
Order	Local name	Class	Number of trees	%	Order	Local name	Class	Number of trees	%
1	Yvá poroitý	D	91.3	28.2	1	Loro blanco	D	2.5	40.0
2	Ñuati arroyo	E	36.3	11.2	2	Laurel canela	C	1.3	20.0
3	Ñangapirý	E	33.8	10.4	3	Tarumá	D	1.3	20.0
4	Yvyrá piú	D	20.0	6.2	4	Yvyrá Katú	D	1.3	20.0
5	Laurel hú	C	15.0	4.6	5				
6	Pakurí	D	15.0	4.6	6				
7	Guatambú	A	13.8	4.3	7				
8	Aguaí	D	12.5	3.9	8				
9	Jagua rata ý	D	7.5	2.3	9				
10	Kokú		6.3	1.9	10				
Total			323.8	77.6	Total			6.3	100.0

b. Characteristics of forest type from the viewpoint of volume

As in the case of the number of trees, the top 10 emerging species in terms of volume per hectare are classified by forest type and by a diameter breast height, 10 cm or more (total surveyed trees) and 41 cm or more (more than medium trees), in Table III-2-9.

As seen from Table III-2-9, trees of a diameter breast height of 10 cm or more account for 76.84 m^3 in high forest, 69.09 m^3 in medium forest, and 38.05 m^3 in low forest. Trees of a diameter breast height of 41 cm or more account for 42.63 m^3 in high forest, 32.54 m^3 in medium forest, and 38.2 m^3 in low forest. Trees of Classes A and B account for 40% or more in high forest and medium forest. Trees of Classes A and B were not found in low forest. High forest and medium forest are almost similar in terms of the number of trees and volume. Low forest is completely different. Regarding emerging species in medium forest and high forest, Cedro and Kurupay, both Class A, occupies the first and second positions in high forest. In medium forest, Guatambú, Class A, occupies the first position.

Table III-2-9 (1) Top 10 species classified by forest type and per hectare volume (Volume of trees without bark of up to commercial height)

High forest

Total surveyed trees					More than medium trees				
Order	Local name	Class	Volume	%	Order	Local name	Class	Volume	%
			m^3					m^3	
1	Guatambú	A	10.84	14.1	1	Cedro	A	6.66	15.6
2	Urunde y pará	C	6.00	7.8	2	Urunde y pará	C	5.14	12.1
3	Aguaí	D	5.61	7.3	3	Incienso	A	3.79	8.9
4	Kurupay	A	4.82	6.3	4	Yvyrá pytá	B	3.15	7.4
5	Laurel hú	C	4.25	5.5	5	Yvyrá piú	D	2.49	5.8
6	Cancharana	B	3.89	5.1	6	Guapo ý	E	1.87	4.4
7	Yvyrá pytá	D	3.25	4.2	7	Cancharana	B	1.74	4.1
8	Yvyrá piú	D	3.07	4.0	8	Laurel hú	C	1.59	3.7
9	Guapo ý	E	2.80	3.6	9	Yvyrá pepé	D	1.57	3.7
10	Yvyrá pepé	D	2.56	3.3	10	Timbó	B	1.42	3.3
Total			47.09	61.3	Total			29.42	69.0

Table III-2-9 (2)

Medium forest

Total surveyed trees					More than medium trees				
Order	Local name	Class	Volume	%	Order	Local name	Class	Volume	%
			m^3					m^3	
1	Guatambú	A	8.37	12.1	1	Guatambú	A	5.45	16.7
2	Yvá poroitý	D	6.19	9.0	2	Urunde y pará	C	3.52	10.8
3	Aguaí	D	5.01	7.3	3	Yvyrá piú	D	2.47	7.6
4	Yvyrá piú	D	4.39	6.4	4	Gua ja y ví	C	2.37	7.4
5	Urunde y pará	C	4.08	5.9	5	Yvyrá pepé	D	2.05	6.5
6	Yvyrá pepé	D	3.93	5.7	6	Kurupay	A	1.95	5.8
7	Laurel hú	C	3.16	4.6	7	Cancharana	B	1.84	5.5
8	Cancharana	B	2.98	4.3	8	Robo itá	E	1.37	4.3
9	Gua ja y ví	C	2.87	4.2	9	Laurel hú	C	1.20	3.7
10	Robo itá	E	2.68	3.9	10	Loro blanco	D	1.16	3.7
Total			43.66	63.2	Total			23.38	71.9

Table III-2-9 (3)

Low forest

Total surveyed trees					More than medium trees				
Order	Local name	Class	Volume (m^3)	%	Order	Local name	Class	Volume (m^3)	%
1	Yvá poroitý	D	6.80	17.9	1	Loro blanco	D	1.19	31.2
2	Laurel hú	C	3.80	10.0	2	Yvyrá katú	D	1.18	30.9
3	Yvyrá piú	D	3.63	9.5	3	Tarumá	D	0.85	22.3
4	Ñuati arroyo	E	2.94	7.7	4	Laurel canela	C	0.60	15.6
5	Loro blanco	D	2.18	5.7	5				
6	Guatambú	A	2.00	5.3	6				
7	Ñangapirý	E	1.83	4.8	7				
8	Pakurí	D	1.52	4.0	8				
9	Yvyrá oví	C	1.38	3.6	9				
10	Aguaí	D	1.28	3.4	10				
Total			27.36	71.9	Total			3.82	100.0

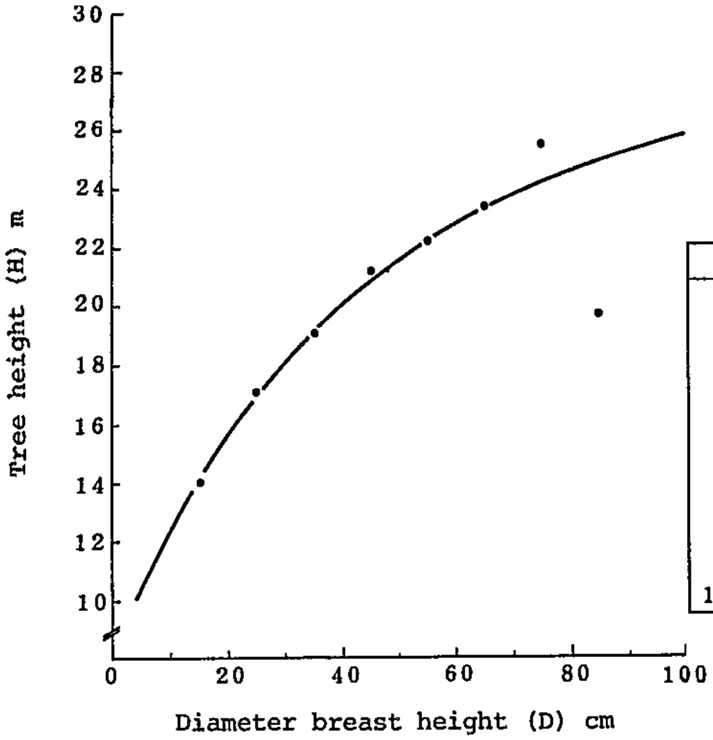
c. Tree height and diameter

V Data 10, 11 give tree height (total tree height, commercial tree height) and diameter (diameter breast height, diameter at 5 m and diameter at commercial height). Averages for all 32 sample plots are as follows:

Table III-2-10 Shape of broad leaved trees in Capiibary region (Average of 32 plots)

Diameter class	Height (m)		Diameter (cm)		
	Total tree height	Commercial height	Diameter breast height	Diameter at 5 m	Diameter at commercial height
10 cm or more	16.50	4.76	25.09	21.90	20.90
41 cm or more	22.03	6.97	52.11	45.85	42.23

Fig. III-2-5 shows the relation between diameter breast height (D) and total tree height (H) of natural broad leaved trees obtained from the results of the study conducted in 32 sample plots in the Capiibary region.



D	H
10	12
20	16
30	18
40	20
50	22
60	23
70	24
80	25
90	25
100	26

Fig. III-2-5 Relation between diameter breast height and total tree height in the Capiibary region

2-2-4 Growing Stock in the Study Area

Preparation of aerial photo volume table

The multiple regression equation was formed by taking the per ha volume of the sample plot which was field surveyed as an objective variable and the tree height, crown density, and crown diameter of the sample plot obtained by aerial photo interpretation as explanatory variables. Next, factors of each forest type division were substituted into the equation, and their areas were multiplied. Then, they added up. This calculation used the volume of trees without bark of a diameter breast height of 10 cm or more including defective trees in the sample plot. Also the same calculation was conducted using the data on trees of a diameter breast height of 41 cm or more. The data used in this calculation are as shown in Table III-2-11.

Table III-2-11 Data used in preparation of volume equation of forest type division on aerial photo

Plot No.	Forest type	Tree height H (m)	Crown density C (%)	Crown diameter D (m)	Volume (without bark, per ha) Total surveyed trees	Volume (without bark, per ha) more than medium trees
1	M	4	40	11	84.81	38.81
2	M	4	30	10	51.48	24.93
3	M	4	15	9	47.26	19.34
4	B	2	5	6	41.46	1.70
5	A	4	20	12	47.19	21.84
6	A	5	20	14	90.04	54.60
7	A	4	25	12	68.21	31.19
8	A	5	15	13	90.22	61.30
9	A	4	20	13	62.75	32.16
10	M	4	25	11	77.25	43.06
11	A	5	20	12	66.91	41.06
12	A	5	20	13	80.77	54.63
13	A	4	15	13	68.09	35.16
14	M	4	20	11	59.86	34.89
15	A	4	35	12	80.84	38.39
16	M	4	20	11	78.01	33.40
17	A	4	25	12	61.14	24.89
18	A	5	15	13	83.09	52.00
19	A	4	20	14	78.95	40.50
20	A	5	25	13	116.46	76.37
21	M	4	15	10	54.46	26.36
22	A	4	20	14	91.40	37.43
23	M	4	30	10	80.89	38.28
24	M	4	25	9	75.29	23.95
25	M	4	20	8	52.27	20.34
26	M	5	20	11	88.05	59.66
27	M	4	15	9	65.48	34.70
28	A	4	15	12	66.61	37.95
29	M	4	20	10	67.56	21.65
30	M	5	20	11	88.01	43.13
31	B	3	5	5	34.63	5.93
32	M	4	30	30	65.70	25.54

As a result, volume per hectare can be estimated from the following equation.

For a diameter breast height of 10 cm or more (total surveyed trees):

$$V\ (m^3) = 11.87648X_1 + 0.488388X_2 + 2.410733X_3 - 14.871191$$

(Coefficient of multiple correlation: 0.766)

where, X_1: Tree height 1 = 1-5 m
2 = 5-10 m
3 = 10-15 m
4 = 15-20 m
5 = 20 m or more

X_2: Crown density In the 5% unit

X_3: Crown diameter In the 1 m unit

In the same way, for a diameter breast height of 41 cm or more (more than medium trees):

$$V\ (m^3) = 15.160499X_1 + 0.05517X_2 + 2.161335X_3 - 51.985112$$

(Coefficient of multiple correlation: 0.843)

For the volume table of forest type division on aerial photo prepared by the use of these equations and areas and volumes classified by forest type division, see the forest inventory register.

The growing stock of the entire study area could be specified as follows:

For total surveyed trees;
1,822,298.99 m^3, 70.08 m^3 per ha

For more than medium trees;
886,999.10 m^3, 34.09 m^3 per ha

Next, the volume distribution of each species class was studied. In this study, a total volume of each forest type was distributed according to the ratio of per ha volume of each species class for each forest type of the sample plot (Table III-2-7). The results of this study are shown in Table III-2-12.

Table III-2-12 (1) Growing stock of the study area

Total growing stock

	High forest		Medium forest		Low forest		Total		
Area (ha)	8,683		15,627		1,712		26,022		volume per ha
Class	Volume (m^3)	%	Volume (m^3)	%	Volume (m^3)	%	Volume (m^3)	%	(m^3)
A	172,343.40	25.9	225,888.06	20.5	3,904.11	7.1	402,135.57	22.1	15.45
B	87,835.25	13.2	106,883.62	9.7	714.84	1.3	195,433.71	10.7	7.51
C	145,061.24	21.8	287,594.07	26.1	9,732.78	17.7	442,388.09	24.3	17.00
D	150,384.59	22.6	338,281.14	30.7	31,452.83	57.2	520,118.56	28.5	19.99
E	93,824.02	14.1	116,800.66	10.6	8,413.08	15.3	219,037.76	12.0	8.42
Defective tree	15,970.05	2.4	26,445.43	2.4	769.82	1.4	43,185.30	2.4	1.66
Total	665,418.55	100.0	1,101,892.98	100.0	54,987.46	100.0	1,822,298.99	100.0	70.03

Table III-2-12 (2)

More than medium trees

	High forest		Medium forest		Low forest		Total		
Area (ha)	8,683		15,627		1,712		26,022		Volume per ha
Class	Volume (m^3)	%	Volume (m^3)	%	Volume (m^3)	%	Volume (m^3)	%	(m^3)
A	110,591.80	29.7	133,266.60	26.3	0	0	243,858.40	27.5	9.37
B	65,163.51	17.5	77,021.01	15.2	0	0	142,184.52	16.0	5.46
C	97,559.10	26.2	169,243.53	33.4	1,243.29	15.7	268,045.92	30.2	10.31
D	51,013.72	13.7	74,994.14	14.8	6,675.73	84.3	132,683.59	51.0	5.10
E	39,842.83	10.7	40,030.65	7.9	0	0	79,873.48	9.0	3.07
Defective tree	8,191.98	2.2	12.161.21	2.4	0	0	20,353.19	2.3	0.78
Total	372,362.94	100.0	506,717.14	100.0	7,919.02	100.0	886,999.10	100.0	34.09

b. Estimation of volume of branches and twigs

Since branches and twigs remaining after cutting down standing trees in the study area can be utilized as charcoal materials, the volume of branches and twigs was surveyed. To estimate the volume of branches and twigs, trees of a diameter breast height of 41 cm were selected in the study area, the length of branches and twigs of a diameter of 10 cm or more was measured excluding branching portions, and then measured lengths were added up (Fig. III-2-6). The number of trees whose volume of branches and twigs was measured was 20. The results of this measurement (for a total of 20 trees) were as follows:

Stem volume (volume under the first main branch)	34 m^3
Volume of branches and twigs	19 m^3

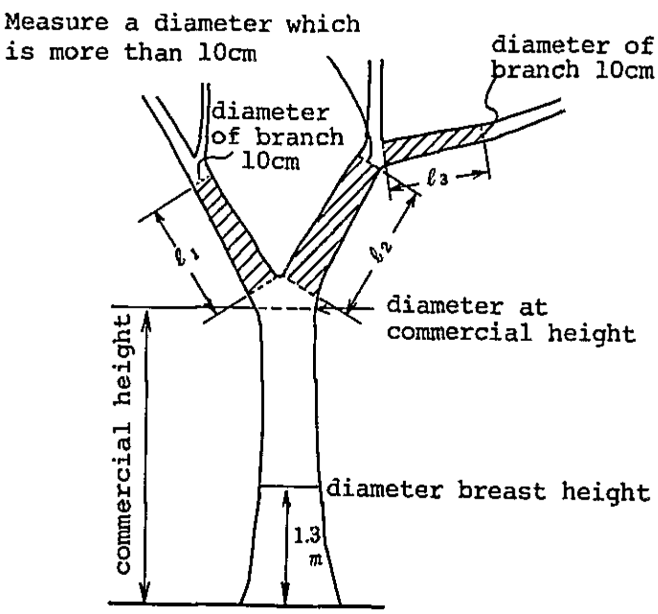


Fig. III-2-6 Measuring positions of branches and twigs

The branch volume survey was conducted on more than medium trees. Since the branch volume per 1 m^3 of stem volume was 0.56 m^3, the branch volume of the study area is as tabulated below.

Table III-2-13 Branch volume of standing trees with more than medium trees

Class	Volume of branches in the entire area of 26,022 ha (m^3)	Volume per ha (m^3)
A	136,560.70	5.25
B	79,623.33	3.06
C	150,105.71	5.76
D	74,302.81	2.86
E	44,729.15	1.72
Defective tree	11,397.79	0.44
Total	496,719.49	19.09

. Volume of unsuitable for charcoal production

Three species, TIMBO, GUA JA Y VI and KURUPIKAY, are picked up as the unsuitable for charcoal production (from the survey of Asepal steel mill), other species are said to be suitable for charcoal production.

From the results of sample plots survey, the volume of above three species are presented in Table III-2-14.

Table III-2-14 Volume of unsuitable for charcoal production (per ha)

(m³)

	Class	High forest	Medium forest
Total surveyed trees	B	1.42	-
	C	1.58	2.86
	Total	3.00	2.86
More than medium trees	B	1.42	-
	C	1.22	2.37
	Total	2.64	2.37

Volume of unsuitable for charcoal production within total growing stock is as tabulated below.

Table III-2-15 Volume of unsuitable for charcoal production

(m³)

Division	Class	High forest	Medium forest	Total
Total surveyed trees	B	12,403.78	-	12,403.78
	C	13,691.56	45,594.18	59,285.74
	Total	26,095.34	45,594.18	71,689.52
More than medium trees	B	12,403.78	-	12,403.78
	C	10,645.98	36,900.38	47,546.36
	Total	23,049.76	36,900.38	59,950.14

(Note): [Calculation of Volume of Trees not Utilizable for Charcoal Production]

1.42/10.17 x 87,835.25 = 12,264.12 (m^3)
(10 cm or more, high forest B)

1.58/16.74 x 145,061.24 = 13,691.56 (m^3)
(10 cm or more, high forest C)

1.42/7.46 x 65,163.51 = 12,403.78 (m^3)
(41 cm or more, high forest B)

1.22/11.18 x 97,559.10 = 10,645.98 (m^3)
(41 cm or more, high forest C)

2.86/18.04 x 287,594.07 = 45,594.18 (m^3)
(10 cm or more, medium forest C)

2.37/10.87 x 169,243.53 = 36,900.38 (m^3)
(41 cm or more, medium forest C)

(For class B of high forest, the equation for trees of a diameter breast height of 10 cm or more is different from that for trees of a diameter breast height of 41 cm. However, in the sample plot, trees not utilizable as charcoal emerge only among trees of a diameter breast height of 41 cm or more. So the estimated volume of trees not utilizable as charcoal of 10 cm or more in a diameter breast height was made the same as that of a diameter of 41 cm or more.)

Table III-2-16 Volume of unsuitable for charcoal production in the branch volume (More than medium trees)

Class	Volume of unsuitable for charcoal production in the branch volume	per ha (m^3)
B	6,946.12	0.27
C	26,625.96	1.02
Total	33,572.08	1.29

3. Growth of Natural Forest

In order to grasp the increment of natural forest in the study area, year ring study of butt end and diameters of lowest part logs was carried out at local cutting locations or at a nearby sawmill.

The number of trees investigated by species is as shown in Table III-3-1.

Table III-3-1 No. of trees investigated year ring study by species

Species	Class	No. of trees	Species	Class	No. of trees
Cedro	A	18	Urundey mí	A	2
Guatambú	A	2	Tvyra ró	A	5
Kurupay	A	2	Timbó	B	7
Lapacho	A	10	Yvyrá pytá	B	6
Peterevy	A	3	Kai Kai qua	C	2
			others		4
Total					61

3-1 Study Method

a. Annual ring study

Annual ring study was carried out by the method of measuring the number of annual rings and annual ring widths at the cross section of stumps or the bottom end of felled trees and logs in the field and entering them on the growth increment survey field notebook. Procedure of the annual ring study are as described below.

1) A straight line is drawn across the center of the cut end of stump or bottom end of log, etc. in the direction of their mean diameter to make two radii.

2) The number of annual rings on the cross area is counted and entered in the age column of the field notebook as the age of that tree.

3) The annual rings corresponding to every ten years from the center are marked along the two radii. When marking them, care must be taken so that the annual rings marked on the two radii are in conformity.

4) A scale is applied on the marked radii, placing zero at the center of the cross area. Then the measurements on the scale are read off from the outside in the sequence of with bark - inside the bark - marked annual ring while the person in charge of entry enters them in the field notebook. Measurement is by the unit of cm and it is read as far as 1 digit belot the unit.

5) The values of the two radii that have been read off are added and deemed to be the diameter of the cross area.

b. Estimation of diameter breast height

1) Using the data of resource survey, the correlation between basal diameter (ds) and diameter breast height (d_B) is figured.

$$d_B = k \cdot ds \quad .... \text{(a)}$$

2) Diameter breast height is estimated for each age grade from the basal diameter measured in 1) above by the use of equation (a).

c. Estimation of stem volume

1) Correlation between diameter breast height (d_B) and stem volume (V) is computed.

$$V = k \cdot d_B \quad .... \quad (b)$$

2) Stem volume for each diameter grade is estimated by the use of equation (b).

d. Estimation of mean increment by diameter grade

1) The number of years to the next higher grade (n) is estimated for each diameter grade.

2) Volume increment for each diameter grade is computed by the use of stem volume for each diameter grade estimated in c. 2) above.

3) The mean annual increment (Zd) for each diameter grade is obtained by dividing the volume increment obtained in the preceding item with the number of years to the next higher grade, as in the following equation.

$$Zd = \frac{Vd_2 - Vd_1}{n} \quad .... \quad (c)$$

Where Vd_1 : stem volume of a certain diameter grade

Vd_2 : stem volume of the next higher diameter grade

n : number of years required to move up from Vd_1 to Vd_2.

e. Estimation of stand volume increment

The number of standing trees by diameter grade per hectare computed from the resource survey results is multiplied by the stem volume increment by diameter grade computed in c. 2) to compute increment per hectare for each diameter grade, and then by summing up the products, stem volume increment per hectare is obtained.

3-2 Study Results

In the resource survey, analysis were made for all surveyed species combined.

a. Relationship between age and basal diameter

The mean basal diameters of 61 trees checked were measured and summarized by age group as shown in Table III-3-2 and Fig. III-3-1.

Table III-3-2 Basal diameter by age

Age (Year)	10	20	30	40	50	60	70	80
Mean of basal diameter (cm)	6.13	11.64	17.24	22.77	26.68	30.77	35.14	39.21
Age (Year)	90	100	110	120	130	140	150	160
Mean of basal diameter (cm)	42.29	45.17	47.92	51.77	55.77	55.89	61.10	68.24

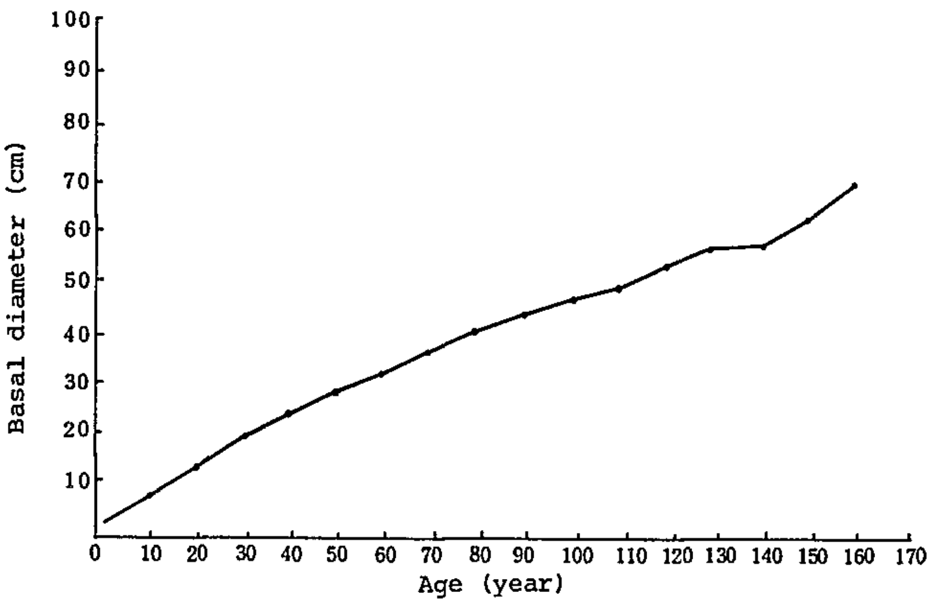


Fig. III-3-1 Aage and basal diameter

b. Relationship between basal diameter and diameter breast height

About the relationship between basal diameter and diameter breast height from the results of forest inventory in the northeastern region of Paraguay, are as follows:

$$D_{1\cdot3} = 0.945637 \cdot D_0 - 1.217449 \quad \text{..........} \quad (d)$$

(r = 0.99594)

(D_0 : basal diameter
$D_{1\cdot3}$: diameter breast height)

c. Relationship between age and diameter breast height

The diameter breast height was converted into basal diameter on the basis of equation (d), and the relationship between age and basal diameter in Table III-3-2 was converted into the relationship between age and diameter breast height.

The results are as shown in Table III-3-3.

Table III-3-3 Relationship between age and diameter breast height

Age (Year)	10	20	30	40	50	60	70	80
Mean d.b.h. for all surveyed trees (cm)	4.58	9.79	15.09	20.31	24.01	27.88	32.01	35.86
Age (Year)	90	100	110	120	130	140	150	160
Mean d.b.h. for all surveyed trees (cm)	38.77	41.50	44.10	47.74	51.52	51.63	56.56	63.31

d. Estimation of growth curve formula

When theoretical growth curve formula is estimated from the relationship between age and diameter breast height obtained in c. above, the following equation exhibits a good fit. (This equation is called single molecular reaction formula.)

$$d_y = D\ (1 - e^{a-\lambda y}) \quad .... \text{(e)}$$

in which D is the limit value of diameter breast height d, y is number of years,

The diameter breast height in y+1 year is defined as dy+1 and coefficient of the difference equation of dy and dy+1 is derived.

$$d_{y+1} = b_0 + b_1 d_y$$

By using coefficient b_1 obtained here, constants for the growth curve formula are derived from the following equations.

$$D = b_0/(1 - b_1)$$

$$-\lambda = \ell n(b_1)$$

$$a = \ell n(1 - d_1/D) + \lambda$$

When the diameter growth curve formula is derived on the basis of the above equations, the following equation results.

$$d_y = 174.3571(1 - e^{(0.0061-0.0028(y-5)}) \quad .... \quad (f)$$

When the age for each diameter grade is computed according to equation (f), Table III-3-4 results.

Table III-3-4 Relationship between diameter breast height grade and age

d.b.h. (cm)	10	20	30	40	50	60	70	80	90	100
Age (Year)	26	49	73	98	126	156	189	225	265	310

e. Estimation of volume according to the single variable volume table

To estimate volume from diameter breast height, a single variable volume table is necessary, which was already obtained in the forest inventory in the northeastern area.

According to the above volume table, the single variable volume equation is as follows:

$$\log V = 2.649281 \cdot \log D + 0.801004 \quad .... \quad (g)$$

$$(r = 0.97749)$$

On the basis of empirical formula (g), volumes by species and by diameter grade were computed as summarized in Table III-3-5 and Fig. III-3-2.

(* Volumes obtained by this equation are the volumes without bark.)

Table III-3-5 Relationship between diameter breast height and volume

d.b.h. (cm)	10	20	30	40	50	60	70	80	90	100
Volume (m^3)	0.014	0.089	0.260	0.558	1.008	1.634	2.458	3.502	4.784	6.324
d.b.h. (cm)	110	120	130	140	150	160	170	180	190	200
Volume (m^3)	8.141	10.251	12.673	15.422	18.515	21.967	25.795	30.012	34.634	39.675

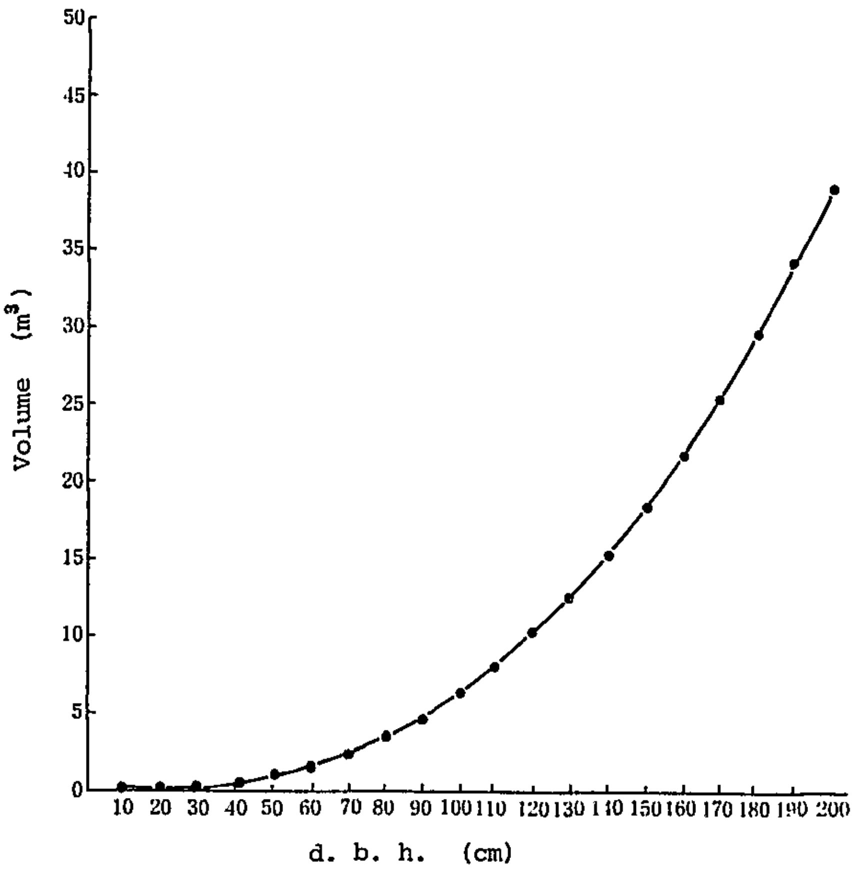


Fig. III-3-2 Relationship between d.b.h. and volume

f. Estimation of mean increment by diameter grade

1) Using the age corresponding to each diameter breast height which was obtained in item d. above (Table III-3-4), the number of years (n) required to advance to the next higher diameter grade (one diameter grade is 10 cm) is obtained.

2) Next, using the stem volume by diameter garde (Table III-3-5) which was obtained in item e. above, mean stem volume increment (Zd) is computed according to equation (c).

The results are as shown in Table III-3-6.

Table III-3-6 Mean increment by diameter grade

d.b.h. (cm)	10	20	30	40	50	60	70	80	90	100
Age (year)	26	49	73	98	126	156	189	225	265	310
Stem volume (m^3)	0.014	0.089	0.260	0.558	1.008	1.634	2.458	3.502	4.784	6.324
No. of years to advance to next higher grade	23	24	25	28	30	33	36	40	45	
Stem volum increment (m^3)	0.075	0.171	0.298	0.450	0.626	0.824	1.044	1.282	1.540	
Mean stem volume increment (Zd)	0.0033	0.0071	0.0119	0.0161	0.0209	0.0250	0.0290	0.0321	0.0342	

g. Estimation of stand volume increment

The number of standing trees by daimeter grade per hectare computed from the resource survey results was multiplied by the mean stem volume increment by diameter grade estimated in the preceding item to otbain the growth rate per hectare by diameter grade, and then, by adding them up, the stem volume increment per hectaje was obtained.

As a result, the stand volume increment of all species (aggregate volume per hectare by totalling the volume for every specie) became 1.93 m^3 per hectare as shown in Table III-3-7.

The stand volume increment for A+B class was also estimated, which resulted in 0.48 m^3 per hectare.

Also, stand volume increment for all species was divided by the standing tree stem volume per hectare to figure out the stem volume growth rate. The growth rate in this area, as a result, was estimated to be approximately 2.8%.

Table III-3-7 Stand volume increment

	d.b.h. (cm)	10-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	90-	Total
All species	No.of trees/ha	119.6	76.4	34.1	16.9	7.5	3.6	2.0	0.2	0.1	260.4
	Mean annual increment/tree	0.0033	0.0071	0.0119	0.0161	0.0209	0.0250	0.0290	0.0321	0.0342	
	Increment/ha	0.3947	0.5424	0.4058	0.2721	0.1568	0.0900	0.0580	0.0064	0.0034	1.9296
A + B	No.of trees/ha	12.7	11.7	9.8	6.9	2.5	1.5	0.9	0.2	0.1	46.3
	Mean annual increment/tree	0.0033	0.0071	0.0119	0.0161	0.0209	0.0250	0.0290	0.0321	0.0342	
	Increment/ha	0.0419	0.0831	0.1166	0.1111	0.0523	0.0375	0.0261	0.0064	0.0034	0.4784

o Growth rate P (%) = $Z/V \times 100 = 1.9296/68.37 \times 100 \fallingdotseq 2.8$

provided that stem volume/ha (V) = 68.37 m^3

4. Forest Soil Survey

Soil indicates natural environment as well as one of the most influential factor for forest growth and productivity. Soil can be basic factor for planting species selection and estimation of yield.

This time, soil survey was conducted at the sample plot of forest resources survey, analized and classified on the basis of characteristic horizon linked formation factors.

4-1 Survey Method

4-1-1 Setting of Survey Plots

Thirty-two plots were selected for survey to represent the normal ground surfaces, flora and floor vegetation according to the chorography while avoiding roads and other man-made influences.

4-1-2 Soil Profile Survey

A 100 cm^3 test pit was excavated to perform a soil profile survey according to the National Forest Soil Survey Manual (by Forestry and Forest Products Research Institute, Forestry Agency, 1955). A stratigraphic chart was prepared to classify the horizons according to soil formation. In addition, profile photos were taken to analyze colors, humus, gravel, structures, texture, hardness, moisture, root, etc. The findings of the soil profile survey were summarized in V Data 12.

The hardness was examined by making use of Yamanaka's hardness matter, etc. The microstructure of soil was also inspected using a magnifying glass. Samples were taken to represent typical cross sections. Spot $_{p}H$ analysis was made and some chemical characteristics were examined.

4-2 Results of Survey

4-2-1 Soil Classification Method

As regards Capiibary, there are soil survey data obtained by FAO in 1980. According to FAO's data, the soil in this area is classified into nine types as combinations of chorography, parent material and terrains.

Chiefly, they are classified according to chorographic characteristics such as flats, slopes along the valley, monadnocks along the valley. The soil along the valley is classified into six type according to parent material and slope.

Namely, the classification is made mechanically according to the combinations of factors influencing soil characteristics, and no soil types are named.

In the survey conducted this time, the soil was surveyed and classified according to formation-linked diagnostic horizons.

As regards South America, a world soil map (1:5,000,000) was drawn by FAO-UNESCO in 1971. Accordingly, the soil classification was made following it.

Namely, as it goes from the mountains bordering on Brazil down to the Paraguay and the Parana, Ferralsols, Acrisols, Nitosols and Planosols appear. Along the rivers, Gleysols and Fluvisols show themselves. This topographical distribution of soils is characteristics of the study area.

The soils in Capiibary are included in Acrisols distributed far and wide in Eastern Paraguay. Acrisols is a non-basic red soil with a basic saturation of up to 50%, and characteristically is accompanied by clear Argillic B horizon.

Acrisols in Capiibary contains ferric oxide enriched by the weathering of red sandstone and deposited on quartz particles.

Ferric oxide moves down by leaching to coat the quartz particles lying under. It goes down further to form laterite crusts or fine clayey deposits in the cracks of the basal weathered horizon. The layer of the iron coating is thin in the leached A horizon, but is thick in the depositary B horizon where quartz particles are turned dark red.

4-2-2 Soil Classification for the Study Area

In Capiibary, the eastern valley site lies the lowest at 160 m above sea level, and the monadnocks stand the highest at 380 m above sea level. The greater part shows a plateau, 250 m or more above sea level. Moderate slopes account for about 85% of the area.

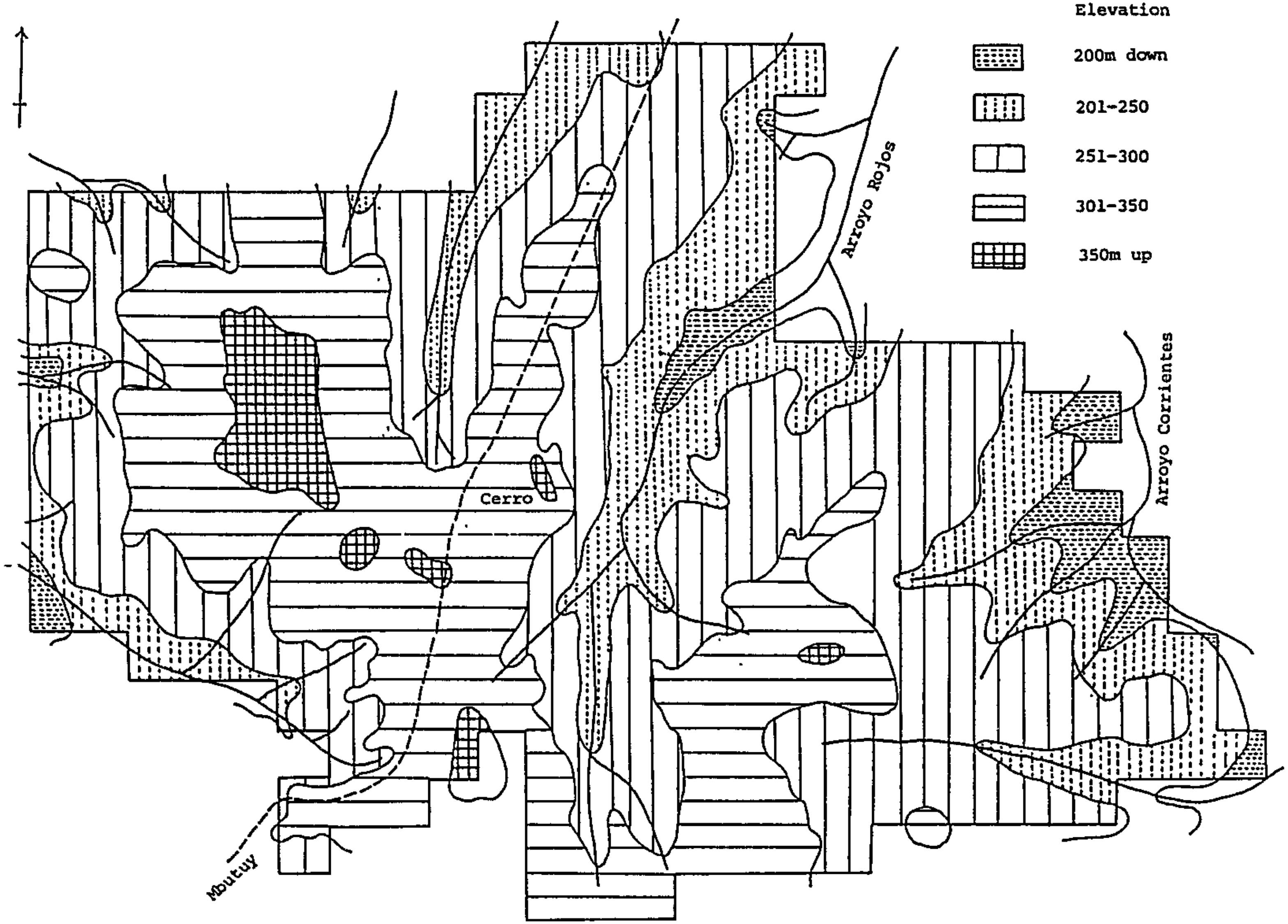


Fig. III-4-1 Topography of Capiibary

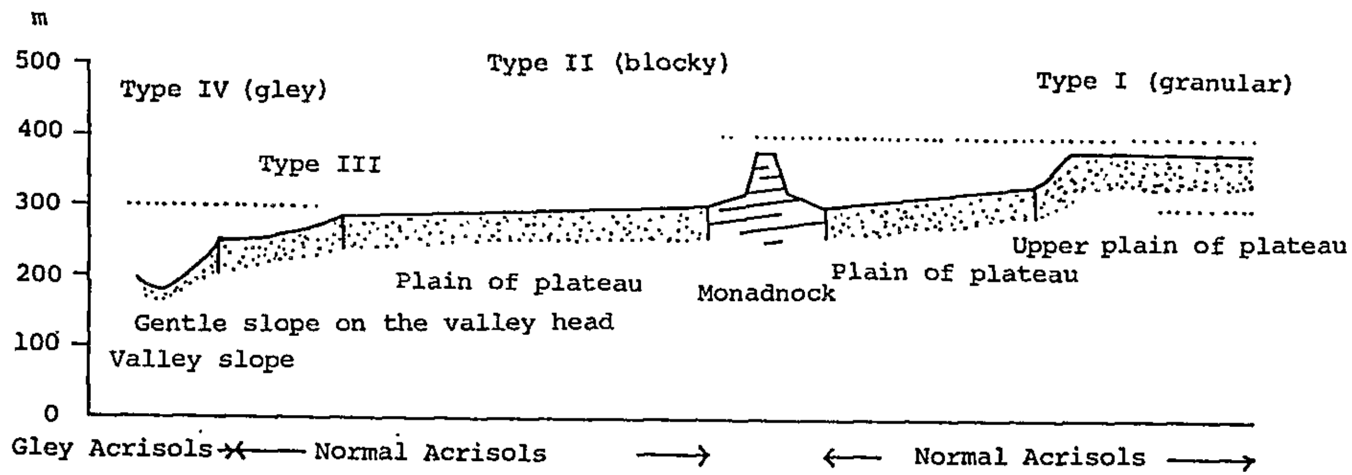


Fig. III-4-2 Collation of soil types with topographical divisions in Capiibary

Flat terrains with a slope less than 6° account for about 99%. Terrains with a relative relief less than 40 m account for more than 70%. Namely, the area 250 m or more above sea level is almost totally accounted for by flat terrains with a relative relief less than 40 m and a slope less than 6°.

A sketchy map showing the existing topography is shown in Fig. III-4-2 by way of reference.

As is clear from Fig. III-4-2, the area is chorographically divided into five parts - upper plain of plateau, plain of plateau, gentle slope on the valley head, valley slope, and monadnocks - as shown in Fig. III-4-3.

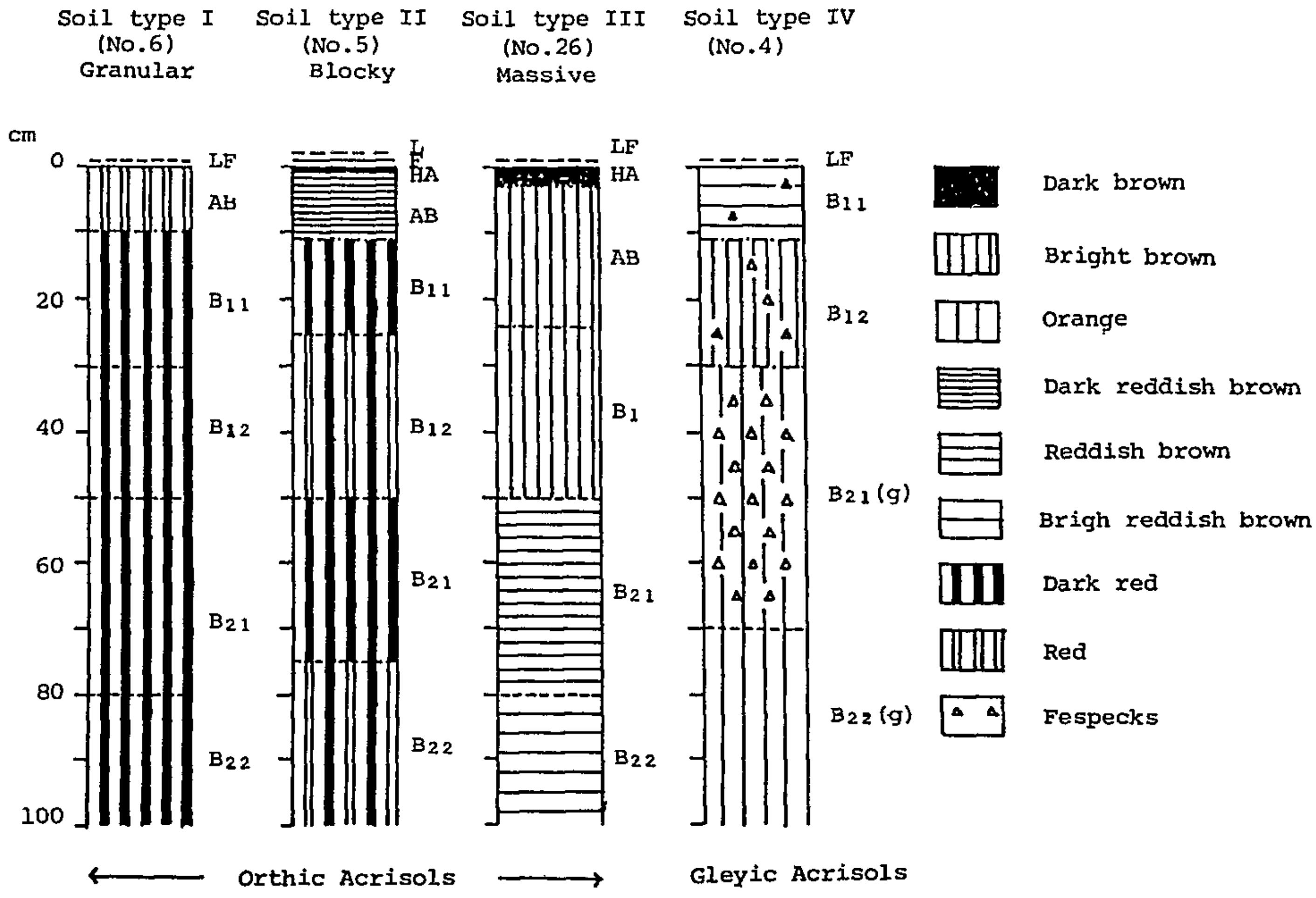


Fig. III-4-3 Soil stratigraphy in Capiibary

Table III-4-1 shows the classification of soils in Capiibary by formations. Categorically, the soils are divided into soil groups, subgroups and soil types.

The soil groups and subgroups are in accordance with FAO-UNESCO classification. The soil types are in accordance with chorographic cross sectional characteristics, particularly color and structure. The graphic units are given in soil types closely associated with chorography. The chorography vs. soil type relationships are as shown in Fig. III-4-3.

Fig. III-4-1 Soil classification of Capiibary

Soil group	Subgroup	Soil type	Type code	Topography	Morphological characteristics of soil profile
Acrisols (low saturation red soils)	Normal Acrisols	Granular	I	Upper plain of plateau 310m	AB: 10R (red), granula, coarse, SL B1: 10R (dark red), Fe-coated quarts particles, coarse to soft, SL B2: 10R (dark red), Fe-coated, soft, SL
		Blocky	II	Plain of plateau 260m	AB: 2.5YR (dark reddish brown), blocky, SL B1: 10R (dark red to red), this Fe coating over quarts grains, soft, SL B2: 10R to 7.5R (dark red to red), Fe coating, soft to hard, SL
		Massive	III	Gentle slope on the valley head 300m	HA: 5YR (dark brown), weak nodules, very coarse SL AB: 5YR (bright brown), soft, SL B1: 5YR (bright brown), soft, SL B2: 2.5YR (reddish brown to bright reddish brown), soft to hard, SL, thin Fe coating over quartz particles
	Gley Acrisols	Gley Acrisols	IV	Valley slope 210m	B1: 5YR to 7.5YR (bright reddish brown to bright brown), coarse to soft, SL, fine Fe specks, this Fe coating over quartz particles B2(g) : 7.5YR (bright brown to orange), soft, SL, Fe specks in B21(g), little Fe coating over quartz particles

4-2-3 Features of Soil Types

The results of soil survey at 32 plots in the study area are summarized in V Data 12. The cross-sectional morphology of typical soils is as follows. (Photos III-4-1 ∿ 4)

Table III-4-2 Typical soil profiles

o Soil profile No. 6, type I soil

Soil type	:	Normal Acrisols, granular structure
Chorography	:	Upper plain of plateau, flat, 310 m above sea level
Parent material	:	Weathered quartziferous sandstone
Sedimentation	:	Residual

LF	:	1 cm, spares sedimentation of humus of broad leaves
AB	:	0 to 10 cm, 10R 4/6 (red), sandy loam including humus, granular structure coarse sedimentation (penetration, 4 mm), wet rich in woody rootage, clear transition
B 11	:	10 to 30 cm, 10R 3.5/6 (dark red , lean humus, sandy loam, soft sedimentation (penetration, 9 mm), wet, medium degree of woody rootage, gradual transition
B 12	:	30 to 50 cm, 10R 3.5/6 (dark red), lean humus, sandy loam, coarse sedimentation (penetration, 5 mm), wet, less woody rootage, gradual transition
B 21	:	50 to 80 cm, 10R 3.5/6 (dark red), lean humus, sandy loam, soft sedimentation (penetration, 9 mm), wet, lean woody rootage, gradual transition

B 22	:	80 cm and deeper, 10R 3/6 (dark red), lean humus, sandy loam, soft to hard sedimentation (penetration, 14 mm), thick Fe-coating over quartz particles

o Soil profile No. 5, type II soil

Soil type : Orthic Acrisols, blocky

Chorography : Plain of plateau, flat, 260 m above sea level

Parent material : Weathered quartziferous sandstone

Sedimentation : Residual

L : 1 cm, new leaves of deciduous trees

F : 1 cm, finely disintegrated leaves

HA : 0 to 1 cm, 2.5YR 2/3 (extremely dark reddish brown), rick humus, sandy loam including white quartz particles, extremely coarse sedimentation (penetration, 3 mm), wet, rich woody rootage, distinct transition

AB : 1 to 11 cm, 2.5YR 3.4 (dark reddish brown), humic sandy loam, weak blocky structure, coarse sedimentation (penetration 4 mm), wet, rich woody rootage, clear transition

B 11 : 11 to 25 cm, 10R 3/5 (dark red), less humus, sandy loam, soft sedimentation (penetration, 12 mm), wet, medium degree of rootage, gradual transition

B 12 : 25 to 50 cm, 10R 3.5/6 (dark red to red), less humus, sandy loam, soft sedimentation (penetration, 8 mm), wet, medium rootage, gradual transition

B 21 : 50 to 70 cm, 10R 3/6 (dark red), lean humus, sandy loam, thick Fe coating over quartz particles, soft sedimentation (penetration, 7 mm), wet, lean rootage, gradual transition

B 22 : 70 cm and deeper, 7.5R 3/6 (dark red to red), lean humus, sandy loam, thick Fe coating over quartz particles, hard sedimentation (penetration, 8 mm), wet

o Soil profile No. 26, soil type III

Soil type : Orthic Acrisols, massive

Chorography : Gentle slop on the valley head, flat, 300 m above sea level

Parent material : Weathered quartziferous sandstone

Sedimentation : Residual

LF : 1 cm, humic broad leaves sparsely deposited

HA : 0 to 3 cm, 5YR 2/1 (dark brown), rich humus, sandy loam, crumbled structure, extremely coarse sedimentation (penetration, 2 mm), wet, w/mycelia, rich woody rootage, abrupt transition

AB : 3 to 24 cm, 5YR 4/6 (bright brown), humic sandy loam, w/partial blocky structure, soft sedimentation (penetration, 10 mm), more consistent than B1, wet, medium rootage, clear transition

B 1 : 24 to 50 cm, 5YR 4/8 (bright brown), lean humus, sandy loam, soft sedimentation (penetration, 7 mm), wet, medium rootage, gradual transition

B 21 : 50 to 80 cm, 2.5YR 4/7 (reddish brown), lean humus, sandy loam, soft sedimentation (penetration, 8 mm), wet, medium rootage, gradual transition

B 22 : 80 cm and deeper, 2.5YR 5/6 (bright reddish brown), lean humus, soft to hard sedimentation (penetration, 13 mm), wet

o Soil profile No. 4, type IV

Soil type : Gleyic Acrisols

Chorography : Valley slope, SSE 5°, 210 m above sea level

Patent material : Weathered quartziferous sandstone

Sedimentation : Residual

LF : 1 cm, humic broad leaves, sparsely deposited, local HA in the bottom

B 11 : 0 to 11 cm, 5YR 5/8 (bright reddish brown), lean humus, sandy loam, coarse sedimentation (penetration, 4 mm), wet, slight Fe coating over quartz particles, medium woody rootage, clear transition

B 12 : 11 to 30 cm, 7.5YR 5/6 (bright brown), lean humus, sandy loam, soft sedimentation (penetration, 12 mm), slight Fe coating over quartz particles, fine Fe specks (5YR 5/8 (bright reddish brown)), medium woody rootage, clear transition

B 21(g) : 30 to 70 cm, 7.5YR 5.5/6 (bright brown to orange), lean humus, sandy loam, soft sedimentation (penetration, 8 mm), wet, Fe specks (5YR 5/6 (bright reddish brown)), no Fe coating over quartz particles, less woody rootage, gradual transition

B22 (g)	:	70 cm and deeper, 7.5YR 6/6 (orange), lean humus, sandy loam, soft sedimentation (penetration, 10 mm), wet, no Fe specks, less woddy rootage

o Soil profile No. 12, soil type II (clayey·conglomerate)

Soil type	:	Orthic Acrisols, blocky structure
Chorography	:	Plain of plateau, flat, 310 m above sea level
Parent material	:	Weathered quartziferous sandstone
Sedimentation	:	Residual

LF	:	1 cm, humic broad leaves, sparsely deposited, local HA in the bottom
AB	:	0 to 10 cm, 2.5YR 3/4 (dark reddish brown), humic sandy loam, weak blocky structure, soft sedimentation (penetration, 5 mm), wet, medium woody rootage, clear transition
B 1	:	10 to 38 cm, 2.5YR 3/6 (dark reddish brown), humic sandy loam, soft sedimentation (penetration, 8 mm), wet, less woody rootage, gradual transition
B 21	:	38 to 77 cm, 10R to 2.5YR 3/6 (dark reddish brown to dark red), lean humus, loam, clayey accumulation, soft to hard sedimentation (penetration, 16 mm), wet, less woody rootage, gradual transition
B 22	:	77 cm and deeper, 10R 3/6 (dark red), lean humus, clay loam, clayey accumulation, clayey matter permeation gaps between quartz particles, hard sedimentation (penetration, 23 mm), wet, less woody rootage

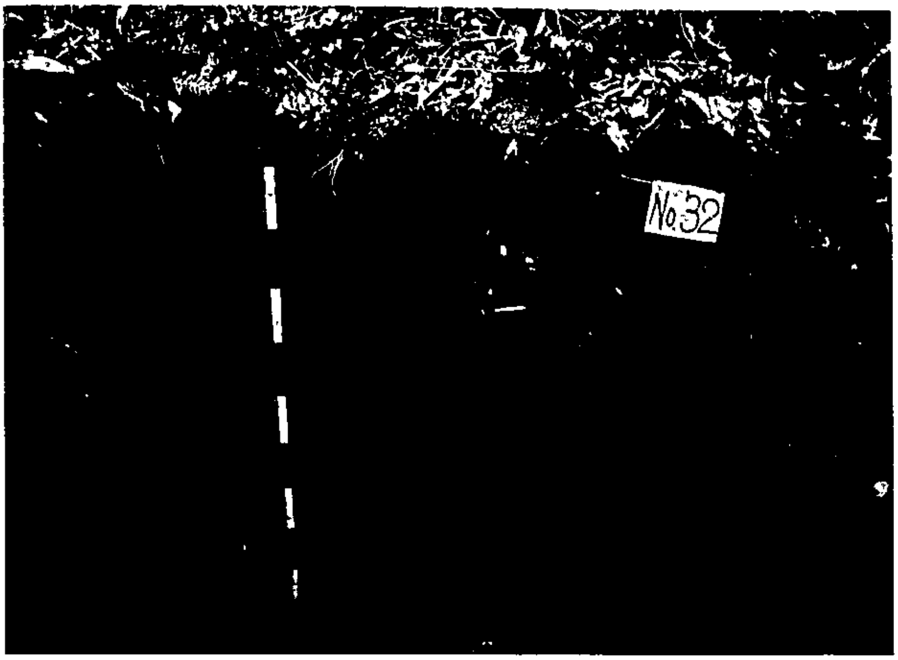


Photo III-4-1 Soil type I: Normal Acrisols, granular

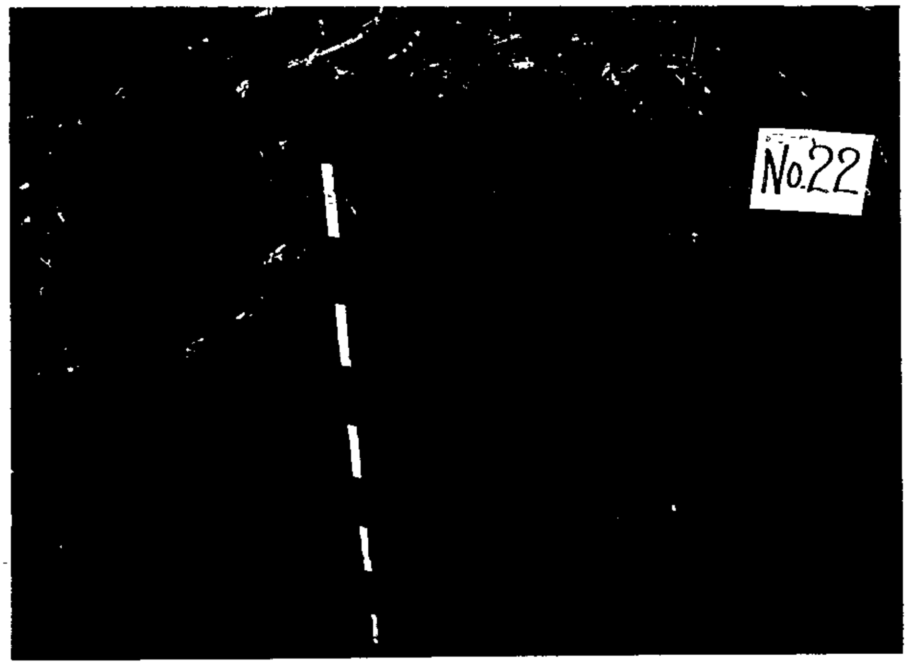


Photo III-4-2 Soil type II: Normal Acrisols, blocky

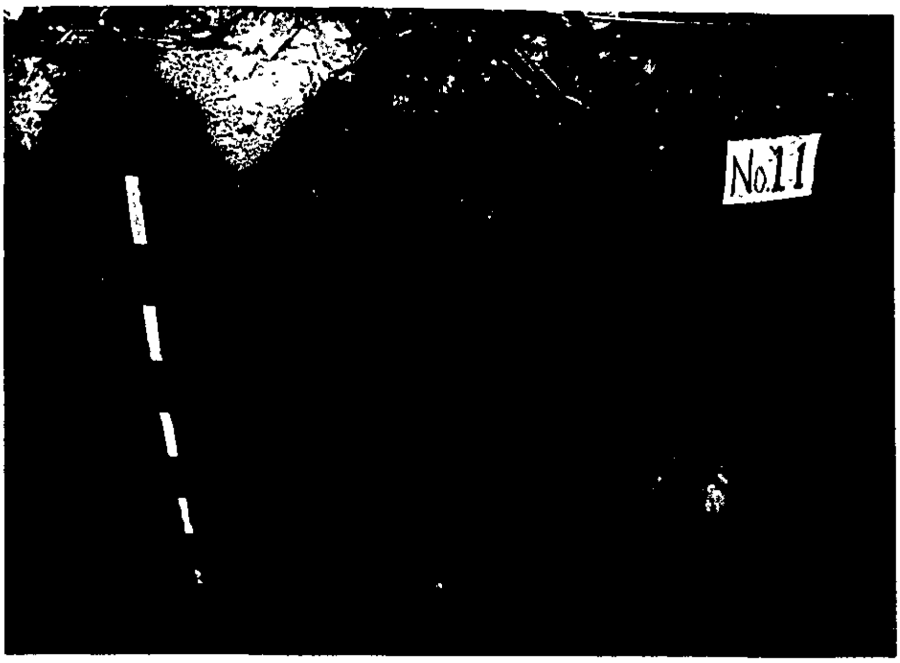


Photo III-4-3 Soil type III: Normal Acrisols, massive

Photo III-4-4 Soil type IV: Gley Acrisols

Photo III-4-5 Forest type A: soil type II

Photo III-4-6 Forest type M: soil type III

Photo III-4-7 Forest type B: soil type IV

So far as the profile shows, all these soils have weathered sandstone of coarse quartz particles as a parent material.

The hue is 10R for soil type I, 2.5YR and 10R for soil type II, 5YR and 2/5YR for soil type III, and 5YR and 7.5YR for soil type IV, proving that there are clear differences in color between soils. As shown in Fig. III-4-2, the altitude falls with soil type transition from I to III and to IV; namely, the soils turn more reducive under the influence of moisture.

In soil types I, II and III, the top soil is leached with accumulation thereunder, as demonstrated by microscopic analysis of soil colors and layers.

Fig. III-4-3 shows a profile morphology of typical soils by colors.

Referring to Fig. III-4-3, soil type I is red or dark red.

As it changes into types II and III, it is tinged with brown, changing from reddish brown to bright brown to bring gley characteristic to the fote. These chorographic color differences may probably reflect the susceptibility to water washing, reduction and oxidation. In support of this, the soil structures in the top layers mirror the differences in moisture environment.

The chemical properties of typical soils are as summerized in Table III-4-3. In Table III-4-3, the pH value of raw soil is almost equal to that of pH; fine soil. The pH value of raw soil measured at site with a portable pH meter is judged highly reliable, accordingly. As regards pH(H_2O), soil types I, II and III are in the range of about 5.0 to 6.0, while soil type IV is strongly acid with 3 to 4.

The difference between pH(H_2O) and pH(KCℓ) generally increases as it goes deeper from the topsoil down. At No. 12 were clayey accumulation is present, the difference is more than 1.0.

In the topsoil and gleyic soil, the difference is around 0.5 or less, showing the presence of violent leaching action.

Exchangeable Ca is distributed more in the lower than in the top layer. It tends to rise even in the bottom layer.

This tendency is also seen in CEC, intimating the conversion of organic into inorganic substances in the top layer and the clay movement in the lower layer.

At No. 12 where clay accumulation is seen, CEC is by far larger than in any other sandy loam, probably because the clay content is large.

Ca saturation is quite large at No. 5 and No. 6, not because Ca is abundant, but because CEC is extremely small.

At No. 12 where clay accumulation is seen, the saturation is as low as 10% or less.

Total nitrogen abounds in the top layer as is usually seen in typical soils. At No. 6 and No. 26, however, a slight increase in total nitrogen is seen in the lower layers.

The nitrogen distribution is considered to reflect the distribution of humus.

Referring to Table III-4-3, the soil characteristics are heavily influenced by the leaching action of ground water,

Table III-4-3 Characteristics of typical soils in Capiibary

Soil type	Soil No.	Horizon	Depth cm	Raw Soil pH	pH (H_2O)	pH (KCℓ)	Total nitrogen %	Exchangeable Ca me/100g	CEC me/100g	Ca Saturation %
I	6	AB	0-10	6.3	6.4	5.9	0.140	5.2	9.0	57.8
		B_{11}	10-30	5.7	6.0	5.4	0.025	1.4	4.1	34.1
		B_{12}	30-50	5.9	5.8	5.0	0.009	0.2	3.3	6.1
		B_{21}	50-80	5.1	4.9	3.9	0.008	1.0	5.3	18.9
		B_{22}	80-	5.1	5.0	3.9	0.011	1.1	5.3	20.8
II	5	AB	1-11	5.4	5.5	5.3	0.130	2.4	6.6	36.4
		B_{11}	11-25	5.5	5.4	5.0	0.056	2.0	4.5	44.4
		B_{12}	25-50	6.3	5.9	5.5	0.019	1.0	2.9	34.5
		B_{21}	50-70	6.2	5.7	5.4	0.017	1.0	2.9	34.5
		B_{22}	70-	6.2	5.9	5.1	0.016	1.6	3.7	43.2
III	26	HA	0- 3	5.6	5.9	-	1.310	-	-	-
		AB	3-24	5.1	5.3	4.5	0.040	-	-	-
		B_1	24-50	5.9	5.8	-	0.021	-	-	-
		B_{21}	50-80	6.0	6.1	5.4	0.016	-	-	-
		B_{22}	80-	5.9	6.1	5.3	0.022	-	-	-
IV	4	B_{11}	0-11	3.6	3.7	3.5	0.030	0.2	3.7	5.4
		B_{12}	11-30	4.0	3.9	3.6	0.008	0.2	2.9	6.9
		B_{21}(g)	30-70	4.6	4.4	4.0	0.008	0.2	2.9	6.9
		B_{22}(g)	70-	4.5	4.2	3.9	0.008	0.2	3.7	5.4
II (Clay accumula-tion)	12	AB	0-10	5.4	5.8	5.2	0.190	-	24.6	-
		B_1	10-38	5.8	5.9	4.9	0.054	-	17.2	-
		B_{21}	38-77	5.5	5.1	4.0	0.050	-	14.3	-
		B_{22}	77-	5.8	5.8	4.6	0.025	-	-	-

and the intensity of leaching action is governed by the chorographic features. The average chemical properties at a depth of 30 cm (AB, B1) were determined. Referring to Table III-4-4, the susceptibility to leaching action increases in the order of soil types I, II, III and IV. Thus, the soil productivity is considered to descend in the said order.

Table III-4-4 Major chemical properties (Aver. at 30 cm depth)

Soil type	pH(H_2O)	N %	Exchangeable Ca me/100g	CEC me/100g
I No.6	6.13	0.063	2.67	5.73
II No.5	5.52	0.077	1.98	5.00
III No.26	5.45	0.034	-	-
IV No.4	3.83	0.016	0.20	3.19
II No.12 (clay accumulation)	5.87	0.099	-	19.67

4-2-4 Soil Distribution

The soil distribution in the study area is shown in the attached drawing using soil types as stratigraphic units.

The distribution pattern shows a close resemblance to Fig. III-4-1 (topographic map). This is because the soil distribution is well in correspondence to chorography as shown in Fig. III-4-2. This distribution pattern has much in common with FAO's soil distribution (1980), though the latter's classification method is different from ours.

Namely, topographic features are also heavily reflected in FAO's map.

The western half of the study area is mainly accounted for by soil types I and II, while the eastern half is occupied conspicuously by soil type III and partly by soil type II.

In the western half, the progress of valley dissection is not so much. In the eastern half, the dissection is well advanced to produce complex terrains, showing a widespread distribution of soil type IV. Particularly in the eastern half, damp land are well developed in the flats spreading along the valleys, and the soils are turned gleyic.

The soil distribution is as follows.

Table III-4-5 Areas by soil types

Soil type	Area (ha)	Percentage (%)
I	1,370	5.0
II	19,353	71.1
III	2,518	9.2
IV	3,959	14.5
Rock	50	0.2
Total	27,250	100.0

According to this, type I and II of plane of plateau occupy 76%, valley slope is 15% and gentle slope on the valley head is 9%, as the results, plane or gentle slopes except valley on the head occupy 85%.

4-3 Soil Type and Forest Growth

The stand volume at 32 sample plots set up by forest type within the survey area for inventory were classified into 'all trees' and 'trees of medium diameter or larger' and tabulated by type of soil in Table III-4-6. Although the table shows large differences in the number of sample plots by soil type, the mean stand volume of trees 10 cm in diameter or larger tends to be larger in the order of Type I   Type II   Type III   Type IV soils. It also shows that the natural forests, on the whole, are growing normally on the plains of plateau but that the conditions of the forests are inferior in the valleys. The fact that the stand volume of trees with medium diameter or larger shows no particular tendency by soil type is probably because the commercially useful trees are felled.

Table III-4-7 shows the stand volumes per hectare of the survey area by type of soil, by tree species class. According to this table, stand volumes of C and D class trees tend to be larger on Type I soil, A and D classes on Type II soil and D and E classes on Type III soil. The stand volume for the area as a whole is 70.03 m^3 per hectare based on the weighted average of the forest resources inventory, with D class trees accounting for about 28% while A, B and C class trees which are considered commercially valuable or semi-valuable account for a total of 39.96 m^3 (57.1%), the breakdown of which is 15.45 m^3 (22.1%), 7.51 m^3 (10.7%) and 17.00 m^3 (24.3%), respectively.

Table III-4-6 Volume by soil types in Capiibary

(m^3)

Soil type I			Soil type II			Soil type III			Soil type IV		
Plot No.	Volume per ha		Plot No.	Volume per ha		Plot No.	Volume per ha		Plot No.	Volume per ha	
	10 cm up	41 cm up		10 cm up	41 cm up		10 cm up	41 cm up		10 cm up	41 cm up
6	90.04	54.60	1	84.81	38.81	2	51.48	24.93	4	41.46	1.70
19	78.95	40.50	3	47.26	19.34	11°	66.91	41.06			
20°	116.46	76.37	5	47.19	21.84	26	88.05	59.66			
27	655.84	34.70	7	68.21	31.19						
28	66.61	37.95	8°	90.22	61.30						
29	67.56	21.65	9	62.75	32.16						
30	88.01	43.13	10°	77.25	43.06						
31	88.01	5.93	12°	80.77	54.63						
32	65.70	25.54	13°	58.09	35.16						
			14	59.86	34.89						
			15°	80.84	38.39						
			16°	78.01	33.40						
			17°	61.14	24.89						
			18	83.09	52.00						
			21	54.46	26.36						
			22	91.40	37.43						
			23	80.89	38.28						
			24	75.29	23.95						
			25	52.27	20.34						
9	74.83	37.81	19	70.73	35.13	3	68.81	41.88	1	41.46	1.70

(Note) 1: The bottom line shows the mean values. 3: Mark (°) shows clay-accumulated soil.
2: The volume refers to barked trees.

Table III-4-7 Volume of trees by soil types and commercial tree classes, in Capiibary

Soil type \ Tree class		A	B	C	D	E	Defected tree	Total
I	m^3/ha	11.12	6.51	22.00	22.14	10.85	2.21	74.83
	%	14.9	8.7	29.4	29.6	14.5	2.9	100.0
II	m^3/ha	20.07	8.23	15.36	18.72	6.73	1.62	70.73
	%	28.4	11.6	21.7	26.5	9.5	2.3	100.0
III	m^3/ha	11.61	12.68	13.45	14.23	16.23	0.61	68.81
	%	16.9	18.4	19.5	20.7	23.6	0.9	100.0
IV	m^3/ha	0	0.48	5.07	25.37	9.74	0.80	41.46
	%	0	1.2	12.2	61.2	23.5	1.9	100.0
Total area	m^3/ha	15.45	7.51	17.00	19.99	8.42	1.66	70.03
	%	22.1	10.7	24.3	28.5	12.0	2.4	100.0

Note) For soil types I through IV, simple averages of sample plots were used, while for the entire area, weighted averages were used.

Table III-4-8 shows a frequency distribution of trees classified by soil types, commercial classes, tree heights and number of trees in order to provide the forest inventory by tree heights as well as a basis of a natural regeneration plan for native trees.

According to Table III-4-8, what appears most in every stand in the study area is Guatambú, Cadro and Kurupay as A class trees, Cancharan as B class tree, and Laurel hú, Urunde y pará and Gua ja y ví as C class trees. These species are generally high in appearance frequency irrespective of soil types.

As above, the mean stand volume per hectare of forest as of now is small at about 70 m^3, of which A + B class trees account for about 23 m^3. On Type I soil, C and D class trees tend to be comparatively abundant, on Type II soil, A and D classes, and on Type III soil, D and E classes. The stumps of selective cutting are large in number on Types I and II soil and fewer on Type III soil. From this, the stand volume in Types I and II soil is presumed to have been abundant in the past. Accordingly, the fostering of natural forests or the development of planted forests on soil Types I and II is considered adequately feasible. Although the environment of Type III soil is excessive in moisture, the development of planted forests seems quite possible although no vigorous growth may be expected. Tye IV soil is intensely affected by the leaching of nutrients and gleization. Topographically, it is susceptible to erosion and, what is more, as it lacks A + B class trees, the forest must be protected by prohibition of logging.

Table III-4-8 Appearance of primary species in Capiibary

Height class m	Species	Class	Tótral area No. of trees /ha	Tótral area Ratio %	1st type area No. of trees /ha	1st type area Ratio %	2nd type area No. of trees /ha	2nd type area Ratio %	3rd type area No. of trees /ha	3rd type area Ratio %	4th type area No. of trees /ha	4th type area Ratio %
26～30	Guatambú	A	1.40	34.4	1.75	33.3	1.50	42.1				
	Urunde y pará	C	0.63	25.0	1.50	55.6	0.50	15.8				
21～25	Cedro	A	1.80	43.8	0.50	22.2	2.50	57.9	0.75	33.3		
	Guatambú	A	7.90	78.1	5.50	55.6	9.75	89.5	5.00	100.0		
	Kurupay	A	2.10	43.8	0.25	11.1	3.25	63.2	0.75	33.3		
	Peterevý	A	0.70	28.1	0.50	22.2	0.75	31.6	0.75	33.3		
	Cancharana	B	2.43	59.4	3.25	55.6	2.00	63.2	2.50	66.7		
	Gua ja y ví	C	1.18	31.3	1.75	44.4	1.00	26.3	0.75	33.3		
	Laurel hú	C	2.73	56.3	3.50	66.7	2.50	52.6	0.75	33.3	2.50	
	Urunde y pará	C	2.50	59.4	4.25	77.8	2.00	57.9	0.75	33.3		
	Yvyrá pepé	C	1.80	34.4	1.00	33.3	2.25	36.8	1.75	33.3		
16～20	Cedro	A	1.40	34.4	0.75	22.2	1.50	36.8	2.50	66.7		
	Guatambú	A	6.03	31.3	4.75	88.9	7.25	89.5	4.25	66.7		
	Kurupay	A	1.33	37.5	1.00	33.3	1.50	42.1	0.75	33.3		
	Cancharana	B	3.35	65.6	4.00	77.8	3.00	63.2	5.00	66.7		
	Gua ja y ví	C	1.65	37.5	1.75	22.2	1.75	47.4	1.75	33.3		
	Laurel canela	C	1.18	28.1	3.00	55.6	0.50	21.1				
	Laurel hú	C	4.60	75.0	4.50	66.7	5.25	78.9	3.25	66.7	2.50	
	Urunde y pará	C	1.65	37.5	1.00	44.4	2.00	36.8	0.75	33.3		
	Yvyrá pepé	C	0.78	59.4	1.75	55.6	4.25	63.2	3.25	66.7		
11～15	Cedro	A	0.85	25.0	1.50	33.3	0.75	21.1	0.75	33.3		
	Guatambú	A	3.05	62.5	3.50	77.8	3.00	57.9	3.25	66.7		
	Cancharana	B	2.10	53.1	1.75	44.4	2.00	57.9	4.25	66.7		
	Laurel hú	C	4.45	75.0	3.50	66.7	4.75	73.7	5.00	100.0		
	Yvyra pepé	C	2.58	50.0	0.75	33.3	3.00	57.9	6.75	66.7		
6～10	Laurel hú	C	0.95	21.9	0.50	22.2	0.50	15.8	5.00	66.7		

(Note) This table shows useful trees that have more than 25% apperance in study area (in case of height class of 6 - 10 m includes one example of about 22%).

5. Forest Plantation Survey

Survey of the planted forest was conducted in order to select the appropriate species for afforestation in Capiibary, to estimate anticipated future yield and to analyze forest land productivity. The survey was conducted by selecting sample plots at near three planted areas and measuring the diameter of every tree and analyzing the results. As for the anticipated yield table and the forest productivity map, they were prepared only for Elliottii pine on account of limited data. For Parana pine and Caribbean pine, only the anticipated yield tables were cited as reference from existing data.

5-1 Growth and Yield

5-1-1 Survey Method

(1) Survey of sample plots

a. Areas surveyed

Survey was conducted in the following three areas.

1) Planted forest adjacent to the study area.
2) Planted forest in the vicinity of Stroessner, Department of Alto Parana.
3) Planted forest of El Dorado, Province of Misiones, Argentina.

Fig. III-5-1 shows the surveying location.

b. Size of plot

The size of a plot was decided to be 20 m x 25 m or 0.05 ha, and it was selected from among the areas that were the most typical of the stands subject to study.

c. Items measured

The following items were measured.

1) age of stand, 2) diameter breast height,
3) tree height, 4) number of trees, 5) soil,
6) topography, 7) slope

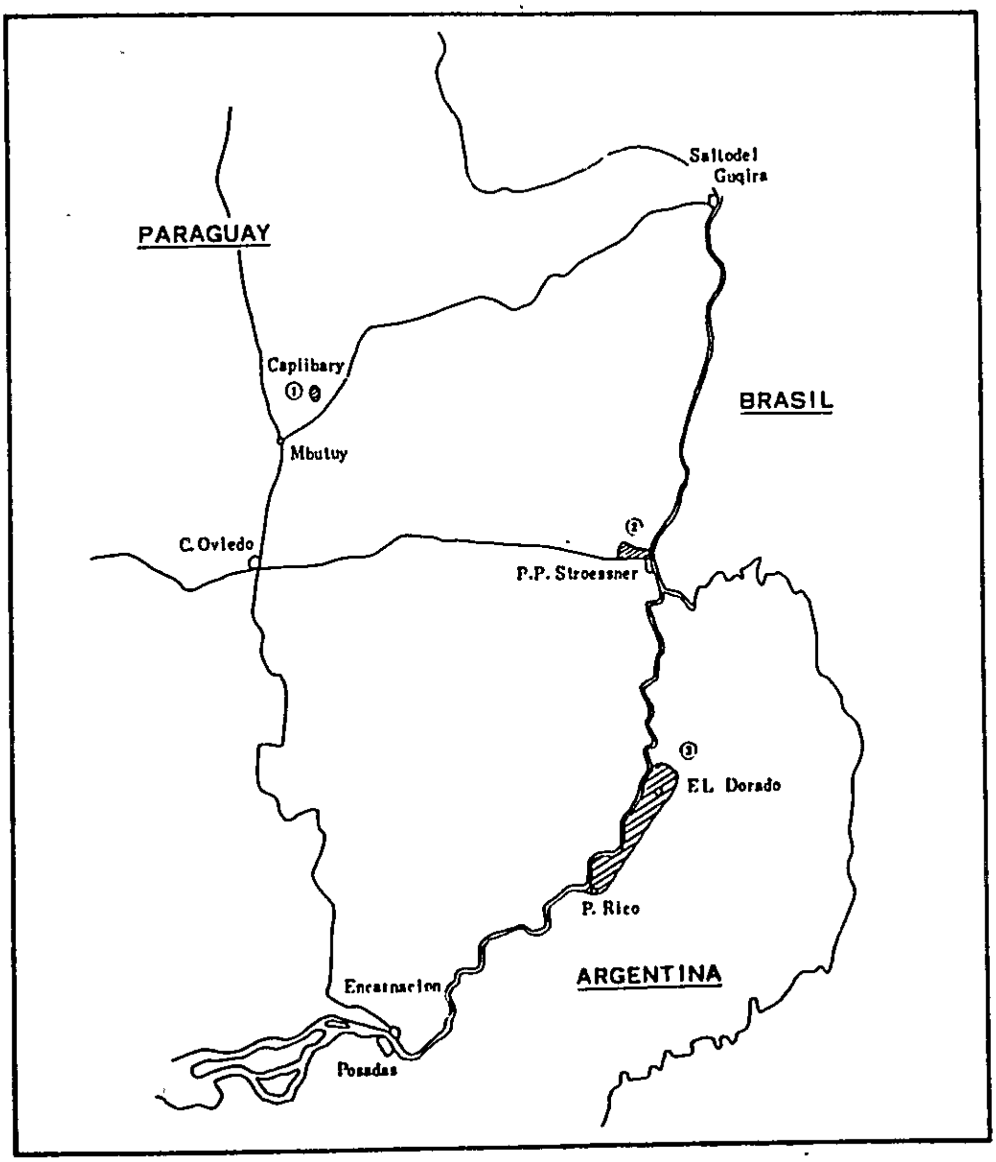


Fig. III-5-1 Surveyed area for planted forest (▨)

(2) Stem analysis

Stem analysis was conducted to make clear the increment progress. The method of stem analysis is as follows.

Type trees (average of the stand in tree height and diameter breast height) in the sample plots were felled. And took disks following the next illustrated figure, and measured four direction's radius at each year rings of each disks.

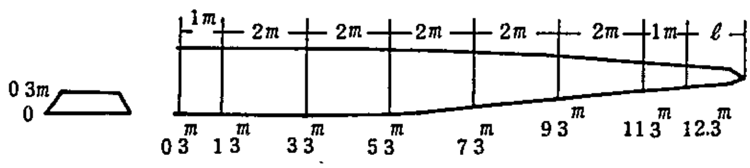


Fig. III-5-2 Positions where disks were

5-1-2 Results of Measurement

Survey was conducted on 11 sample plots in Capii-bary, 7 sample plots in Stroessner and 12 sample plots in Argentina (Province of Misiones), totalling 30 sample plots. Their breakdown by species is 19 Elliottii pine plots, 8 Parana pine plots and 3 Taeda pine plots. Findings are as summarized in Table III-5-1.

Stem analyses were conducted on 13 Elliottii pines and 3 Parana pines (Araucarias). Results of stem analyses are as presented in Table III-5-2.

Table III-5-1 Planted forest survey results

Elliottii pine

Serial No.	Stand age	Upper story tree height	Mean tree height	Mean d.b.h.	No. of trees/ha	Stem volume without bark/ha	Survey area
	Year	m	m	cm		m^3	
16	5	3.7	3.6	9.4	1,800	24.99	Stroessner
17	6	6.8	6.7	12.9	2,000	86.41	"
11	8	12.8	12.7	20.4	1,200	216.79	Capiibary
5	9	9.0	8.6	12.7	1,680	94.01	"
15	9	14.5	14.1	16.8	2,360	331.41	Misiones
1	10	8.8	8.5	13.0	1,740	101.68	Capiibary
8	10	12.5	11.8	15.4	1,160	123.06	"
9	11	12.4	11.7	15.8	1,720	186.52	"
14	11	11.8	11.6	16.0	2,220	239.02	Misiones
2	12	11.5	11.2	15.4	1,620	177.68	Capiibary
3	12	11.1	10.6	16.3	1,520	169.18	"
4	12	12.7	12.4	15.8	2,140	244.22	"
7	12	13.5	13.1	17.3	1,580	224.38	"
6	13	15.0	14.9	17.9	1,720	283.75	"
10	13	16.5	16.2	22.0	920	267.09	"
13	14	19.0	19.0	21.7	1,140	333.05	Misiones
19	15	21.5	20.7	22.3	900	313.09	Stroessner
18	16	21.5	21.2	22.9	1,120	401.78	"
12	17	21.3	21.0	24.4	860	344.49	Misiones

Parana pine (Araucaria)

Serial No.	Stand age	Upper story tree height	Mean tree height	Mean d.b.h.	No. of trees/ha	Stem volume without bark/ha	Survey area
3	4	3.7	3.7	7.4	1,200	9.63	Misiones
8	7	10.5	10.4	13.1	1,460	91.74	Stroessner
1	8	9.1	9.1	14.1	1,900	125.79	Misiones
2	11	12.0	11.9	18.1	1,280	172.29	"
6	13	16.6	15.0	19.9	1,140	255.24	Stroessner
7	15	19.1	16.3	21.5	1,000	290.31	"
4	20	19.0	18.8	25.8	560	229.06	Misiones
5	22	19.6	19.6	29.8	400	219.73	"

Taeda pine

Serial No.	Stand age	Upper story tree height	Mean tree height	Mean d.b.h.	No. of trees/ha	Stem volume without bark/ha	Survey area
2	6	10.2	9.9	15.0	1,820	149.36	Misiones
3	7	10.6	10.3	14.8	2,020	172.13	"
1	10	14.5	13.6	17.7	1,460	237.61	"

Table III-5-2 Stem analysis results

(1) Elliottii pine

a) Tree height (m)

No. of year rings \ Sample plot	1	2	3	4	5	6	7	8	9	13	16	17	*	Total	Mean
1	1.3	1.2	1.2	1.6	0.9	2.4	3.1	1.1	2.8	1.8	0.8	0.8	1.3	20.3	1.6
2	2.1	2.0	3.3	2.3	2.0	4.8	3.9	2.6	3.9	3.5	1.5	2.4	2.3	36.6	2.8
3	3.1	4.0	4.2	3.8	2.8	6.5	4.8	4.3	4.8	5.3	2.3	4.8	2.9	53.6	4.1
4	4.5	5.2	5.3	6.2	3.9	8.8	6.0	5.6	6.6	7.2	4.3	6.3	3.5	73.4	5.6
5	6.3	6.8	5.8	7.8	4.9	10.0	7.8	6.4	8.4	9.2	5.0	7.4		85.8	7.2
6	7.8	7.9	6.3	8.9	6.3	11.3	8.7	8.2	9.8	10.4		7.9		93.5	8.5
7	8.2	8.6	8.5	9.8	7.8	11.8	10.4	9.4	10.5	11.6				96.6	9.7
8	8.6	7.5	9.9	10.8	8.3	12.6	12.2	10.3	11.7	12.3				106.2	10.6
9	9.4	10.1	10.3	12.5	8.7	14.1	13.3	11.6	12.8	13.3				116.1	11.6
10	9.5	11.1	11.7	13.0		15.2	14.3	12.6	14.2	15.0				116.8	13.0
11		12.0	12.5	13.6		16.2	14.6		14.5	16.4				99.8	14.3
12		12.3	12.8	14.0		16.8	14.9			17.6				88.4	14.7
13						17.6				18.3				35.9	18.0
14										19.2				19.2	19.2

b) Diameter breast height without bark (1.3m) . (cm)

No. of year rings \ Sample plot	1	2	3	4	5	6	7	8	9	13	16	17	*	Total	Mean
1	-	-	-	0.6	-	1.4	0.7	-	1.9	0.9	-	-	-	5.5	1.1
2	1.6	1.0	0.9	1.9	1.3	2.9	2.0	1.9	3.4	4.3	0.6	1.8	1.6	25.2	1.9
3	3.3	3.9	1.4	4.8	2.9	6.3	6.4	4.0	4.7	8.1	2.4	5.4	2.9	56.5	4.3
4	5.0	6.1	2.6	6.4	5.1	9.2	9.2	5.4	6.1	10.9	6.4	7.8	4.8	85.0	6.5
5	7.0	7.6	5.5	8.0	7.5	11.2	11.1	7.4	7.1	13.6	7.3	10.3		103.6	8.6
6	8.8	8.5	7.4	8.7	8.6	12.3	12.1	9.2	8.3	15.4		10.7		110.2	10.0
7	10.0	9.8	9.5	9.9	9.5	13.1	13.6	10.5	9.7	16.5				112.1	11.2
8	10.5	10.6	10.5	11.3	10.1	13.7	15.1	11.1	10.9	17.1				121.1	12.1
9	11.3	11.5	11.0	12.4	10.3	14.6	16.0	12.1	11.8	17.8				128.8	12.9
10	11.5	11.7	11.9	13.2		15.1	16.6	12.6	13.0	18.5				124.1	13.8
11		12.1	12.8	14.2		15.5	17.4		13.6	19.1				104.7	15.0
12		12.2	13.0	14.5		16.1	17.7			19.4				92.7	15.5
13						16.4				19.6				36.0	18.0
14										19.9				19.9	19.9
With bark	12.3	13.8		16.0	11.5	18.1	19.3	13.9	15.2	21.9	8.5	12.0	5.7	-	-

Table III-5-2 (Cont.)

c) Stem volume without bark (m^3)

No.of year rings \ Sample plot	1	2	3	4	5	6	7	8	9	13	16	17	*	Total	Mean
1	0.0001	0.0002	0	0.0001	0	0.0004	0.0001	0.0002	0.0007	0.0005	0.0001	0	0.0001	0.0025	0.0002
2	0.0006	0.0006	0.0002	0.0008	0.0005	0.0020	0.0011	0.0010	0.0025	0.0041	0.0008	0.0009	0.0005	0.0156	0.0012
3	0.0024	0.0034	0.0005	0.0048	0.0018	0.0091	0.0094	0.0039	0.0051	0.0159	0.0024	0.0065	0.0019	0.0671	0.0052
4	0.0050	0.0087	0.0018	0.0108	0.0057	0.0243	0.0218	0.0074	0.0105	0.0359	0.0091	0.0168	0.0048	0.1626	0.0125
5	0.0110	0.0166	0.0069	0.0204	0.0126	0.0432	0.0379	0.0152	0.0170	0.0691	0.0120	0.0322		0.2941	0.0245
6	0.0207	0.0237	0.0145	0.0271	0.0183	0.0611	0.0477	0.0285	0.0288	0.1036		0.0371		0.4111	0.0374
7	0.0285	0.0334	0.0300	0.0368	0.0236	0.0736	0.0661	0.0406	0.0429	0.1370				0.5145	0.0515
8	0.0332	0.0431	0.0393	0.0547	0.0324	0.0871	0.0716	0.0511	0.0610	0.1591				0.6526	0.0653
9	0.0440	0.0551	0.0478	0.0731	0.0353	0.1073	0.1147	0.0673	0.0768	0.1892				0.8106	0.0811
10	0.0471	0.0630	0.0659	0.0895		0.1252	0.1309	0.0799	0.1031	0.2266				0.9312	0.1035
11	0.	0.0748	0.0793	0.1091		0.1435	0.1546		0.1208	0.2546				0.9367	0.1338
12	0.	0.0778	0.0857	0.1204		0.1678	0.1726			0.2816				0.9057	0.1510
13	0.					0.1872				0.3121				0.4993	0.2497
14	0.									0.3328				0.3328	0.3328
With bark	0.0542	0.0940	0.1056	0.1533	0.0427	0.2140	0.1776	0.0731	0.1500	0.3977	0.0163	0.0468	0.0067	-	-

(2) Parana pine (Araucaria)

a) Tree height

No.of year rings \ Sample plot	1	2	3	Total	Mean
1	1.3	0.7	0.7	2.2	0.9
2	2.4	2.0	1.4	5.8	1.9
3	4.1	4.2	3.6	11.9	4.0
4	6.1	6.0	4.3	16.4	5.5
5	7.0	8.2		15.2	7.6
6	9.0	10.4		19.4	9.7
7	9.6	11.4		21.0	10.5
8	10.2	11.8		22.0	11.0
9		12.1		12.1	12.1
10		12.5		12.5	12.5
11		12.7		12.7	12.7

b) Stem volume without bark (m^3)

No.of year rings \ Sample plot	1	2	3	Total	Mean
1	0.0001	0.0001	0	0.0002	0.0001
2	0.0007	0.0009	0.0003	0.0019	0.0006
3	0.0038	0.0035	0.0039	0.0112	0.0037
4	0.0125	0.0129	0.0085	0.0339	0.0113
5	0.0247	0.0264		0.2887	0.1444
6	0.0407	0.0441		0.0848	0.0424
7	0.0581	0.0668		0.1249	0.0625
8	0.0677	0.0851		0.1528	0.0764
9		0.0995		0.0995	0.0973
10		0.1153		0.1153	0.1153
11		0.1268		0.1268	0.1268
With bark	0.0892	0.1554	0.0108	-	-

c) Diameter breast height without bark (1.3m) (cm)

No.of year rings \ Sample plot	1	2	3	Total	Mean
1	-	-	-	-	-
2	1.7	0.9	0.2	2.8	0.9
3	4.2	3.8	4.2	12.2	4.1
4	7.0	7.0	6.2	20.2	6.7
5	8.9	9.1		18.0	9.0
6	10.4	10.7		21.1	10.6
7	11.7	12.3		24.0	12.0
8	12.2	13.0		25.2	12.6
9		13.6		13.6	13.6
10		14.4		14.4	14.4
11		14.9		14.9	14.9
With bark	13.8	16.3	7.0	-	-

5-1-3 Preparation of Volume Table

A table of volume without bark was prepared using the yearly diameter without bark, tree height and stem volume obtained by the stem analysis.

This volume table is to get the value of volume without bark from the value of diameter breast height with bark.

To obtain the diameter with bark, the following formula was derived from the relationship between the diameter with bark and the diameter without bark at each sectional height.

$$D = -0.3178 + 1.1177d$$

in which D: Diameter with bark
d: Diameter without bark
No. of data: 116

Using the above equation, the diameter with bark was computed from the diameter without bark measured for each tree age in the stem analysis.

When these diameters and the stem volumes obtained by the stem analysis are plotted on a logarithmic graph paper (with logarithmic scale on both axes), a point of inflection is seen to occur at around 9 cm in diameter so that volume equations were derived separately for diameters below 11 cm and for diameters above 7 cm (with duplication between 7 cm and 11 cm).

On trees with diameter above 11 cm:

$$\log V = -5.632901 + 1.792375 \log D + 0.464325 \log H$$

Multiple correlation coefficient $r_{V \cdot D \cdot H} = 0.993$

On trees with diameter above 7 cm:

$$\log V = -6.494117 + 2.051205 \log D + 0.893010 \log H$$

Multiple correlation coefficient ($r_{V \cdot D \cdot H}$) = 0.995

The volume table, Table III-5-3, was prepared by the use of the above regression equations for volume estimation.

Table III-5-3 Stem volume table of Elliottii pine (m^3)

d.b.h. (cm) / Tree height (m)	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
2	0.0024	0.0049																	
3	0.0029	0.0060	0.0083	0.0127															
4	0.0033	0.0068	0.0101	0.0154	0.0203	0.0279	0.0367												
5	0.0037	0.0076	0.0117	0.0180	0.0248	0.0341	0.0448	0.0570	0.0708										
6	0 0040	0.0082	0.0132	0.0203	0.0292	0.0401	0.0527	0.0671	0.0833	0.1013									
7	0 0043	0.0088	0.0147	0.0226	0.0335	0.0460	0.0605	0.0770	0.0956	0.1162	0.1390								
8	0.0045	0.0094	0.0161	0.0247	0.0378	0.0518	0.0681	0.0868	0.1077	0.1310	0.1565	0.1845							
9	0.0048	0.0099	0.0174	0.0268	0.0420	0.0576	0.0757	0.0964	0.1197	0.1455	0.1739	0.2049	0.2386						
10	0.0050	0.0104	0.0187	0.0288	0.0461	0.0632	0.0832	0.1059	0.1315	0.1598	0.1911	0.2252	0.2621	0.3020					
11	0.0053	0.0109	0.0200	0.0307	0.0502	0.0689	0.0906	0.1153	0.1431	0.1740	0.2080	0.2452	0.2854	0.3288	0.3753				
12	0.0055	0.0114	0.0212	0.0325	0.0543	0.0744	0.0979	0.1246	0.1547	0.1881	0.2249	0.2650	0.3085	0.3554	0.4057	0.4594			
13	0.0057	0.0118	0.0224	0.0344	0.0583	0.0799	0.1051	0.1339	0.1662	0.2020	0.2415	0.2846	0.3313	0.3817	0.4357	0.4934	0.5548		
14	0.0059	0.0122	0.0235	0.0361	0.0623	0.0854	0.1123	0.1430	0.1775	0.2159	0.2580	0.3041	0.3540	0.4078	0.4655	0.5272	0.5928	0.6623	
15	0.0061	0.0126	0.0247	0.0379	0.0662	0.0908	0.1195	0.1521	0.1888	0.2296	0.2744	0.3234	0.3765	0.4337	0.4951	0.5607	0.6304	0.7044	0.7825
16			0.0258	0.0396	0.0701	0.0962	0.1266	0.1611	0.2000	0.2432	0.2907	0.3426	0.3988	0.4595	0.5245	0.5940	0.6678	0.7462	0.8290
17			0.0268	0.0412	0.0740	0.1016	0.1336	0.1701	0.2111	0.2567	0.3069	0.3617	0.4210	0.4850	0.5537	0.6270	0.7050	0.7877	0 8751
18			0.0279	0.0429	0.0779	0.1069	0.1406	0.1790	0.2222	0.2702	0.3230	0.3806	0.4431	0.5104	0.5827	0.6598	0.7419	0.8287	0.9209
19				0.0445	0.0818	0.1122	0.1475	0.1879	0.2332	0.2835	0 3389	0.3994	0.4650	0.5357	0.6115	0.6925	0.7786	0.8699	0.9665
20				0.0460	0.0856	0.1175	0.1545	0.1967	0 2441	0.2968	0.3548	0.4181	0 4868	0.5608	0.6402	0.7249	0.8151	0.9107	1.0117
21				0.0476	0.0894	0.1227	0.1613	0.2054	0.2550	0.3100	0.3706	0.4368	0.5085	0.5858	0.6687	0.7572	0.8514	0.9513	1.0568
22					0.0932	0.1279	0.1682	0.2141	0.2658	0.3232	0.3863	0.4553	0.5300	0.6106	0.6970	0.7893	0.8875	0.9916	1.1016
23					0.0970	0.1331	0.1750	0.2228	0.2766	0.3363	0.4020	0.4737	0.5515	0.6353	0.7253	0.8213	0.9235	1.0318	1.1462
24						0.1382	0.1818	0.2314	0.2873	0.3493	0.4176	0.4921	0.5729	0.6599	0.7534	0.8531	0.9592	1.0717	1.1906
25						0.1434	0.1885	0.2400	0.2979	0.3623	0.4331	0.5103	0.5941	0.6844	0.7813	0.8848	0.9948	1.1115	1.2348
26							0.1952	0.2486	0.3086	0.3752	0.4485	0.5285	0.6153	0.7088	0.8092	0.9163	1.0303	1.1511	1.2789
27							0.2019	0.2571	0.3191	0.3881	0.4639	0.5466	0.6364	0.7331	0.8369	0.9477	1.0656	1.1906	1.3227
28								0.2656	0.3297	0.4009	0.4792	0.5647	0.6574	0.7573	0.8645	0.9790	1.1008	1.2299	1.3664
29								0.2741	0.3402	0.4136	0.4944	0.5827	0.6783	0.7814	0.8921	1.0102	1.1358	1.2691	1.4099
30									0.3506	0.4263	0.5096	0.6006	0.6992	0.8055	0.9195	1.0412	1.1708	1.3081	1.4532

(Note) 1. Diameter breast height is with bark (cm).
2. Volume is without bark (m^3).

5-1-4 Preparation of Anticipated Yield Table

(1) Tree height

The growth curve of mean tree height was derived from the tree heights of upper story in the sample areas. Result is as follows.

$$1/\sqrt{H} = 0.1125 + 0.1827 \times (10/A)$$

correlation coefficient : 0.913

standard deviation : 2.32

(Note) H : mean upper story height
A : stand age

Mean tree heights relative to stand age by site classes were obtained from the value of above mentioned equation, by amendment as final step with due consideration to the distribution of mean tree height.

Result is presented in Table III-5-4.

(2) Diameter breast height

Diameter breast height relative to stand age was obtained by indicating these relationship and by amendment from the relationship of height and diameter.

Result is presented in Table III-5-5.

(3) Number of trees per hectare

Number of trees per hectares relative to stand age was obtained by indicating these relationship and by amendment from the relationship of diameter and number of trees.

Result is presented in Table III-5-6.

(4) Stem volume per hectare and mean volume per single tree

The relationship of stem volume per hectare and that of mean volume per single tree to stand age were illustrated, then modified in relation to tree height, diameter breast height and number of tree per hectare, and determined the stem volume per hectare and mean volume per single tree.

The results are presented in Table III-5-6.

Table III-5-4 Stand age and mean tree height

Stand age \ Tree height \ Site	1		2	
	Range	Mean	Range	Mean
	m	m	m	m
1	1.2 - 1.6	1.4	0.8 - 1.2	1.0
2	2.0 - 2.6	2.3	1.4 - 2.0	1.7
3	2.9 - 3.8	3.3	2.0 - 2.9	2.5
4	4.1 - 5.3	4.7	2.9 - 4.1	3.5
5	5.5 - 7.2	6.3	3.9 - 5.5	4.7
6	7.0 - 9.1	8.1	4.9 - 7.0	6.0
7	8.6 - 11.2	9.9	6.0 - 8.6	7.3
8	10.2 - 13.3	11.7	7.1 - 10.2	8.7
9	11.8 - 15.3	13.6	8.3 - 11.8	10.0
10	13.3 - 17.3	15.3	9.3 - 13.3	11.3
11	14.7 - 19.1	16.9	10.3 - 14.7	12.5
12	16.0 - 20.8	18.4	11.2 - 16.0	13.6
13	17.2 - 22.4	19.8	12.0 - 17.2	14.6
14	18.3 - 23.8	21.0	12.8 - 18.3	15.6
15	19.3 - 25.1	22.2	13.5 - 19.3	16.4
16	20.2 - 26.3	23.2	14.1 - 20.2	17.2
17	21.0 - 27.3	24.2	14.7 - 21.0	17.9
18	21.7 - 28.2	25.0	15.2 - 21.7	18.4
19	22.3 - 29.0	25.6	15.6 - 22.3	19.0
20	22.8 - 29.6	26.2	16.0 - 22.8	19.4
21	23.3 - 30.3	26.8	16.3 - 23.3	19.8
22	23.7 - 30.8	27.3	16.6 - 23.7	20.1
23	24.0 - 31.2	27.6	16.8 - 24.0	20.4
24	24.2 - 31.5	27.8	16.9 - 24.2	20.6
25	24.4 - 31.7	28.0	17.1 - 24.4	20.7

Table III-5-5 Stand age and diameter breast height

Stand age \ Diameter \ Site	1		2	
	Range	Mean	Range	Mean
	m	m	m	m
1	1.2 - 1.6	1.4	1.0 - 1.2	0.8
2	2.2 - 2.9	2.5	1.5 - 2.2	1.9
3	3.9 - 5.1	4.5	2.7 - 3.9	3.3
4	5.9 - 7.7	6.8	4.1 - 5.9	5.0
5	8.1 - 10.5	9.3	5.7 - 8.1	6.9
6	10.3 - 13.4	11.8	7.2 - 10.3	8.8
7	12.4 - 16.1	14.3	8.7 - 12.4	10.5
8	14.4 - 18.7	16.6	10.1 - 14.4	12.2
9	16.3 - 21.2	18.7	11.4 - 16.3	13.9
10	18.1 - 23.5	20.8	12.7 - 18.1	15.4
11	19.8 - 25.7	22.8	13.9 - 19.8	16.8
12	21.4 - 27.8	24.6	15.0 - 21.4	18.2
13	22.9 - 29.8	26.3	16.0 - 22.9	19.5
14	24.3 - 31.6	27.9	17.0 - 24.3	20.7
15	25.6 - 33.3	29.4	17.9 - 25.6	21.8
16	26.8 - 34.8	30.8	18.8 - 26.8	22.8
17	27.8 - 36.1	32.0	19.5 - 27.8	23.6
18	28.7 - 37.3	33.0	20.1 - 28.7	24.4
19	29.5 - 38.4	33.9	20.7 - 29.5	25.1
20	30.2 - 39.3	34.7	21.1 - 30.2	25.7
21	30.8 - 40.0	35.4	21.6 - 30.8	26.2
22	31.3 - 40.7	36.0	21.9 - 31.3	26.6
23	31.8 - 41.3	36.6	22.3 - 31.8	27.0
24	32.2 - 41.9	37.0	22.5 - 32.2	27.4
25	32.6 - 42.4	37.5	22.8 - 32.6	27.7

Table III-5-6 Number of trees per hectare, stem volume and volume per single tree

Stand age	1st site class			2nd site class		
	No. of trees/ha	Volume/ha	Mean volume	No. of trees/ha	Volume/ha	Mean volume
		m^3	m^3		m^3	m^3
1						
2						
3						
4						
5	2,353	60.0	0.0255			
6	2,011	92.3	0.0459			
7	1,721	130.5	0.0758	2,218	55.9	0.0252
8	1,477	169.0	0.1144	2,014	86.4	0.0429
9	1,272	206.1	0.1620	1,831	117.9	0.0644
10	1,099	239.3	0.2177	1,667	148.4	0.0890
11	953	268.6	0.2818	1,520	176.9	0.1164
12	833	294.2	0.3532	1,389	202.9	0.1461
13	735	316.7	0.4309	1,272	226.3	0.1779
14	654	336.3	0.5142	1,168	247.0	0.2115
15	588	353.5	0.6012	1,076	265.1	0.2464
16	535	369.0	0.6897	995	280.8	0.2822
17	492	382.0	0.7764	924	294.0	0.3182
18	457	393.2	0.8606	862	305.1	0.3539
19	430	403.2	0.9377	808	314.1	0.3887
20	409	411.9	1.0071	762	321.6	0.4220
21	393	419.5	1.0674	723	327.7	0.4532
22	381	426.1	1.1184	691	332.7	0.4816
23	372	431.7	1.1605	665	336.8	0.5064
24	366	436.4	1.1923	645	340.2	0.5274
25	362	440.2	1.2160	629	343.1	0.5454

(Note) Volume indicates stem volume without bark.

(5) Preparation of anticipated yield table (Elliottii pine)

An anticipated yield table (Elliottii pine planted forest) was prepared by adjusting collectively the mean upper story tree height, mean diameter breast height, number of trees per hectare, stem volume per hectare and mean volume per single tree.

Result is presented in Table III-5-7.

On the assumptions in the preparation of anticipated yield table are as follows:

1) classification of site: 1st and 2nd

2) number of trees to be planted: 2,000 per hectare

3) cutting period: 25 years

4) thinning: Fig. III-5-3 shows the relationship between thinning period and the number of trees to be cut.

For reference, relationships of each factors at the time of thinning are tabulated in Table III-5-8, according to which the final cutting volume is 440 m^3 and total increment is 739 m^3 for the 1st site class, and 343 m^3 and 535 m^3 respectively for the 2nd site class.

Table III-5-7 Anticipated yield table for Elliottii pine stand

(1st site class)

Stand age	Mean			Per hectare			Mean increment
	d.b.h.	Height	Volume per single tree	No. of trees	Volume	Thinning volume	
1	cm	m	m^3		m^3	m^3	m^3
2							
3	4.5	3.3					
4	6.8	4.7					
5	9.3	6.3					
6	11.8	8.1					
7	14.3	9.9	0.0758	953	72	62	19
8	16.6	11.7	0.1144	953	109		21
9	18.7	13.6	0.1620	953	154		24
10	20.8	15.3	0.2177	953	207		27
11	22.8	16.9	0.2818	535	151	118	30
12	24.6	18.4	0.3532	535	189		31
13	26.3	19.8	0.4309	535	231		32
14	27.9	21.0	0.5142	535	275		33
15	29.4	22.2	0.6012	535	322		33
16	30.8	23.2	0.6897	362	250	119	34
17	32.0	24.2	0.7764	362	281		34
18	33.0	25.0	0.8606	362	312		34
19	33.9	25.6	0.9377	362	339		34
20	34.7	26.2	1.0071	362	365		33
21	35.4	26.8	1.0674	362	386		33
22	36.0	27.3	1.1184	362	405		32
23	36.6	27.6	1.1605	362	420		31
24	37.1	27.8	1.1923	362	432		30
25	37.5	28.0	1.2160	362	440		30

(Note) Volume indicates stem volume without bark.

Table III-5-7 Anticipated yield table for Elliottii pine stand (Cont.)

(2nd site class)

Stand age	Mean			Per hectare			Mean increment
	d.b.h.	Height	Volume per single tree	No. of trees	Volume	Thinning volume	
1	cm	m	m^3		m^3	m^3	m^3
2							
3	3.3	2.5					
4	5.0	3.5					
5	6.9	4.7					
6	8.8	6.0					
7	10.5	7.3					
8	12.2	8.7					
9	13.9	10.0	0.0644	1,272	82	37	13
10	15.4	11.3	0.0890	1,272	113		15
11	16.8	12.5	0.1164	1,272	148		17
12	18.2	13.6	0.1461	1,272	186		19
13	19.5	14.6	0.1779	862	153	73	20
14	20.7	15.6	0.2115	862	182		21
15	21.8	16.4	0.2464	862	212		21
16	22.8	17.2	0.2822	862	243		22
17	23.6	17.9	0.3182	862	274		23
18	24.4	18.4	0.3539	629	223	82	23
19	25.1	19.0	0.3887	629	244		23
20	25.7	19.4	0.4220	629	265		23
21	26.2	19.8	0.4532	629	285		23
22	26.6	20.1	0.4816	629	303		23
23	27.0	20.4	0.5064	629	319		22
24	27.4	20.6	0.5274	629	332		22
25	27.7	20.7	0.5454	629	343		21

(Note) Volume indicates stem volume without bark.

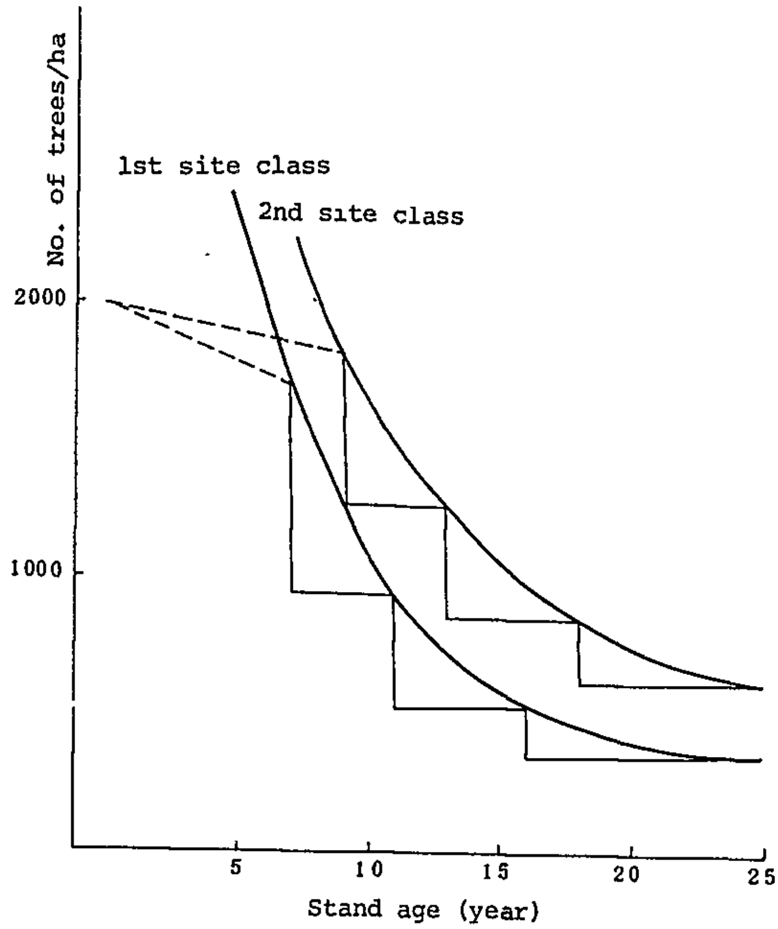


Fig. III-5-3 No. of trees per hectare relative to thinning

Table III-5-8 Stand factors at the final cutting and thinning

Site	Stand age (year)	Height (m)	d.b.h. (cm)	Volume			Total increment (m³)	Mean increment (m³)
				Main trees (m³)	Thinnings (m³)	Cumulate thinnings (m³)		
1	7	9.9	14.3	72	62	62	134	19
	11	16.9	22.8	151	118	180	331	30
	16	23.2	30.8	250	119	299	549	34
	25	28.0	37.5	440	-	-	739	30
2	9	10.0	13.9	82	37	37	119	13
	13	14.6	19.5	153	73	110	263	20
	18	18.4	24.4	223	82	192	415	23
	25	20.7	27.7	343	-	-	535	21

5-1-5 The Others Anticipated Yield Table

Table III-5-9 is the yield table of Parana pine stand in the Province of Misiones, Argentina, and Table III-5-10 is the yield table of Caribbean pine stand near São Paulo, Brazil compiled from collected data.

Table III-5-9 Anticipated yield table for Parana pine

In the province of Misiones, Argentina
(1st site class)

Year	No. of trees	Mean d.b.h.	Annual increment	Stand tree volume		
				Main trees	Thinnings	Total
	/ha	cm	m^3	m^3	m^3	m^3
4	2,250	6.6	11.4	27.00	-	27.00
5	2,000	8.4	26.7	38.40	-	38.40
6	1,750	10.0	18.24	65.10	-	65.10
7	800	11.7	18.01	48.00	35.34	83.34
8	715	13.4	20.48	60.91	5.10	101.35
9	612	15.2	21.01	74.33	7.07	121.84
10	565	16.9	21.82	87.46	7.88	142.85
11	505	18.6	24.14	99.98	9.29	164.66
12	447	20.5	26.27	112.64	11.48	188.81
13	398	22.1	27.04	126.56	12.35	215.08
14	352	23.8	23.78	138.97	14.63	242.11
15	313	25.6	22.84	147.24	15.40	265.90
16	280	27.3	22.03	154.56	15.52	288.73
17	255	29.1	20.68	162.79	13.80	310.76
18	236	30.8	19.26	171.34	12.13	320.64
19	223	32.6	18.84	181.16	9.43	350.70
20	215	34.5		193.50	6.50	369.54

Table III-5-10 Anticipated yield table for Caribbean pine

(near São Paulo, Brazil)

Site	Stand age (year)	Mean height (m)	No. of trees	Volume (m^3)	Thinnings (m^3)
1st	1	-	2,500	-	-
	7	13.29	1,500	350	70
	10 - 12	17.00	900	480	114
	14 - 17	21.00	540	595	118
	18 - 26	23.00	324	652	140
	35 - 40	28.00	-	670	-
2nd	1	-	4,444	-	-
	6	9.50	2,222	226	63
	10 - 12	13.00	1,333	300	99
	14 - 18	17.00	800	379	102
	18 - 25	21.00	480	428	105
	35 - 37	27.00	-	519	-
3rd	1	-	2,500	-	-
	7	9.00	1,500	158	35
	10 - 12	11.50	900	195	47
	14 - 17	14.80	540	342	59
	18 - 26	17.50	324	271	67
	35 - 40	23.00	-	338	-

5-2 Preparation of Forest Productivity Map

5-2-1 Primary Factor Analysis

The preparation of forest productivity map, using data of Elliottii pine, was conducted by the following measure.

(1) Forest productivity factors

Picked up soil, slope and topography which were considered most relevant forest productivity, and classified respectively as shown in Table III-5-11.

Table III-5-11 Forest productivity factors

Category \ Item	Soil	Slope	Topography
1	Granular	0 - below 3°	Upper plain of plateau
2	Blocky	3° - 6°	Plain of plateau
3	Massive	6° - 9°	Gentle slope on the valley head
4	Gley	9° - 12°	Valley slope
5	Rock, etc.	Above 12°	Monadnock

(2) Interpretation of productivity factors

Based on the coordinates entered on a topographic map on the scale of 1/50,000, 2.5 x 2.5 cm (25 ha) meshes were drawn on the map of the study area on the scale of 1/20,000, productivity factors were interpreted by each mesh.

The number of interpreted mesh are 1,199.

(3) Multivariate analysis

Multivariate analysis was conducted by using site classification of each sample plots as the external standard.

Using the results of this calculation, normal distribution curve in Fig. III-5-4 was drawn.

$$f(x) = \frac{1}{\sqrt{2\pi}\sigma} \times e^{-\frac{(x-\mu)^2}{2\sigma^2}} \qquad x : \text{arbitrary value}$$

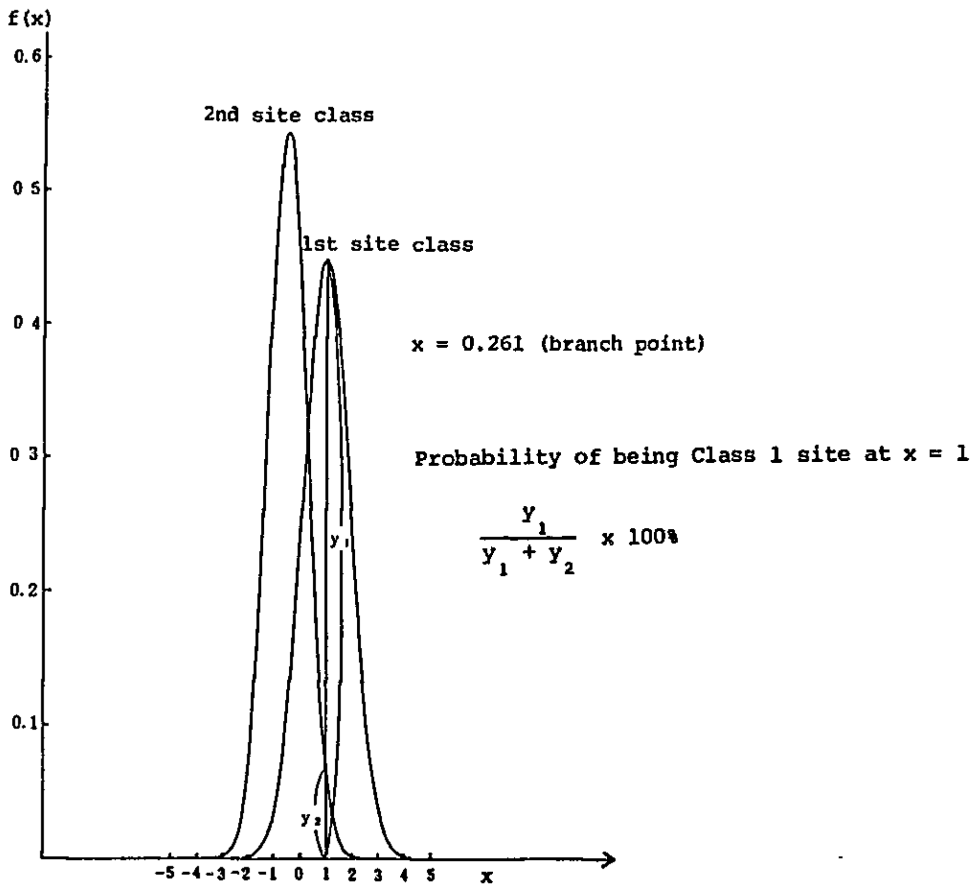


Fig. III-5-4 Normal distribution curve

5-2-2 Forest Productivity Map

In applying these scores to Capiibary area, the meshes that include the categories which did not appear in the sample plots (for example, gleization of soil and rocky soils, slopes steeper than 6°, gentle slope or the valley head, valley slope, monadnock in topography) cannot be interpreted. Therefore, the foregoing scores were applied to 842 meshes that do not include the above categories, and as a result, the meshes that were classified into 1st site class were 169 (4,225 ha), and those into 2nd site class were 673 (16,825 ha).

5-3 Planting Species

5-3-1 Planting Species from the Viewpoint of Natural Conditions

Macroscopically, topography, soil and meteorological conditions in Capiibary area are similar to those in the Province of Misiones, Argentina. Although there are some microscopic differences, they are not considered to constitute a restraining factor; therefore, the same major tree species which are achieving success in the Province of Misiones such as Elliottii pine, Caribbean pine, Parana pine (Araucaria), Taeda pine, Eucalyptus, etc., are considered to be the right species to be introduced to Capiibary. The fact that adult stands of the above tree species can be observed in Paraguay, although only over small areas, such as at Hakone Ueki (Co., Ltd.) Stroessner Forestry School, the Japanese settlements and among windbreaks and street trees, suggests the possibility of these species for planting.

Also, indigenous species like Cedro, Lapacho and Peterevý ought to be considered as candidates for planting. Also, MELIA sp. of MELIACEAE family (its local name is Paraiso) which has been introduced although only on a few occasions in the past seems promising in view of its wood quality and growth rate.

5-3-2 Planting Species from the Demand Aspect

As for the trend of timber in Paraguay, new large demands are expected to be created for telephone pole timbers accompanying the construction of dams at Itaipu and Yacyreta, for charcoal wood for Acepal Ironworks and for construction of pulp plants and also for construction of houses and building materials. Forest products have been important export items heretofore, and a continued demand for them for export can be counted on.

Under these circumstances, pines (including araucaria), which are introduced species, are considered appropriate for the foregoing demands for paper and pulp and building and construction materials, and eucalyptus for charcoal making and telephone poles.

As stock raising carries an important economic weight in Paraguay, the planting of forage trees must also be considered.

5-3-3 Objective Planting Species

It is considered that following species are appropriate for planting, as the results from the viewpoint of natural conditions and the demand aspect.

. Species for afforestation

Coniferous trees : Elliottii pine, Caribbean pine, Taeda pine, Parana pine (Araucaria)

Broad-leaved trees : Eucalyptus

. Species for pirot afforestation

Broad-leaved trees : Paraiso, Cedro, Lapacho, Peterevý, Forage trees

5-4 Silviculture System

Based on the anticipated yield table prepared as above, investigated silviculture system of planted forest (Elliottii pine).

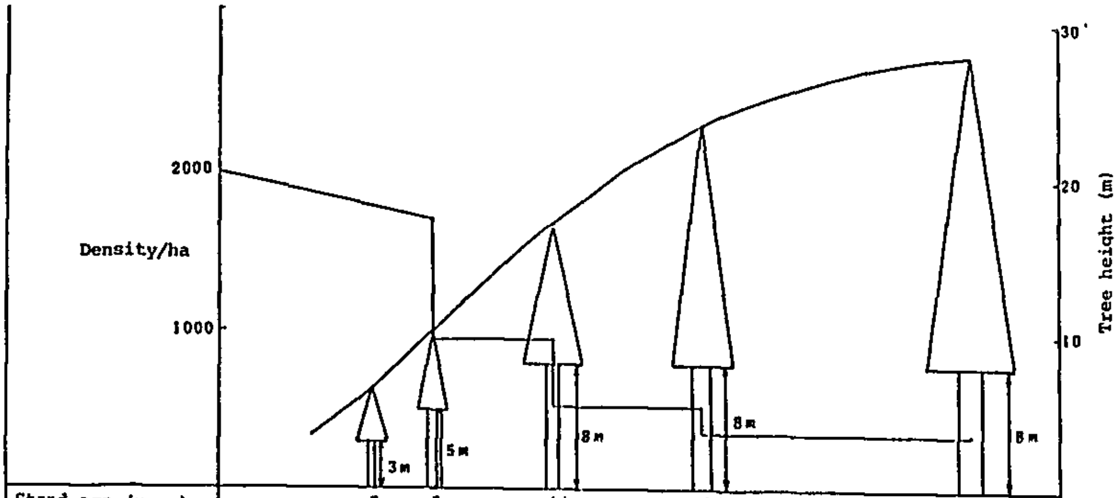
Resulting diagrams are as per Fig. III-5-5, and Fig. III-5-6.

1) Number of trees to be planted is 2,000 per hectare.

2) Weeding is to be carried out three times a year on both the 1st and 2nd site classes up to the third year, and clearing of trees and grasses that have grown too high from the fourth year onward.

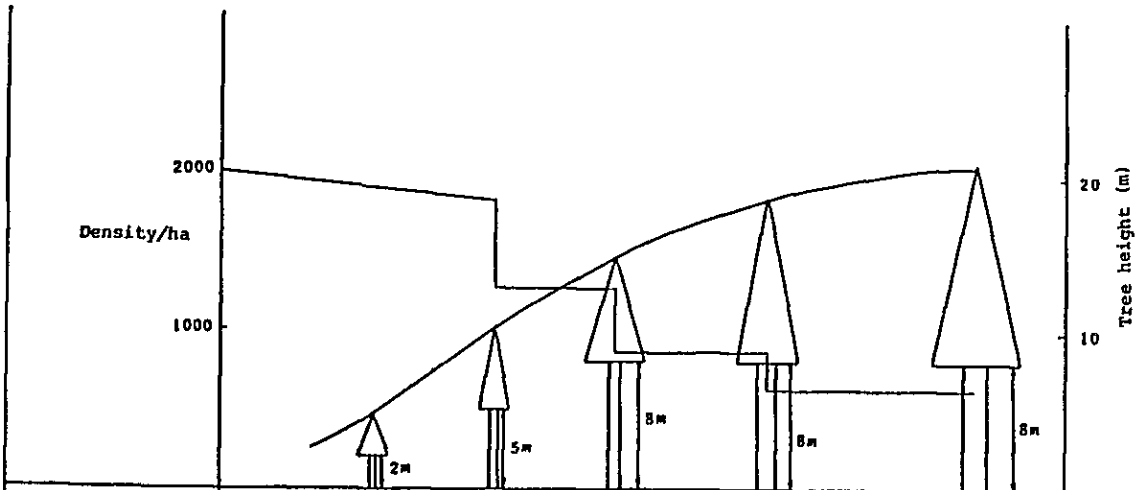
3) Pruning is to be carried out three times on both the 1st and 2nd site classes in order to grow trees without knots. The final clear length is to be 8 m. The second and third pruning are to be carried out at the same time with thinning on standing trees earmarked for retaining until final cutting.

4) As a general rule, thinning is to be carried out three times, and objective number of trees at the final cutting age is to be 360 per hectare for the 1st site class, and 630 per hectare for the 2nd site class.



Stand age (year)		5	7	11	16	25
Tree height (m)		63	99	169	232	280
d.b.h. (cm)		93	143	228	308	375
Stem volume (m^3)			134	269	369	440
Weeding (cleaning) (times)	3 3 3 1					
Pruning (times)			535	362		
Thinning (times)			768 62㎥(46%)	418 118㎥(44%)	173 119㎥(32%)	

Fig. III-5-5 Elliottii pine silviculture system (on 1st site class)



Stand age (year)		5	9	13	18	25
Tree height (m)		47	100	146	184	207
d.b.h. (cm)		69	137	195	244	277
Stem volume (m^3)			117	226	305	343
Weeding (cleaning) (times)	3 3 3 1					
Pruning (times)			862	629本		
Thinning (times)			559 37㎥(31%)	410 73㎥(32%)	233 82㎥(27%)	

Fig. III-5-6 Elliottii pine silviculture system (on 2nd site class)

6. Natural Regeneration Survey

6-1 Survey Method

This study analyzes the relationship between the forest type (high forest, medium forest and low forest) and the number of infant trees, the trends in the growth of infant trees and the number of living trees, the relationship between soil type and the number of infant trees, the relationship between upper story trees and infant trees of the forests within the study area.

6-1-1 Number of Sample Plots Surveyed and their Location

The survey on regeneration was carried out in the same plots where forest resource was surveyed. The number of plots surveyed was the same 32 plots as the forest resource survey. By forest type, they are 15 high forest, 15 medium forest and 2 low forest.

6-1-2 Survey Plot

As illustrated in Fig. III-6-1, small plots of 1m × 20m were set up at three spots, in the front, middle and back of the 100m × 40m (divided into four 50m × 20m blocs) sample plot which was surveyed for forest resource, and a regeneration survey was carried out on these three small plots totalling 60 m^2.

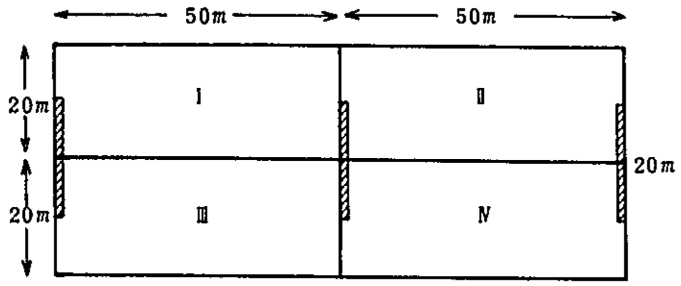


Fig. III-6-1 Plot for regeneration survey (20m x 1m)

Infant trees with diameter breast height of 10cm or less were covered by the survey. They were classified into three groups of (1) tree height below 1.3m (but above 30cm), (2) tree height 1.3m and above (with diameter breast height of 4 cm or less), and (3) diameter breast height in the range of 5-10cm, and the number of infant trees was surveyed for each species class.

6-2 Survey Results

The tree species classes were grouped into A + B, A + B + C, and D + E and tabulated in Table III-6-1 for each sample plot and for each of the tree classes of infant trees ((1) tree height above 0.3 m but below 1.3 m, (2) tree height 1.3 m and above, diameter breast height 4 cm or less, (3) tree height 1.3 m or above, diameter breast height 5 cm up to 10 cm). On the basis of Table III-6-1, the number of infant trees was tabulated by forest type and by soil type in Table III-6-2.

Table III-6-1 summarizes the number of infant trees by plot, by each of the three classifications ((1) tree height below 1.3 m but above 0.3 m, (2) tree height above 1.3 m, diameter breast height below 4 cm, (3) diameter breast height between 5 to 10cm), and by species class grouped into A + B, A + B + C, and D + E. Based on Table III-6-1, the number of infant trees was recapitulated by forest form and by type of soil as presented in Table III-6-2.

Table III-6-1 Number of infant trees by plot and by species class (per ha)

Plot No. Forest type	Tree height 0.3∿1.3m				Tree height 1.3m∿ d.b.h. ∿4 cm				d.b.h 5∿10 cm				Total			
	A+B	A+B+C	D+E	Sub-total	A+B	A+B+C	D+E	Sub-total	A+B	A+B+C	D+E	Sub-total	A+B	A+B+C	D+E	Total
1 M	500	1350	7,000	8,350	—	—	—	—	150	650	4,350	5,000	650	2,000	11,350	13,350
2 M	150	2,150	6,500	8,650	—	350	5,500	5,850	—	—	—	—	150	2,500	12,000	14,500
3 M	150	1,000	6,150	7,150	—	—	—	—	—	—	3,650	3,650	150	1,000	9,800	10,800
4 B	500	1,500	14,500	16,000	—	—	—	—	—	—	2,000	2,000	500	1,500	16,500	18,000
5 A	1,000	2,350	6,500	8,850	350	1,000	3,150	4,150	—	—	150	150	1,350	3,350	9,800	13,150
6 A	150	1,350	6,650	8,000	—	—	—	—	350	850	3,500	4,350	500	2,200	10,150	12,350
7 A	—	850	7,000	7,850	—	150	2,000	2,150	—	—	350	350	—	1,000	9,350	10,350
8 A	1,150	3,150	6,150	9,300	—	350	650	1,000	—	350	—	350	1,150	3,850	6,800	10,650
9 A	350	1,350	8,150	9,500	—	—	850	850	—	—	1,350	1,350	350	1,350	10,350	11,700
10 M	150	1,000	11,850	12,850	350	500	3,150	3,650	—	—	500	500	500	1,500	15,500	17,000
11 A	850	2,150	9,850	12,000	350	500	1,500	2,000	150	150	150	300	1,350	2,800	11,500	14,300
12 A	500	3,500	13,000	16,500	—	—	—	—	350	350	1,650	2,000	850	3,850	14,650	18,500
13 A	150	2,000	8,150	10,150	—	—	—	—	—	—	1,350	1,350	150	2,000	9,500	11,500
14 M	650	2,500	12,000	14,500	—	—	—	—	—	350	1,150	1,500	650	2,850	13,150	16,000
15 A	500	1,150	14,000	15,150	150	150	1,000	1,150	150	150	650	800	800	1,450	15,650	17,100
16 M	650	1,650	9,650	11,300	—	—	1,500	1,500	500	500	650	1,150	1,150	2,150	11,800	13,950

Table III-6-1 (Cont.)

Plot No. Forest type	Tree height 0.3∿1.3 m				Tree height 1.3m∿ d.b.h. ∿4 cm				d.b.h. 5∿10 cm				Total			
	A + B	A+B+C	D + E	Sub-total	A + B	A+B+C	D + E	Sub-total	A + B	A+B+C	D + E	Sub-total	A + B	A+B+C	D + E	Total
17 A	850	3,350	13,150	16,500	—	—	1,350	1,350	—	150	1,150	1,300	850	3,500	15,650	19,150
18 A	500	1,850	11,650	13,500	—	150	850	1,000	150	150	—	150	650	2,150	12,500	14,650
19 A	150	2,150	11,150	13,300	—	—	3,650	3,650	—	—	1,850	1,850	150	2,150	16,650	18,800
20 A	650	2,850	13,500	16,350	—	150	3,850	4,000	150	150	350	500	800	3,150	17,700	20,850
21 M	1,000	1,650	11,850	13,500	150	150	500	650	—	—	850	850	1,150	1,800	13,200	15,000
22 A	500	1,500	9,850	11,350	—	150	1,000	1,150	150	150	650	800	650	1,800	11,500	13,300
23 M	850	2,150	14,150	16,300	1,000	1,150	4,150	5,300	—	150	650	800	1,850	3,450	18,950	22,400
24 M	500	1,000	15,350	16,350	350	350	2,000	2,350	150	150	650	800	1,000	1,500	18,000	19,500
25 M	1,150	1,350	10,850	12,200	850	850	1,850	2,700	850	850	500	1,350	2,850	3,050	13,200	16,250
26 M	1,500	3,150	10,350	13,500	650	1,000	4,650	5,650	—	—	500	500	2,150	4,150	15,500	19,650
27 M	350	500	9,650	10,150	150	150	850	1,000	350	350	850	1,200	850	1,000	11,350	12,350
28 A	650	1,850	10,350	12,200	—	—	1,500	1,500	150	150	500	650	800	2,000	12,350	14,350
29 M	1,000	2,500	10,650	13,150	350	350	1,000	1,350	350	350	1,000	1,350	1,700	3,200	12,650	15,850
30 M	850	2,000	11,500	13,500	—	—	1,150	1,150	—	—	1,350	1,350	850	2,000	14,000	16,000
31 B	500	2,850	13,650	16,500	350	500	4,000	4,500	350	350	350	700	1,200	3,700	18,000	21,700
32 M	500	1,150	11,350	12,500	150	650	850	1,500	150	150	1,150	1,300	800	1,950	13,350	15,300
合 計	18,900	60,850	336,100	396,950	5,200	8,600	52,500	61,100	4,450	6,450	33,800	40,250	28,550	75,900	422,400	498,300

Table III-6-2 Number of infant trees (per ha) by species class by forest type, by soil type

(number of trees)

Classification		Tree height 0.3∿1.3 m				Tree height 1.3 m or higer								Total			
						d.b.h.≤ 4 cm				5 cm ≦ d.b.h. ≦ 10 cm							
		A+B	A+B+C	D + E	Tree class total	A+B	A+B+C	D+E	Tree class total	A+B	A+B+C	D+E	Tree class total	A+B	A+B+C	D+E	Tree class total
by forest type	A	530	2,093	9,940	12,033	57	173	1,423	1,596	107	173	910	1,083	693	2,440	12,273	14,713
	M	663	1,673	10,590	12,263	267	367	1,810	2,177	167	233	1,187	1,420	1,097	2,273	13,587	15,860
	B	500	2,175	14,075	16,250	175	250	2,000	2,250	175	175	1,175	1,350	850	2,600	17,250	19,850
	Mean for the area	591	1,901	10,503	12,404	162	269	1,641	1,910	139	202	1,056	1,258	892	2,372	13,200	15,572
by soil type	I	533	1,911	10,939	12,850	111	200	1,872	2,072	206	261	1,211	1,472	850	2,372	14,022	16,394
	II	584	1,826	10,340	12,166	169	261	1,263	1,524	129	208	1,066	1,274	882	2,295	12,668	14,963
	III	833	2,483	8,900	11,383	333	617	3,883	4,500	50	50	217	267	1,217	3,150	13,000	16,150
	IV	500	1,500	14,500	16,000	–	–	–	–	–	–	2,000	2,000	500	1,500	16,500	18,000

a. Number of infant trees by forest type

From Table III-6-2, Fig. III-6-2 was prepared to illustrate the number of infant trees per ha in total by the tree classifications of forest type (A: high forest, M: medium forest, B: low forest).

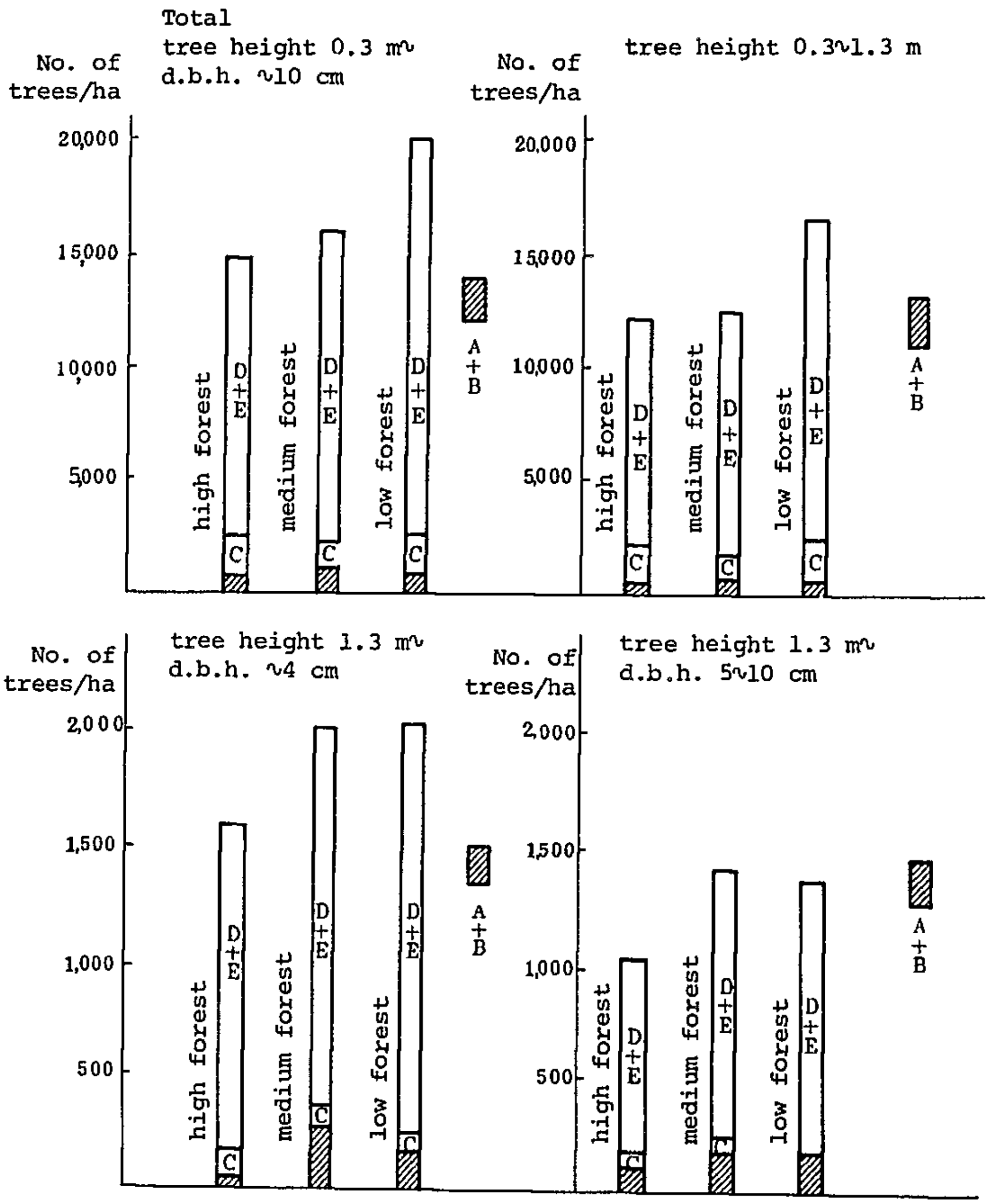


Fig. III-6-2 Number of infant trees by forest type (species class A ∿ E)

A review of Fig. III-6-2 indicates that the number of infant trees (tree height above 0.3m, diameter breast height below 10cm) is larger in the order of low forest (19,850 trees, medium forest (15,860 trees) and high forest (14,713 trees). As for A + B class, the number is larger in the order of medium forest (1,097 trees), low forest (850 trees) and high forest (693 trees).

With respect to A + B class, therefore, two classifications (diameter breast height 10 ∿ 40 cm and above 41cm) of overwood have been added to the three classifications of infant trees, as illustrated in Fig. III-6-3.

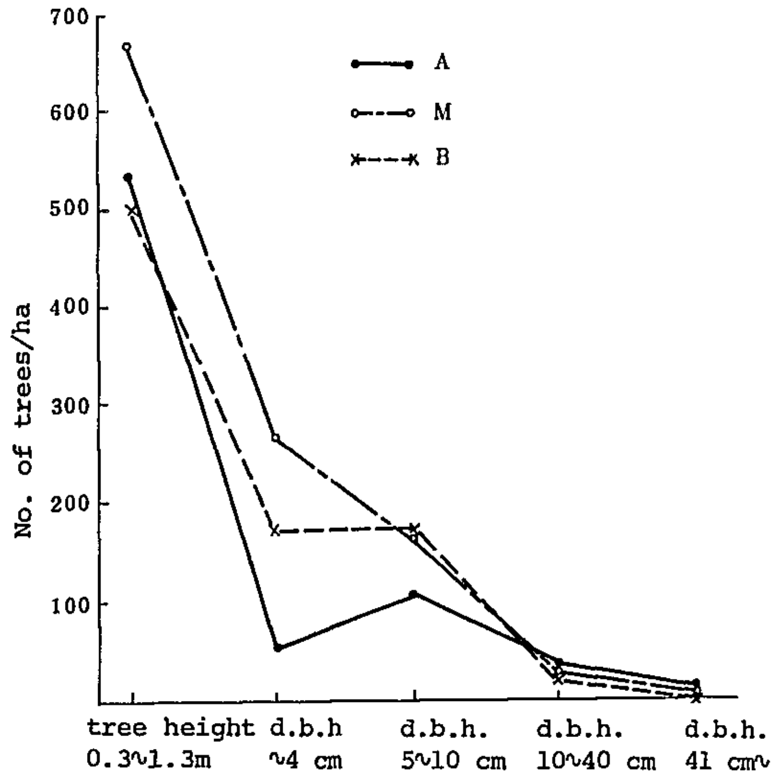


Fig. III-6-3 No. of growing trees of A+B class by forest type

What the figure generally seems to suggest is that the smaller the trees, the larger the number of trees, and that as they grow, the number of trees tends to decrease. However, in medium forest the number of trees are seen to gradually decrease whereas in high forest, the number of trees are seen to grow larger among trees with diameter breast height in the stratum of 5 cm to 10 cm than among those in the stratum of below 4 cm. In low forest, the number of trees is the same in these two strata. One of the conceivable factors that might have accounted for this phenomenon is the anthropic factor by which infant trees below 4 cm in diameter breast height were damaged at the time of selective cutting of useful trees, or the natural factor by which the cycle of fruiting year as a result of which, the number of trees in these strata become reversed.

Meanwhile, a review of the study area as a whole in terms of averages indicates the number of infant trees to be about 15,600 per hectare including all species classes, or 1.6 trees per square meter, of which A + B class trees which are regarded useful are about 900 (5.7% of all infant trees), and A + B + C class trees about 2,400 (15.2% of all infant trees). In other words, even when C class trees are included, the number is only 0.24 tree per square meter, or one tree in about 4 m^2, which means that the number of infant trees that germinate and survive on the forest floor is quite small.

Fig. III-6-4 shows the percentage ratio of infant trees by stratum.

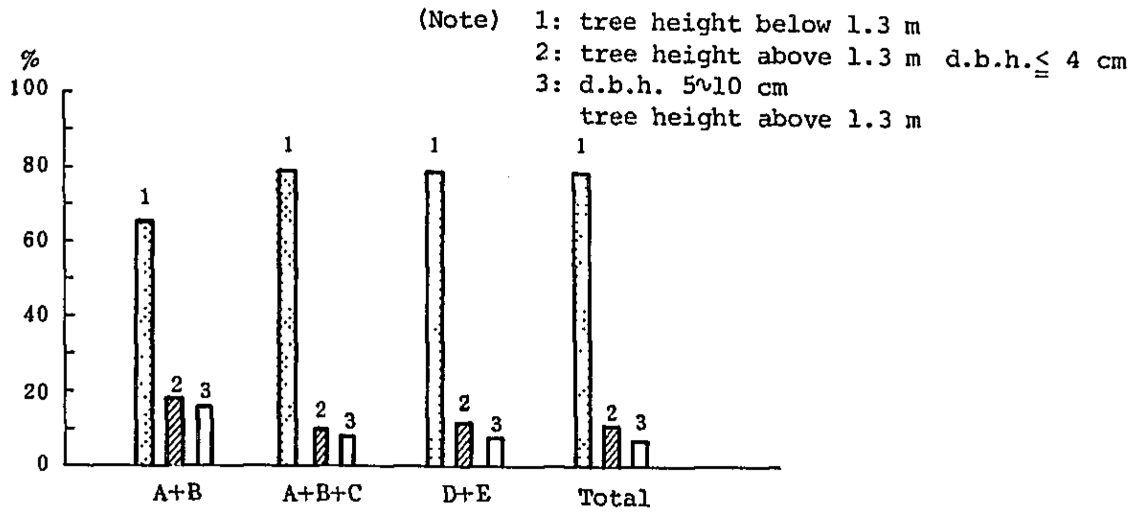


Fig. III-6-4 Percentage ratio of infant trees by stratum by species class

Fig. III-6-4 shows that trees above 30 cm and below 1.3 m in height account for 70 to 80% of the total, and that in both A + B class and A + B + C class, the trees above 1.3 m in tree height that qualify as infant trees for regeneration are only 11 to 18% and those 5 ∿ 10 cm in diameter breast height only 9 to 16%, which means that most of the infant trees are unstable ones as trees for regeneration.

Fig. III-6-5 shows the percentage ratio of infant trees in number of trees by species class.

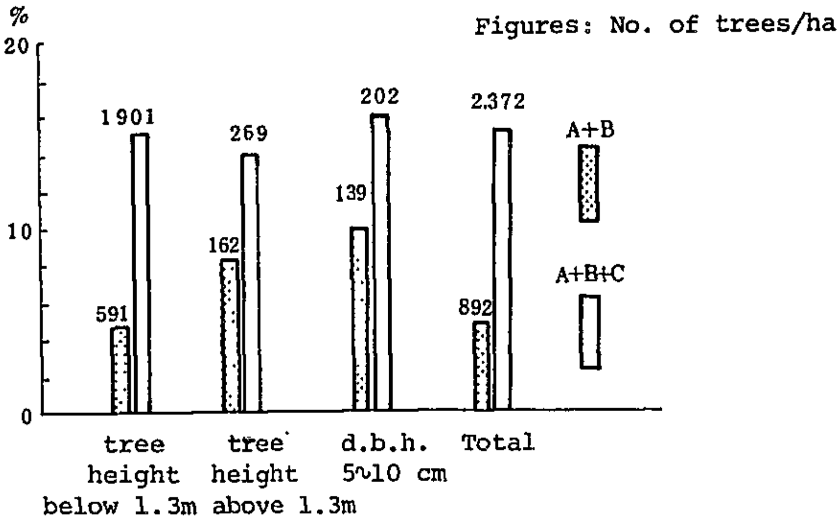


Fig. III-6-5 Germination ratio of infant trees by stratum by species class

Fig. III-6-5 shows that A + B class accounts for 5.7% of the total and A + B + C class for 15.2%, and that infant trees of A + B class tend to increase their share in the number of trees as they grow. However, trees above 1.3m in height and 5 ∿ 10 cm in diameter breast height are only 20% of the total, so that even though they may have the potential to become regeneration species, their problem as regeneration trees is that their number of trees germinated is extremely small.

b. Changes in the number of infant trees and living trees by soil type.

Next, germinating status of infant trees of A + B class and A + B + C class by soil type are as shown in Fig.

III-6-6. Generally, infant trees of useful species tend to increase in the order of type I < type II < type III soil both in terms of number of trees and the percentage ratio of number of trees.

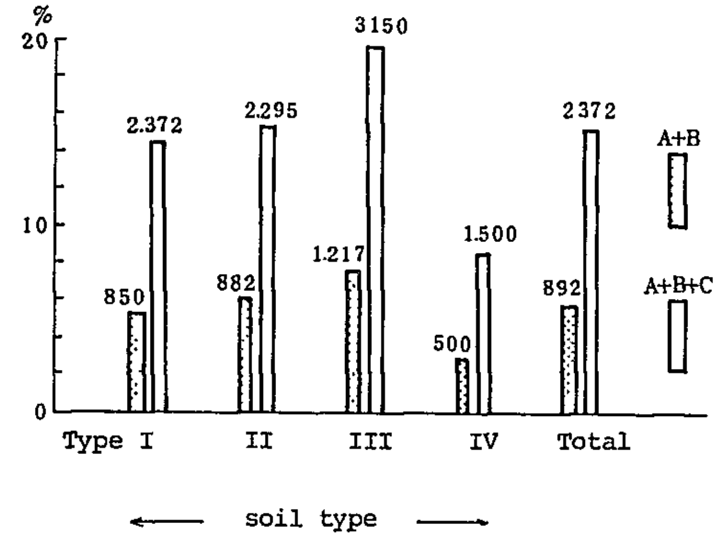


Fig. III-6-6 Percentage ratio of infant trees germinated by species class by soil type (Figures : No. of tree/ha)

Fig. III-6-7 shows the changes in the number of living trees by the five classifications (tree height 0.3 m ∿ 1.3 m, d.b.h. less than 4 cm, d.b.h. 5 ∿ 10 cm, d.b.h. 10 ∿ 40 cm, d.b.h. 41 cm and more) and soil types.

The figure shows the same results as the analysis by forest type: that is, in type I, the number of trees in the category of diameter breast height below 4 cm is smaller than that of the trees in the category of diameter breast height between 5 ∿ 10 cm. The conceivable reasons for this are probably the same as those in the analysis by forest form.

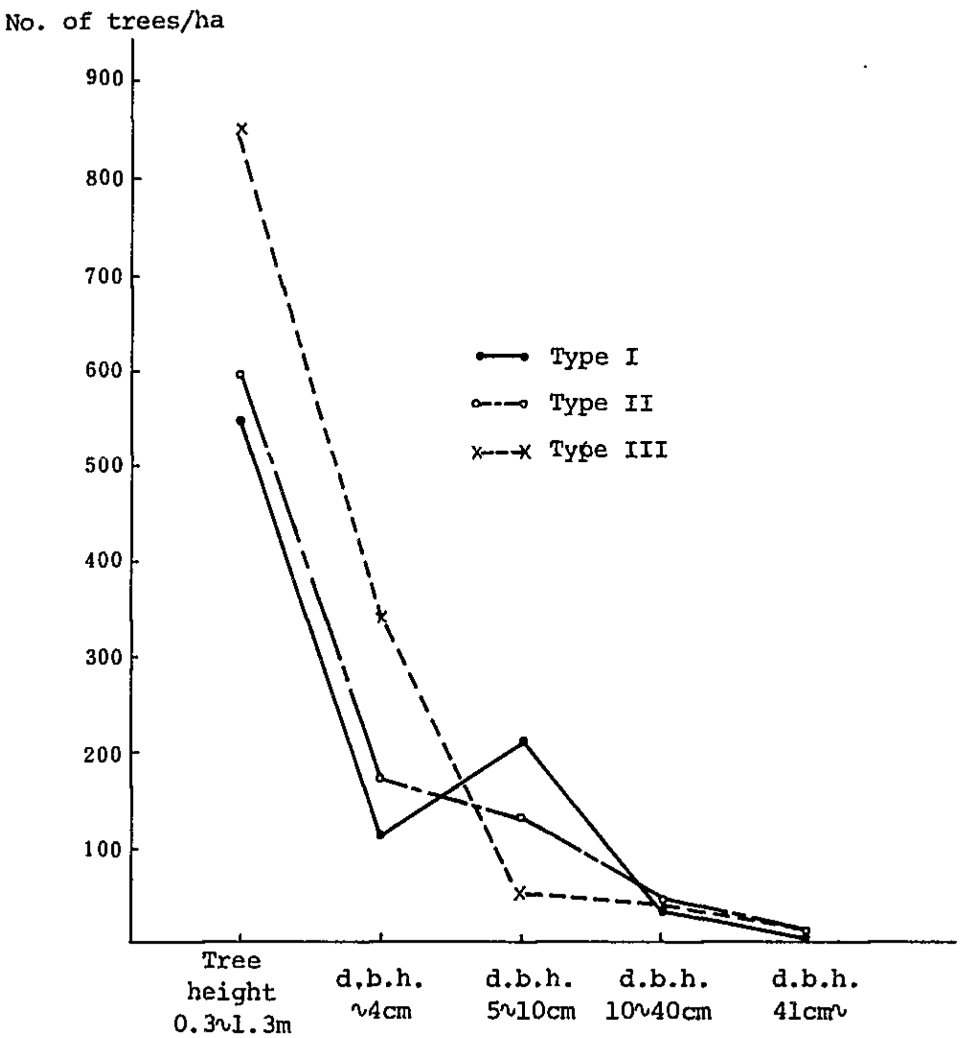


Fig. III-6-7 Growing number of trees of A + B class by soil type

6-3 Review of Testing and Research Methods for Natural Regeneration

Table III-6-3 shows the existing useful species (A and B classes) and species considered promising in future (C class) by height grade, based on the frequency of occurrence of species by height grade obtained from forest survey. A review of this table shows that as species with high frequency of occurrence in each height grade within the stands of the natural forests in Capiibary area are, in Class A, Guatambú, Cedro, Kurupay; in Class B, Cancharana; and in Class C, Laurel hú, Urunde y pará, and Gua ja y ví.

As the candidate species for natural regeneration, A and B classes mentioned above will be considered in the main, but the existing infant trees of A + B class are only about 900 trees per hectare (5.7% of the total) which mostly consist of unstable ones below 1.3 m in tree height. If C class is included in the species for natural regeneration, the number of trees per hectare would rise to 2,400 trees (15.2% of the total), Species in the A, B and C classes with relatively high frequency of occurrence, therefore, ought to be considered for regeneration.

Capiibary area comprises subtropical broad leaved forests with an abundance of epiphytes, with crown layers covered by tree lianas, which exhibit a physiognomy similar to the tropical rain forest.

However, neither plank buttress nor stilt root, both of which are peculiar to tropical species, is seen among high trees.

The tropical rain forest characteristically consists mostly of high trees and their young offsprings, and the broad leaved forests in this area show a composition similar to the

Table III-6-3 Frequency of occurrence of useful species

Height grade m	Species	Species class	No. of trees/ha	Frequency occurrence
26~30	Guatambú	A	1.40	34.4
	Urunde y pará	C	0.63	25.0
21~25	Guatambú	A	7.90	78.1
	Cancharana	B	2.43	59.4
	Urunde y pará	C	2.50	59.4
	Laurel hú	C	2.73	56.3
	Cedro	A	1.80	43.8
	Kurupay	A	2.10	43.8
	Yvyrá pepé	C	1.80	34.4
	Gua ja y ví	C	1.18	31.3
	Peterevy	A	0.70	28.1
16~20	Laurel hú	C	4.60	75.0
	Cancharana	B	3.35	65.6
	Yvyrá pepé	C	0.78	59.4
	Kurupay	A	1.33	37.5
	Guajayví	C	1.65	37.5
	Urunde y pará	C	1.65	37.5
	Cedro	A	1.40	34.4
	Guatambú	A	6.03	31.3
	Laurel canela	C	1.18	28.1
11~15	Laurel hú	C	4.45	75.0
	Guatambú	A	3.05	62.5
	Cancharana	B	2.10	53.1
	Yvyrá pepé	C	2.58	50.0
	Cedro	A	0.85	25.0
6~10	Laurel hú	C	0.95	21.9

(Species with frequency of occurrence of 25∿30% or more) tropical rain forest, with common species occurring in every stratum of the stands. In other words, since it is the species that compose the high tree stratum that become the regeneration species, the existence of useful species in the upper story crown cover is important in order to regenerate useful species.

Even though subtropical broad leaved forest is stable in its climatic climax community, partial death of overmatured trees, invasion by fast growing pioneering species and the process of natural plant succession (transitional process) to slow growing and shade bearing native species are being incessantly repeated within the forest. It is said that for a plant to stabilize itself amidst the process of natural plant succession, a time period of a few hundred years or more is necessary (Kira, 1983).

Natural regeneration in the rain forest, under natural conditions, occurs among the gaps generated by the death of overmatured upper story trees, and if the gaps are large, they become occupied by pioneer species with the result that the existing infant trees of the natural forest are suppressed. Such plant succession process in the natural forest is similarly observed among deciduous broad leaved forests in the cold temperature zone.

Taking Java as an example, the advance regeneration young trees of the native species are prone to successfully survive and grow on an artificial cut-over area of 10 ares or less, but are said to become completely suppressed by fast growing secondary growth species when the cut-over area is 20 - 30 ares (written by Richards and translated by Kira, et al. 1979). Accordingly, if native species are made to naturally regenerate, it is necessary that cutting be limited to below 0.1 ha in case of gap cutting and below 10m in width in case of strip cutting, and to render artificial aid as required after cutting until regeneration is completed.

When resorting to natural regeneration, the question is what to consider as a benchmark for regeneration to have been completed. In the forest of Siebold's beech trees (Fagus crenata) in the cold temperature zone of Japan, it is only when the infant trees above 60 cm in height exceeds 10,000 per hectare and they are seen occuring uniformly over the forest floor that regeneration is assumed to have been completed and that clear cutting of the upper trees is executed; but if the height of the infant trees is lower than 60 cm or the number of trees is smaller than above, 10 to 20 seed trees per hectare are set aside either in spots or in rows as a rule to assure safety of regeneration (Seibold's Beech in the Northeastern Region of Japan, 1979). In the broad leaved forests in Capiibary area, the number of infant trees in the A + B + C class is about 2,400 trees per hectare, of which 80% is below 1.3 m in tree height. Since it is difficult to count on natural regeneration under the current situation, it is considered necessary to cut overwood to prompt germination of infant trees and thus promote the growth of preregeneration trees.

As hardly any precedence exists in which natural regeneration has been carried out with respect to broad leaved natural forest in the tropical or subtropical zone, the regeneration technique has not been elucidated yet. Therefore, if natural regeneration of indigenous useful species is to be attempted in the broad leaved natural forest in Capiibary area, it is advisable to set up experimental plots for natural regeneration and apply whatever regeneration techniques that might be found promising as a result of experiments, and confirm them step by step, rather than try to tackle with the project right away.

SECTION IV

SOCIO-ECONOMIC SURVEY

SECTION IV SOCIO-ECONOMIC SURVEY

1. General Conditions

1-1 Society of Paraguay

1-1-1 Population

(1) Population trends

According to the national census of 1982, the total population of Paraguay was 3.03 million, and population density 7.4 persons/km^2. This is extremely low compared to the world's mean population density of 32 persons/km^2 and the developing world's mean population density of 48 persons/km^2. However, taking Paraguay's eastern region only, the population density there is 18.6 persons/km^2 because of the fact that only 2% of Paraguay's total population live in the Chaco region in the west which accounts for 60% of Pargauay's total territorial land.

After the war against the three countries, the population of Paraguay in 1887 is said to have been just a little over 200,000. Since then, its population continued to increase in the order of 2% a year, reaching 1,330 thousand in 1950 and 2,360 thousand by 1972. The country's population growth rate during the ten years between 1972 and 1982 was 2.5% a year on average, substantially overrunning the world average of 1.8%. The birth rate was 36 persons per 1,000 persons of population.

Reflecting such a population trend, the population composition by age group is 1.56 million persons of ages below 15, 1.64 million between the ages of 15 and 60, and 0.17 million of ages above 60, with the population aged below 15 accounting for about 50% of the total. (As the population by age group is based on the 1982 estimates, the total does not agree with the total population per national census.) Such an age distribution of the population has an important bearing upon the nation's future economic policy.

When the population trend is reviewed from the aspect of urbanization, Asuncion, the country's capital, was the only city with a population of more than 20,000 during the period between 1950 and 1961/62. The ratio of urban population to total population then ranged between 16.5% to 16.8%. The ratio of urban population to total population reached 22.7% in 1978 and that of the capital city to total population, 16%.

(2) Percent distribution of employed workers by occupation

A review of the percent distribution of all employed workers in Table IV-1-1 shows that as of 1983, workers in the primary industry such as agriculture, stock raising and forestry account for 41.3% of the total, and constitute the mainstay of the labor force. It shows that Paraguay is an agricultural country. Changes in the percent distribution during the 10 years between 1973 and 1983 however indicate a 10% decline in the share of agriculture, stock raising, forestry and mining with compensating increases in the shares of manufacturing, commerce and other secondary and tertiary sectors.

Table IV-1-1 % distribution of employed workers by occupation

Occupation	1983	1977	1973
	%	%	%
Agriculture, livestock, forestry & mining	41.3	43.5	51.3
Manufacturing	17.7	17.7	14.2
Construction	6.2	5.6	4.2
Electricity, water & transportation	4.3	3.7	3.2
Commerce	14.4	13.2	9.3
Services	16.1	16.3	17.8
Total	100.0	100.0	100.0

1-1-2 Politics and Religion

(1) Form of government

Ever since the existing constitution was established in 1967, Paraguay has been adopting the republican system of government based on the separation of the three powers.

1) Legislature:

The bicameral system of upper house and lower house is adopted, with members of both houses being elected to a five-year term.

2) Administration:

Under the Office of the President are the Economic Council, Ministry of Interior and other ministries and councils. The Forestry Agency (del Servicio

Forestal Nacional - SFN) belongs to the Ministry of Agriculture and Livestock.

Incumbent President Stroesner has been in office since May, 1954.

The administrative organization of the Paraguayan government is outlined in Fig. IV-1-1.

3) Judiciary:

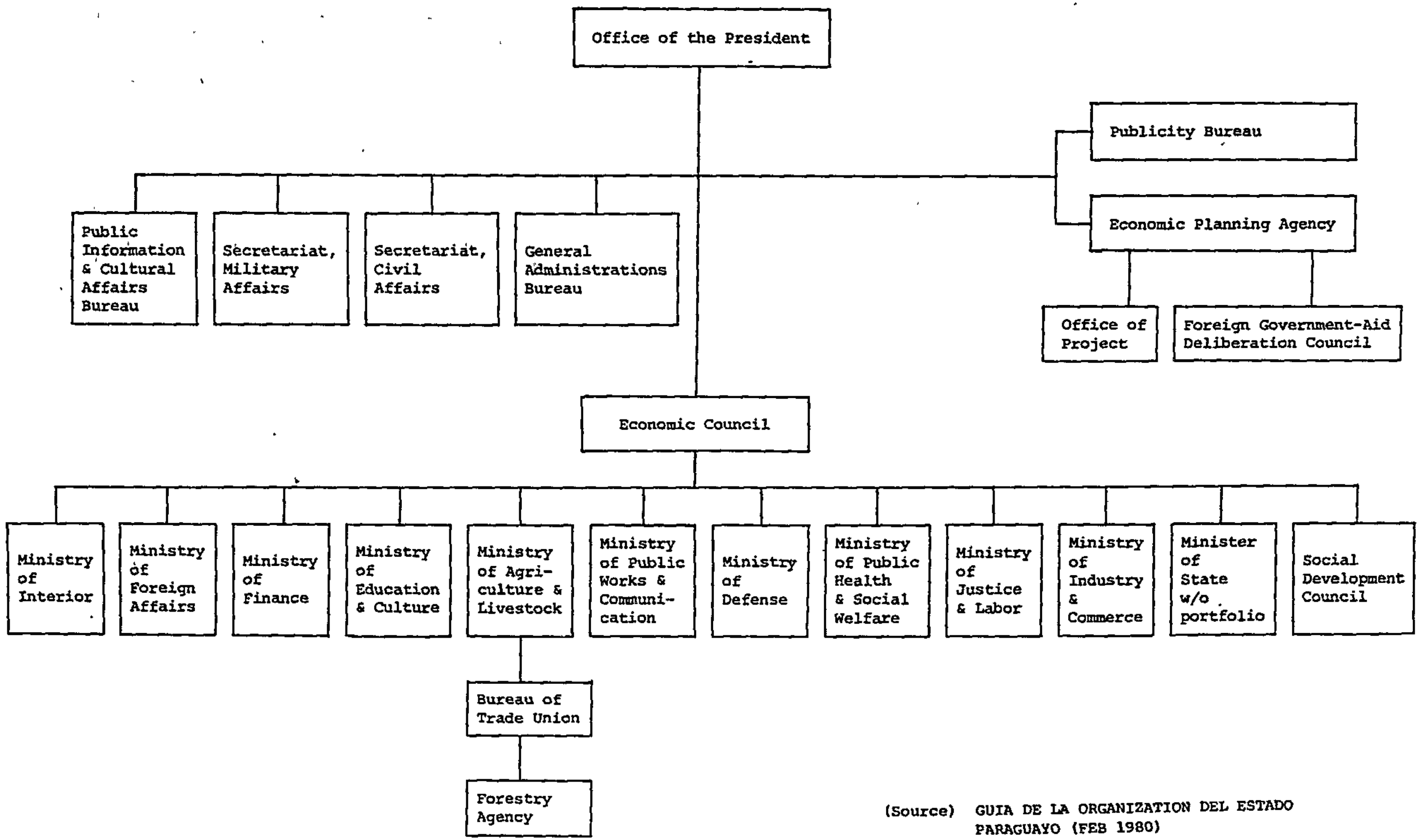
Composed of the Supreme Court and lower courts. Three judges of the Supreme Court are appointed by the President for a six-year term. There are also the Public Prosecutor's Office and the Board of Audit.

4) Local administration:

Consists of the capital and 18 Departments, the governor of each department is appointed by President. Mayors of cities, towns and villages are elected to the office.

(2) Religion

Even though the freedom of belief is assured under the constitution, Catholicism is the national religion and the large majority of its people are Catholic.



(Source) GUIA DE LA ORGANIZATION DEL ESTADO PARAGUAYO (FEB 1980)

Fig. IV-1-1 Organization chart of the Paraguayan Government

1-2 Economy of Paraguay

1-2-1 GDP

The economic growth of Paraguay has been stable. The average annual growth of GDP during the ten years up to 1965 hovered at a level of 2.8%, but during the next ten years from 1965 to 1975, it recorded a growth of 5.2% a year on average. Particularly during the 1977-1980 period, a growth of more than 10% was achieved on account of surging overseas demand for its products and large scale projects like the Itaip power plant. Although its pace of economic growth has slowed down since 1981, Paraguay is continuing to grow relatively steadily despite the serious recession and rampant inflation that plagues the neighboring countries.

In terms of composition by sector, the production sector accounted for 54.1% of GDP in Fiscal Year 1981, just slightly over the 45.9% by the service sector.

Of the production sector, the agricultural sector with such major crops as soybeans and cotton accounted for 20.5% of GDP, and the industrial sector followed with 16.6%. The forestry sector earned 3.2%. The combined share of agriculture and stock raising was 30.3%, which make them the two key industries of Paraguay, but compared to 35.7% in 1975, their weight is on a declining trend. The decline in the position of stock raising in particularly conspicuous.

In terms of the 1981 production indices with 1977 as a base year at 100, that of agriculture was 135, stock raising 116, and forestry 145 against 148 for total production. The most spectacular growth was attained by the construction sector (with production index of 252), as a result of large scale projects such as the construction of the Itaip and Yasileta hydraulic power plants.

The service sectors are recording even growth as a whole. Particularly, the share of the power industry is anticipated to increase sharply with the commencement of large-scale electricity supply from Itaip Dam. In terms of the 1981 composition ratio, the commerce and finance sector indicated the largest share of 26%. The share of government enterprises was small at 4.1%.

Table IV-1-2 Trend of GDP

(US$ millions)

Fiscal year	Value (US$ millions)	Equivalent in FY1977 prices	Growth rate %
1962	3607	890.5	
1963	3839	925.0	3.9
1964	408.4	961.0	3.9
1965	443.6	1,012.5	5.4
1966	465.9	1,024.3	1.2
1967	492.7	1,111.5	8.5
1968	517.7	1,146.5	3 1
1969	556.3	1,193.7	4.1
1970	594.6	1,2521	4.8
1971	664.6	1,320.2	5.4
1972	769.0	1,405.2	6.4
1973	995.5	1,5063	7.2
1974	1,3335	1,630.4	8.2
1975	1,511.4	1,733.4	6.3
1976	1,699.0	1,855.1	7.0
1977	2.092.1	2,092.2	12.8
1978	2,560.0	2,3193	10.9
1979	3,417.0	2,567.5	10.7
1980	4,448.1	2,860.2	11.4
1981	5,624.5	3,101.9	8.5

(Source) Banco Central del Paraguay, 1982

1-2-2 Import and Export

(1) Balance of trade

The balance of trade was approximately in equilibrium between 1960 and 1977, but after 1978, a trade deficit was recorded every year on account of across the board rise in imports of capital goods, producer's goods and consumer's goods, coupled with the rise in the price of oil. The deficit in 1981 reached US$2.1 billion. (Table IV-1-3)

(2) Import and export merchandise

Paraguay is a typical exporter of primary products and importer of industrial products. Almost all of its exports are accounted for by agricultural, livestock and forestry products. Of the 1981 total exports of US$296 million, textile goods accounted for 43.0%, earning about $130 million foreign currency, followed by soybeans and other grains (17.8%), lumber products (12.5%), etc. The share of lumber products in the total exports rose sharply from 8.0% in 1978 to 13.8% in 1979 and 21.4% in 1980 but was suddenly halved in 1981. As forestry-related products, there are wood oils with tung oil in the main (7.6%) and quebracho extracts (1.9%). (Table IV-1-4)

In imports, specific items which are necessary for economic development such as machinery, fuels etc. account for it's large share. When reviewed by type of product, machinery, apparatus and motors account for the largest share of 21.3% in total imports, followed by 18.7% for fuels and lubricating oils, 12.9% for motor vehicles and accessories. Imports of petroleum products, such as fuels and lubricating oils, reached as high as 25% of total imports in 1980, but due to a glutted oil market, their import share declined to 18.7% in 1981. If electric power comes to be supplied in abundance by the construction of the Itaip Dam and Yasireta Dam, the import of oil as factory energy is anticipated to decline.

Imports of paper, paper board and processed paper products amounted to about US$10 million in 1981, accounting for 1.9% of total imports. (Refer to Table IV-1-5 Import values by major type of product.)

Table IV-1-3 Balance of trade

(Unit: F.O.B Million US$)

Fiscal year	Export	Import	Balance
1960	27.0	32.4	-5.4
1965	57.2	47.4	9.8
1970	64.1	63.8	0.3
1975	176.7	178.4	-1.7
1976	181.8	180.2	1.6
1977	278.9	255.4	23.5
1978	256.9	317.7	-60.8
1979	305.2	431.8	-126.6
1980	310.2	517.1	-206.9
1981	295.5	506.1	-210.6

(Source) the Economic Planning Agency

Table IV-1-4 Import values by major type of product

(Unit: One million US$)

Items	1978	1979	1980	1981	1981 share
					%
Cotton (textile)	99.5	97.6	104.5	127.2	43.1
Lumber products	20.5	42.2	66.5	36.9	12.5
Grains	41.6	81.3	45.3	52.5	17.8
Oil cakes (strained lees, extracted lees)	10.2	14.2	22.3	14.4	4.8
Vegetable oils	16.8	19.1	17.0	22.4	7.6
Tobacco	9.2	8.5	10.1	6.5	2.2
Refined oil	8.5	9.7	9.1	6.6	2.2
Quebracho extracts	5.2	3.2	4.4	5.6	1.9
Calf skin (tanned)	7.8	6.2	3.1	6.5	2.2
Meat products	24.0	5.5	1.1	-	-
Others	13.6	17.7	26.9	16.9	5.7
Total	256.9	305.2	310.3	295.5	100.0

(Source) Banco Central del Paraguay

Table IV-1-5 Import values by major type of product

(Unit: Million US$)

Items	1978	1979	1980	1981	1981 share
					%
Foodstuff	14,453	19,977	24,074	32,604	6.4
Beverages & tobacco	28,979	41,567	39,664	37,222	7.3
Fuels & lube oils	39,644	87,520	129,518	94,588	18.7
Paper, paper board and processed paper products	7,111	8,693	12,301	9,797	1.9
Chemical products	16,333	26,229	31,719	31,070	6.1
Motor vehicles & accessories	60,133	63,310	93,252	65,493	12.9
Textile goods & apparels	6,733	9,436	9,816	9,767	1.9
Agricultural equipment & accessories	10,478	11,083	9,483	13,196	2.6
Steel materials & processed goods	14,655	30,899	20,002	22,657	4.5
Base metals & processed goods	5,222	4,448	6,414	7,616	1.5
Machinery, apparatus & motor	53,831	74,737	79,739	107,757	21.3
Others	40,166	48,859	61,159	74,344	14.7
Total	317,738	431,758	517,141	506,111	100.0

(Source) the Economic Planning Agency

(3) <u>Export destinations and import sources</u>

When export destinations and import sources are reviewed by region, intra-regional transactions within LAFTA (the Latin American Free Trade Association) are the largest. Particularly, the shares of Brazil and Argentina are overwhelmingly high.

The 1981 actual exports by destination were US$69 million to Argentina (23.2%), US$40 million to Brazil (13.6%), US$33 million to West Germany (11.1%), US$25 million to Japan (8.4%) and then US$15 million to the United States (5.2%), with these five countries accounting for more than 60% of total exports.

When reviewed by geographic region, exports to the European countries used to carry a large weight, but recently, exports to Latin American countries exceed 50% of the total. (Refer to SECTION V 16, Export Values by Major Destinations)

As import sources, Brazil with US$131 million (25.9%) and Argentina with US$100 million (19.8%) jointly accounted for 45.7%, or almost half of total imports. Other import sources were in the order of the United States with US$49 million (9.7%), Japan with US$42 million (8.3%) and then West Germany with US$41 million (8.1%). These five countries together accounted for more than 70% of Paraguay's imports. (Refer to SECTION V 17, Import Values by Major Source Countries)

1-2-3 Economy Outlook

The factors which supported the relatively stable growth of the Paraguayan economy up to the recent past are its brisk exports of cotton, soybeans and lumber, the inflow of foreign capital accompanying the execution of big projects like the construction of the Itaip and Yasireta hydraulic power plants which activated the project-related industries.

However, changes have since occurred in the big projects and in the export environment which were the major driving forces of its economic growth. When the first stage of the Itaip project was completed and the Yasireta project was suspended, activities of the related industries subsided. In 1981, export became sluggish due to a decline in the international prices of agricultural produce. Although the export of agricultural products recovered in 1982, the harvested volumes decreased due to meteorological disasters. The production of lumber in particular has had to be cut back due to decreased demand by the curtailment of big projects and also due to sluggish export caused by the price differential between the actual domestic market price and export price under the official exchange rate. This situation has not changed since.

Accordingly, the production of soybeans shifted from 650,000 tons in 1980 to 750,000 tons in 1982 and that of cotton, from 235,000 tons in 1980 and to 254,000 tons in 1982. And production of sawmill products exhibited a sharp declining trend from 1,148,000 tons in 1980 to 639,000 tons in 1981 and to 631,000 tons in 1982.

Total export values fell from US$310.2 million in 1980 to US$295.5 million in 1981 but recovered to US$329.8 million in 1982. The share of each major commodity in total export values (on F.O.B. basis) in 1980 was led by cotton with 34%, lumber in second place with 21% and soybeans in third place with 14%; in 1981, cotton at the top with 43% soybeans in second place with 16% and lumber in third place with 12%; then in 1982, cotton with 37%, soybeans in second place with 27% and lumber in third place with 13%.

The economy outlook is as follows by the document which was prepared by Paraguay government "Outlook of latest socio-economic conditions":

1) GDP is expected to increase 518 billion Gs in 1985 against 391 billion Gs in 1981. During these years, 7% increase is expected a year on average. In order to secure this, political and economic measures are requested.

2) The growth of exports is expected 11.1%, also growth of imports is 10.6%. For the purpose of this, internal investment for export expansion, political measures of circulation of primary products and investment for selective import measures are requested.

3) Investment rate of GDP is expected increase up to 7%, in order to secure this figures, internal or foreign investment for planning and executing enterprise are requested.

4) The growth of primary industry sector is expected 7.8% a year on average in future. This section will be occupied 30.6% of GDP in 1985.

5) The growth of secondary industry sector is also expected 8.1% a year on average, and it will be occupied 24.5% of GDP in 1985.

6) The growth of basic service sector is also expected 10.4% a year on average, and it will be occupied 6.5% of GDP in 1985.

7) The growth of other service sector is also expected 6% a year on average, but the ratio in GDP, it will be reduced 38.2% in 1985 from 40.1% in 1981.

In order to attain above mentioned outlook, following measures are indispensable.

1) Expansion of circulation of primary products and investment expansion to secondary industry centering processing of agricultural products and introduction of selective import's system.

2) By the law of No. 36013 (1982), a) establishment of special committee for the future industry principal plan; b) promotion of measures to enlarge production and export.

3) Except usual primary product, exploitation of export market about new articles which have high merchantable value or additional value such as meat, etc.

4) About basic service sector, arrangement and completion of social infrastructure.

5) In the field of other service sector, enlargement and welfare's completion about politics, economy, housing and internal market.

(Data: nation's efforts and foreign loan --- latest situation and outlook of socio-economic ---)

Paraguay is currently pushing forward such industrialization projects as the construction of hydraulic power plants in Itaip and Yasireta and the construction of Asepal Steelmill and, at the same time, taking subsidizing measures to aggressively promote industry. For Paraguay's economic development, it is indispensable to proceed with these industrialization projects and also to improve product quality and productivity of agricultural, livestock and forestry products by improving administrative techniques and production technologies.

It has already been pointed out that the fluctuations in production and export of lumber and other forest products strongly affect the welfare of the Paraguayan economy. Considering the natural environment and resource endowment of this country and other factors, the promotion of forestry and forest industry is indeed an extremely important prerequisite for the economic development of Paraguay.

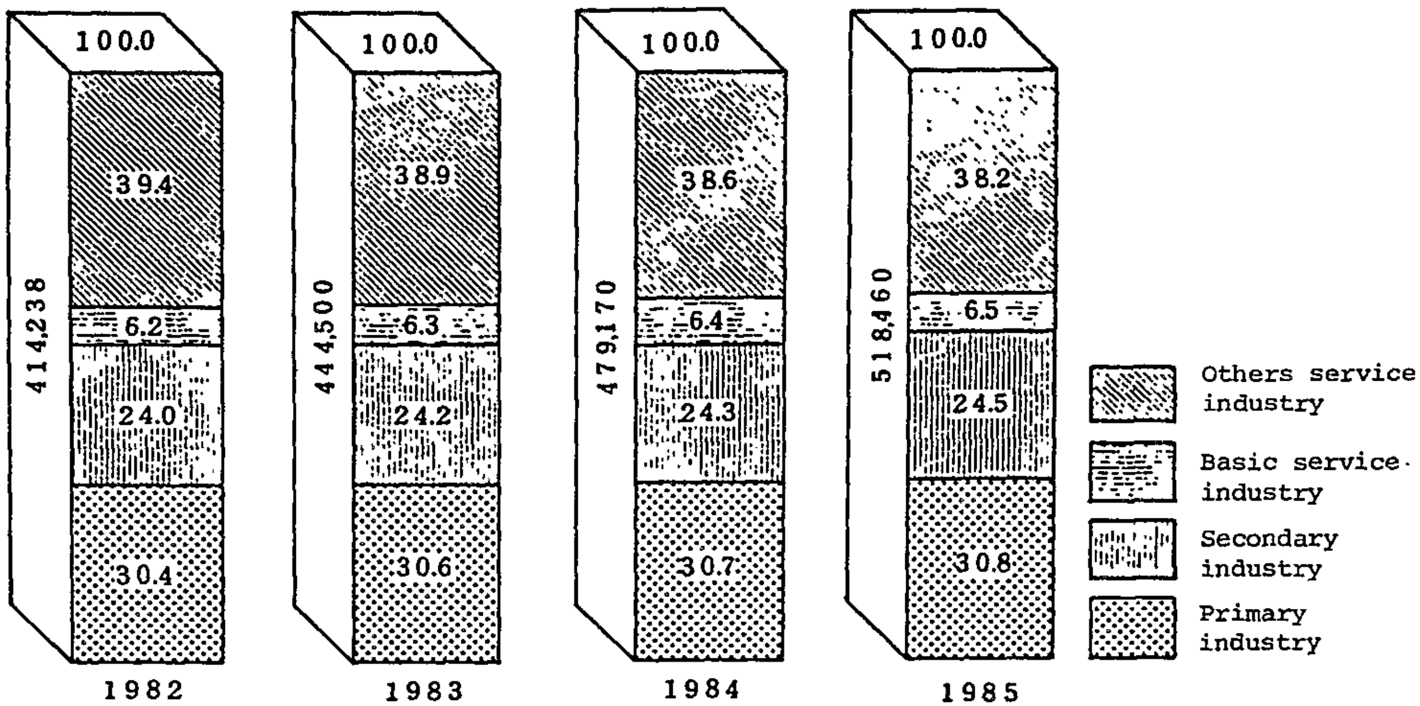


Fig. IV-1-2 Gross domestic product

Table IV-1-6 Gross domestic product (market prices)

(Unit: Gs Million based on 1977 %)

Items	1981	1982	1983	1984	1985
Agriculture	20.5	20.7	20.8	20.9	20.9
Livestock	6.5	6.4	6.5	6.5	6.5
Forestry	3.2	3.2	3.2	3.2	3.3
Hunting & Fishers	0.1	0.1	0.1	0.1	0.1
Primary industry Sub-total	30.3	30.4	30.6	30.7	30.8
Mining	0.4	0.5	0.6	0.6	0.7
Manufacturing	16.6	16.7	16.8	16.9	16.9
Construction	6.8	6.8	6.8	6.8	6.9
Secondary industry Sub-total	23.8	24.0	24.2	24.3	24.5
Production sector total	54.1	54.4	54.8	55.0	55.3
Electricity	1.8	2.0	2.0	2.1	2.2
Water and sanitation	0.3	0.3	0.3	0.3	0.3
Transport & communication	3.7	3.9	4.0	4.0	4.0
Basic service industry Sub-total	5.8	6.2	6.3	6.4	6.5
Commerce	26.0	25.6	25.3	25.2	25.1
Government enterprises	4.1	3.5	3.5	3.5	5.4
Housing	2.2	2.3	2.3	2.3	2.3
Other services	7.8	8.0	7.8	7.6	7.4
Others service industry Sub-total	40.1	39.4	38.9	38.6	38.2
Service sector total	45.9	45.5	45.2	45.0	44.7
Grand total (%)	100.0	100.0	100.0	100.0	100.0
Total of GDP (Gs million)	390,837	414,328	444,500	479,170	518,460

(Source) División de Estadística y Cuentas Nacionales, Secretaría Técnica de Planificación.