INTERIM REPORT OF THE FEASIBILITY STUDY
ON THE AFFORESTATION PROJECT
IN CAPIIBARY,
DEPARTMENT OF SAN PEDRO,
REPUBLIC OF PARAGUAY

MARCH 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)

INTERIM REPORT OF THE FEASIBILITY STUDY

ON THE AFFORESTATION PROJECT

IN CAPIIBARY,

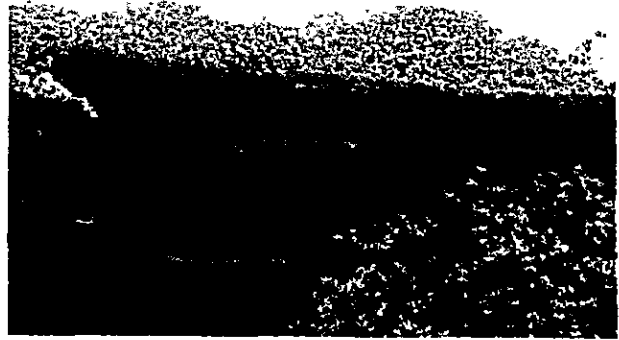# DEPARTMENT OF SAN PEDRO,

REPUBLIC OF PARAGUAY

MARCH 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

(J I C A)

Discussion with the Director General of Servicio Forestal Nacional (SFN)

Forest in Capiibary District viewed from the top of Cerro Dos de Oro

Surveying of boundaries, confirming aerial marker

Forest resources survey (Standing stock inventory) of natural forest

Socio-economic survey, charcoal kiln for pilot test at Acepal Steel Mill in the back

Planted forest survey, Linear thinning of Elliottii Pine in Department of Misiones, Argentina

PREFACE

The objective of this study is to formulate a forest management plan on the study area in Capiibary District of the Department of San Pedro, Paraguay, which is designed in order to contribute to the development of highly productive forest and rural communities.

The study is to be carried out over a period of two years starting from April 1983 in accordance with the Scope of Work (S/W) agreed upon on June 23, 1983.

This report summarizes the findings of the forest survey and socio-economic investigation which were conducted in the first year. A final report with maps of aerial photographs of the study area will be prepared in the end of the second year after completion of various kinds of studies and assessments.

March 1984

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SECTION IV   SOCIO-ECONOMIC SURVEY

SECTION V   DATA

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(SUMMARY)

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S U M M A R Y

SECTION I

OUTLINE OF STUDY

1. Background of Survey

The forests of Paraguay are rapidly diminishing because of the unplanned felling, so that the Government of Paraguay is trying to promote afforestation activities throughout the country. The government, however, finds it difficult to carry out afforestation by itself and has requested the Japanese Government technical cooperation in preparing an afforestation plan in a selected model area.

In compliance with the above request, the Government of Japan has decided to extend its technical cooperation according to the Scope of Work (S/W) which was signed on June 23, 1983 between Japan International Cooperation Agency (JICA) and Paraguayan Authorities concerned, in preparing the Master Plan (M/P) and implementing the Feasibility Study (F/S) on establishing plantations of pine and other indigenous tree species as well as on research method for regenerating its natural forest in the model area set up by the Goverment of Paraguay.

2. Purpose of Survey and Outline of Study Area

The objective of this study is to formulate a forest management plan in the study area for the conservation of forest resources and the development of rural communities.

The study area is located in Capiibary district of San Estanislao in the southeastern part of Department of San Pedro, Paraguay, and 225 km from the Capital City of Asuncion.

The study area was formerly under the possession of Fianciiera Piccolo (FINAP), but due to its bankruptcy it was taken over by Banco Nacional de Fomento (BNF) as mortgage. BNF subsequently is to be transferred the title of the property to the Ministerio de Hacienda (MH) which in turn plans to place it under the jurisdiction of the Servicio Forestal Nacional (SFN) of the Minesterio de Agriclutura y Ganaderia (MAG) and formal procedural steps are now being taken.
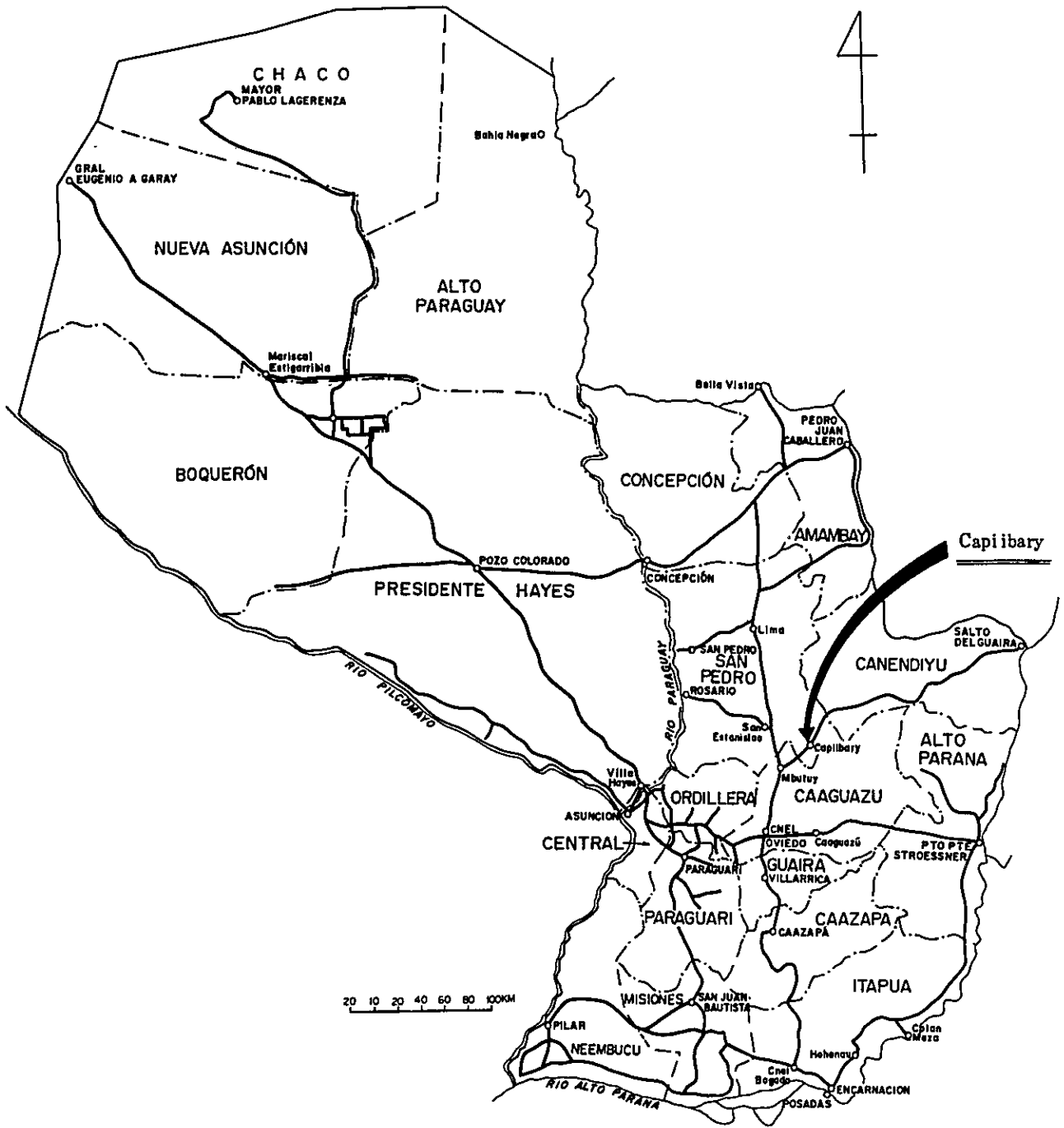
Location of Study Area

3. Contents of Survey

The survey is to be conducted for a period of two years from April 1983 to March 1985.

The plan for the first year was to obtain basic data for preparing the afforestation plan in order to grasp the present state of forests, by way of taking aerial photographs, drafting basic forest maps and carrying out field surveys of sample plots including soil and topography surveys and analyses. Basic data were to be collected also on socio-economic conditions, forest industries and market conditions of forest products, forestry-related enterprises and agroforestry.

The second year will be devoted to prepare working plans for the afforestation plan, which will cover nursery construction and operation, planting, and construction and maintenance of forest road and other facilities. Guidelines will be prepared for a proper management of the natural forests. Further investigations will be made into possible utilization of trees from the natural forests and the plantations as sawlogs or raw materials for pulp and charcoal production. Development effects of agroforestry and other activities on the local inhabitants will also be studied.

All these studies and investigations will culminate in the economic and financial analyses and the appraisal of the development impact of the afforestation program.

4. Survey in Fiscal Year 1983

(1) Composition of Survey Team and Field Work

Field work was separately conducted for aerial photography and for forest inventory and other surveys.

Composition of the survey team and their field work were as follows.

Composition of Survey Team and Field Work   (1983)

Classification	Responsibility	Name	Period	Employee of
Aerial photography	Photographing, mapping	SUNAOSHI, Mitsuo	Aug. 15 – Sept. 18, 1983	KOKUSAI KOGYO CO., LTD.
First afforestation survey	General leader, forest survey	YAMAYA, Koichi	Oct. 7 – Dec. 5, 1983	Japan Forest Technical Association
	Socio-economic survey, forestry-related facilities	NAKANO, Masato	ditto	ditto
	Demarcation of boundaries, appraisal of land and stumpage	SHOJIGUCHI, Seishiro	ditto	ditto
	Appraisal of land and stumpage and forest survey	MASUI, Hiroaki	ditto	ditto
	Demarcation of boundaries	KAWAMURA, Misao	ditto	ditto
	Forest survey	AZUMA, Yozo	ditto	ditto
Second afforestation survey	Forest survey	MASUI, Hiroaki	Jan. 13 – Feb. 6, 1983	ditto
	" "	AZUMA, Yozo	ditto	ditto

(Note)   All members belong to the joint venture for survey on Afforestation Project in Capiibary, Paraguay.

(2) **Officials Concerned of the Government of Paraguay**

       The officials of the Servicio Forestal Nacional (SFN), the Government of Paraguay who have been taking part in the survey are listed below.

Ing. Agr. y Ftal. Director	Pedro F. Calabrese
Ing. Agr.	Rogelio Vidal
Ing. Agr.	Luciano Cabral
Ing. Agr.	Carlos Cuevas
Ing. Agr.	Dionisio González
Ing. Agr.	Hipolito López
Tech. Ftal.	Gilbert Bareiro
Tech. Ftal.	Miguel León
Tech. Ftal.	Ramón Lombardo

5. Supervisory Committee

       In accordance with its rules, JICA established a Supervisory Committee for the Feasibility Study on the Afforestation Project in Capiibary, Paraguay.

       The roster of the committee members and the itinerary of the members who were dispatched to Paraguay during the field survey period are as follows:

Roster of the Supervisory Committee

Assignment	Name	Affiliation	Field dispatch period
Chairman, General supervision	SUZUKI, Susumu	Curriculum Counsellor, Forestry Training Institute, Forestry Agency	
Member, Socio-economic analysis	YASUNAGA, Tomomi	Director, Management Research Office, Kyushu Branch, Forestry and Forest Products Research Institute	Oct. 14 - Nov. 1, 1983
Member, Market analysis	MIYAZAKI, Nobumitsu	Assistant Director, Forest Products Division, Forestry Agency	Oct. 14 - Nov. 1, 1983
Member, Soil and silviculture	KARIZUMI, Noboru	Senior Research Officer, Silviculture Sub-Division, Silviculture Division, Forestry and Forest Products Research Institute	Oct. 14 - Nov. 1, 1983
Member, Resources survey	KAMIJO, Kunihiro	Chief, Forest Resources Survey Unit, Planning Division, Forestry Agency	
Member, Forest management	WATANABE, Yoshihiko	Forest Planning Officer, Planning Division, Forestry Agency	

SECTION II

AERIAL PHOTOGRAPHY AND
DEMARCATION OF THE STUDY AREA

1. Aerial Photography

Aerial photographs of the study area of about 27,000 ha were taken on September 9, 1983. On the basis of these photographs and the existing basic maps (the scale 1/50,000), basic maps of the scale of 1/20,000 (with 5 m contour lines) were prepared.

2. Demarcation of the Study Area

The boundaries of the study area were established on the basis of the survey results of the Banco Nacional de Fomento (BNF). After air photo signals were installed, aerial photographs were taken, and those air photo signals were confirmed on the spot and indicated on the aerial photographs.

When the boundaries were first surveyed by the Banco Nacional de Fomento, it had set up marking stakes at every corner and at an interval of 1 km along the course of traverse. Some of these marking stakes at major points were therefore confirmed and the cleared forest survey lines and the boundaries were also determined by stereoscopy of photographs.

3. Area of the Study Area

The study area was to be about 25,000 ha by S/W. However, it was decided to use the survey results of BNF as the study area. The BNF's survey results excluded national road and others (about 180 ha) from the study area, but because of its shape and area, these areas were included in the survey area. As a result, the study area expanded to cover 27,250 ha.

4. Land Use Pattern

The present land use pattern in the survey area was identified by photo interpretation and ground check as follows.

The Present Condition of Land Use

Land Use	Area (ha)	Percentage (%)
Forest	26,022	95.49
Farmland	401	1.47
Pasture	128	0.47
Cutover area	471	1.73
Damp land	133	0.49
Road	85	0.31
Others	10	0.04
Total	27,250	100.00

5. Planned Demarcation of the Afforestation Project Area

(1) Afforestation Plan Area

The SFN's basic ideas on the afforestation plan area are as follows.

1) A width of 1 km on each side of National Highway No. 10 would be excluded from the afforestation plan area except the sites for the facilities.

2) The already cultivated lands of the settlers which are found to be large in area and clustered together, would be expanded by planning future settlements in areas adjacent to it, and also be excluded from the afforestation plan area.

3) Small and scattered settlements which could be relocated would be included in the afforestation plan area.

4) The area around Cerro between National Highway No. 10 and Arroyo Rojas would be reserved as the sites for the facilities.

5) The areas excluded from the afforestation plan area would be about 6,000 ha.

According to these ideas, the afforestation plan area would amount to 22,032 ha (See the following table).

Planned Demarcation of Afforestation Plan Area

Division	Item	Area (ha)
Afforestation plan area	Forests	21,553
	Reserved for the facilities	479
	Total	22,032
Excluded from the afforestation plan area	A width 1 km of road except sites for the facilities	3,345
	Expanded settlements (East side)	572
	Expanded settlements (West side)	1,301
	Total	5,218
Total Area		27,250

(2) Establishment of Compartments

To identify the location of the forests as well as to facilitate project implementation, the project area should be divided into compartments. It would be suitable to use the mesh division or the artificial blocs allotting about 400 ha to one compartment.

Subcompartments would be set up by dividing the compartment into smaller portions taking into account the difference in species, treatment methods, stand ages, site classes, localities or hauling routes. Land use patterns or administrative boundaries could be considered too when making subcompartments.

Following figure shows the suggested plan for setting up compartments. It would be appropriate to use Arabic figures to indicate compartments, capital letters of alphabet for subcompartments and small letters for excluded areas. (See following figure).

6. Appraisal of Land and Stumpage

The study area is to be transferred with compensation from Ministerio de Hacienda (MH) to Servicio Forestal Nacional (SFN). The Consefo Nacional de Coordinacion Economia held on October 27, 1983 decided to transfer the land and stumpage to SFN without compensation. Appraisal of land and stumpage was undertaken as planned and the results are presented in a separate volume.

Boundary of
compartment

Boundary of
area for the
facilities

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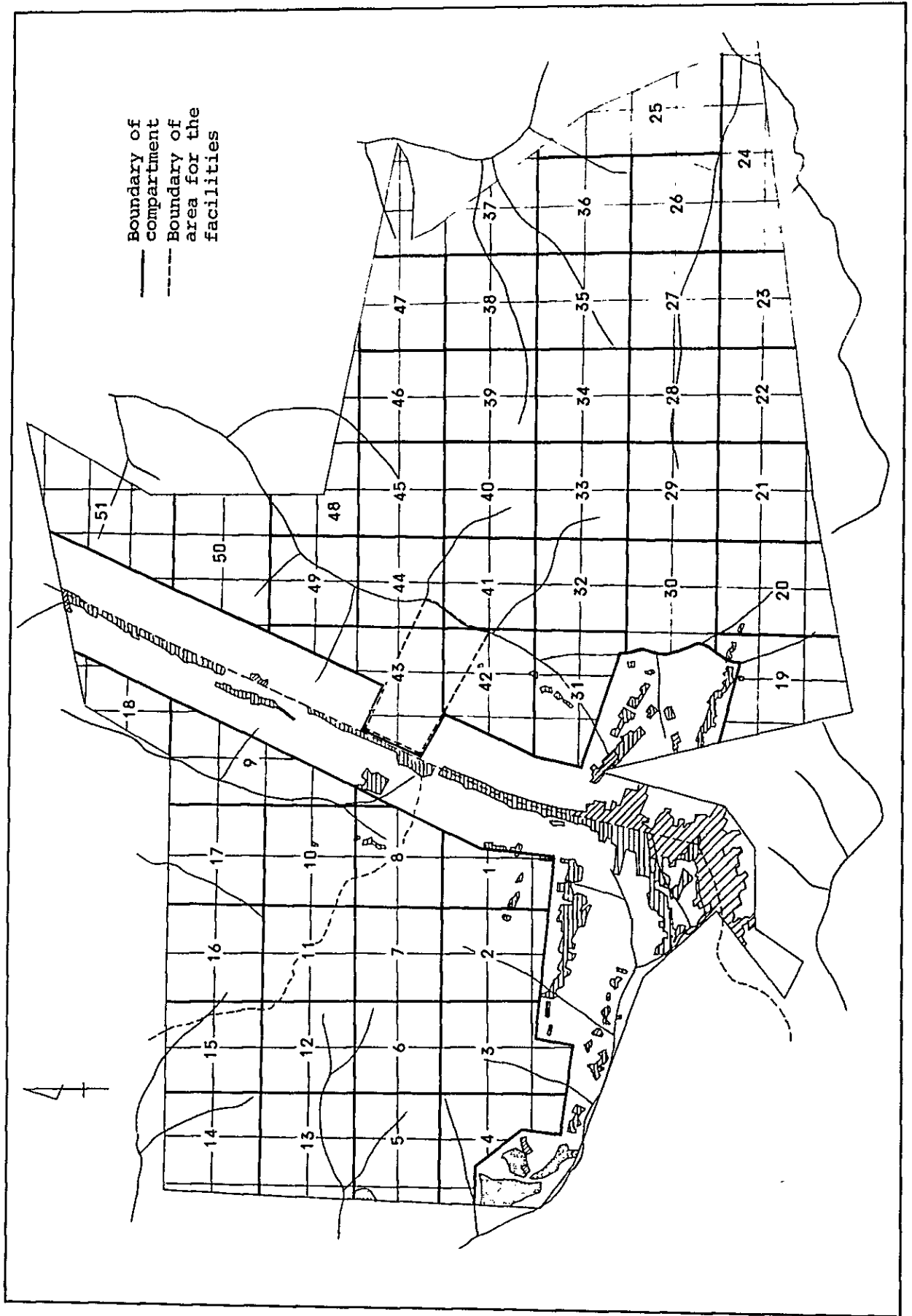
SECTION III

SURVEY OF NATURAL CONDITIONS

1. Climate, Soil and Topography

(1) Climate

According to the observed data during the 1961 -
1970 period of the Villarrica Meteorological Observatory of
which the meteorological conditions seem to be similar to
those of Capiibary, annual mean temperature is 22.2°C,
maximum temperature 38.6°C, minimum temperature -2.4°C, with
a range of 11.3°C between the highest and lowest annual mean
temperatures.

Annual precipitation is 1,659.3 mm, with 100 mm or
more rainfall being recorded every month except the months
of June, July and August. The number of rainy days in each
month is not much different, ranging between six and nine
days.

Prevailing winds are NE and S every month. In
terms of annual average, NE winds account for 21%, S 28%,
both together accounting for about 50% of the year, and
windless days account for 20%.

(2) Soils and Topography

Capiibary area is included in Jurassic Misiones
formation. This formation consists of amorphous red
sandstone called Misiones sandstone and small quantity of
red shale and pelite.

The results of the mesh analysis (one mesh = 25 ha) of the topography of the study area by factor are tabulated below.

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General Situation of Topography

(%)

Division	Upper plain of plateau	Plain of plateau	Gentle slope on the valley head	Valley slope	Monadnock	
Topography						
%	(12.0)	(59.2)	(15.8)	(12.6)	(0.4)	(100.0)
Elevation	Above 300 m (max. 380 m)	300–250 m	250–200 m	200–150 m (min. 160 m)	–	
%	(34.1)	(42.4)	(19.8)	(3.7)	–	(100.0)
Slope	0–3°	3–6°	6–9°	9–12°	Above 12°	
%	(77.9)	(21.1)	(0.8)	(0.2)	(0.0)	(100.0)
Bearing	N	E	S	W	Nil	
%	(27.5)	(24.9)	(20.4)	(22.4)	(4.8)	(100.0)

2. Forest Inventory

As for forest inventory, growing stock of the study area was estimated by aerial photo-interpretation coupled with the sample plot survey in the field. Thirty-two sample plots of 0.4 ha each were selected, and all trees with diameter breast height (DBH) of 10 cm or more were checked for species, DBH, tree height, etc. were measured. The plot locations were selected in consideration of the area ratio by forest type (high forest, medium forest, and low forest) and deviation of classification factors for interpretation. In addition, 20 trees with DBH of 41 cm or more were selected within the survey area, and the branch volume of each was estimated. The volume unsuitable for charcoal production was also estimated.

(1) Areas by Forest Types

The following table shows the area of each forest type.

Areas by Forest Types

Forest Type	Symbol	Area (ha)	Percentage (%)
High forest	A	8,683	33.37
Medium forest	M	15,627	60.05
Low forest	B	1,712	6.58
Total		26,022	100.00

(2) Number of Trees, Volumes

The following table is the results of the sample plot survey showing the distribution of the number of trees and volume per hectare by species class for each forest type, tabulated separately for trees with DBH of 10 cm or more (total surveyed trees) and for those of 41 cm or more (more than medium-sized trees).

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 increasing future
D	Species whose demand is expected to increase in the domestic market
E	Species whose market prices are difficult to set

Distribution of the Number of Trees and Volume
Without Bark(m3) per Hectare by Species Class
by Forest Type

High Forest Type (A)

Diameter / Species class	Total surveyed trees		More than medium-sized trees	
	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 / Species class	Total surveyed trees		More than medium-sized trees	
	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

Medium Forest Type (M)

Diameter / Species class	Total surveyed trees		More than medium-sized trees		Total surveyed trees		More than medium-sized trees	
	Number of trees	%	Number of trees	%	Volume	%	Volume	%
A	29.8	11.2	7.5	26.1	14.17	20.5	8.55	26.3
B	13.0	4.9	4.0	13.9	6.67	9.7	4.94	15.2
C	43.8	16.4	9.2	32.1	18.04	26.1	10.87	33.4
D	128.7	48.3	4.4	15.3	21.23	30.7	4.81	14.8
E	44.0	16.5	2.8	9.8	7.31	10.6	2.57	7.9
Defective trees	7.2	2.7	0.8	2.8	1.67	2.4	0.80	2.4
Total	266.5	100.0	28.7	100.0	69.09	100.0	32.54	100.0

Low Forest Type (B)

Diameter / Species class	Total surveyed trees Number of trees	%	More than medium-sized trees Number of trees	%
A	17.5	5.4	0	0
B	3.7	1.1	0	0
C	28.8	8.9	1.3	20.6
D	182.5	56.4	5.0	79.4
E	86.3	26.7	0	0
Defective trees	5.0	1.5	0	0
Total	323.8	100.0	6.3	100.0

Diameter / Species class	Total surveyed trees Volume	%	More than medium-sized trees Volume	%
A	2.71	7.1	0	0
B	0.49	1.3	0	0
C	6.75	17.7	0.60	15.7
D	21.74	57.2	3.22	84.3
E	5.82	15.3	0	0
Defective trees	0.54	1.4	0	0
Total	38.05	100.0	3.82	100.0

(3) Growing Stocks

A multiple regression equation was derived using the volume per hectare of sample plots as the objective (dependent) variable and interpreted values of tree height, crown density and crown diameter of sample plots as the explanatory (independent) variables. Factors for each forest type were substituted into this equation and multiplied by the area of each forest type. The resulting growing stocks in the survey area are as follows:

Total Growing Stock

Growing Stock of the Study Area

Area (ha)	High forest 8,683		Medium forest 15,627		Low forest 1,712		Total 26,022		
Class	Volume (m³)	%	Volume (m³)	%	Volume (m³)	%	Volume (m³)	%	volume per ha (m³)
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

More than Medium Trees

Class	High forest		Medium forest		Low forest		Total		
Area (ha)	8,683		15,627		1,712		26,022		
	Volume (m³)	%	Volume (m³)	%	Volume (m³)	%	Volume (m³)	%	Volume per ha (m³)
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

(4) The Branch Volume

The branch volume survey was conducted for trees with DBH of 41 cm or more. Since the branch volume per 1 m³ of stem volume was 0.56 m³, the branch volume of the study area is tabulated below.

Branch Volume of Standing Trees
with More than Medium Trees

Class	Volume of Branches in the Entire Area of 26,022 ha (m³)	Volume per ha (m³)
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 trees	11,397.79	0.44
Total	496,719.49	19.09

(5) Volume Unsuitable for Charcoal Production

Volume unsuitable for charcoal production is tabulated as follows.

Volume of Unsuitable for Charcoal Production (per ha)

(m³)

Division	Class	High Forest	Medium Forest	Total
Total surveyed tree	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
Trees larger than medium-sized	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

Volume of Unsuitable for Charcoal Production in the Branch Volume (More than Medium Trees)

Class	Volume Unsuitable for Charcoal Production in the Branch Volume	Per ha (m³)
B	6,946.12	0.27
C	26,625.96	1.02
Total	33,572.08	1.29

3. Growth of Natural Forest

As for growth of natural forest, annual ring survey was conducted on the bottom diameter of logs at logging sites and sawmills in Colonel-Oviedo. The mean increment was estimated by diameter grade for 61 logs in all by combining this survey with the results of the forest inventory conducted in the northeastern region of Paraguay. It was then multiplied by the number of standing trees by diameter grade per hectare estimated from the results of the inventory to obtain the stem growth per hectare. The resulting growth per year in the survey area was 1.93 m³/ha for all species combined and 0.48 m³/ha for A + B classes. Accordingly, the growth rate in this area was estimated to be around 2.8%.

4. Forest Soil Survey

Test pits of 100 cm each in length, width and depth were dug at 32 spots in the sample plots and forest soil survey was conducted according to the National Forest Soil Survey Manual in Japan. The soil map was prepared by classifying the soil into four types on the basis of characteristic horizon originating from pedogenic factors. Characteristics of each soil type as collated with topographical divisions are as follows:

(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

(2) <u>Collation of Soil Types with Topographical Divisions in Capiibary</u>

Type IV (gley) Type III Type II (blocky) Type I (granular)

m
500
400
300
200
100
0

Valley slope — Gentle slope on the valley head — Plain of plateau — Monadnock — Plain of plateau — Upper plain of plateau

Gley Acrisols ⟶←— Normal Acrisols ⟶ ←— Normal Acrisols ⟶ ←— Normal Acrisols ⟶
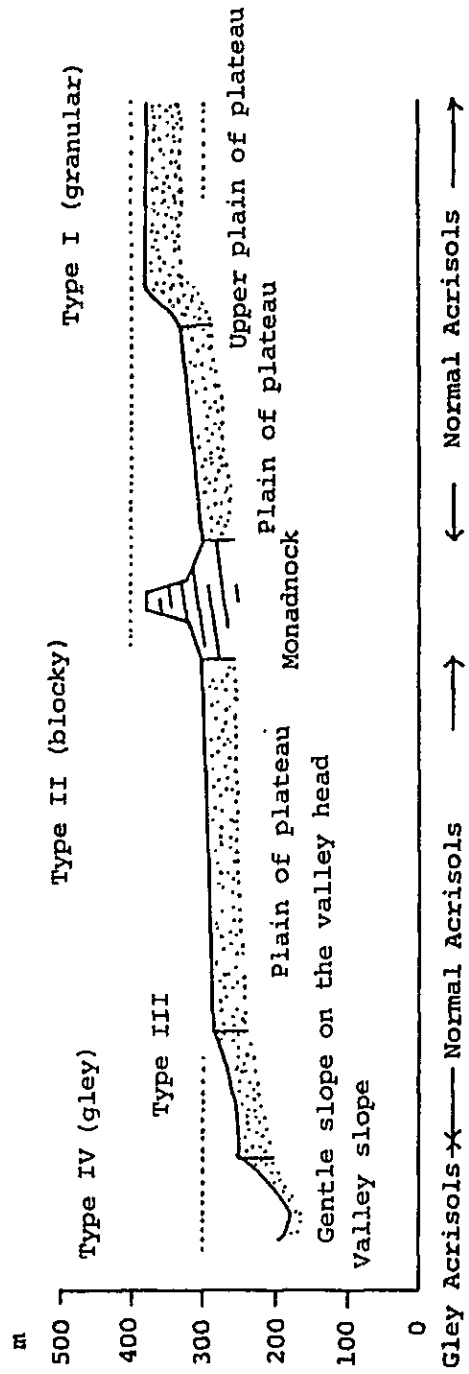
(3) Soil Distribution

Each soil type is distributed as follows.

Areas by Soil Types

Soil Type	Area (ha)	Percentage (%)
I	1,370	5.0
II	19,353	71.1
III	2,518	9.8
IV	3,959	14.5
Rock	50	0.2
Total	27,250	100.0

(4) Soil Type and Forest Growth

Productivity by soil type is larger in the order of Type I, Type II, Type III and Type IV.

Accordingly, fostering of natural forest and development of artificial forest would be promising on Types I and II soils. Development of artificial forest would also be possible on Type III soil although soil moisture seems rather excessive, and no vigorous growth can be expected. Type IV soil is strongly affected by leaching of nutrients and gleization and is topographically susceptible to erosion; it also lacks A and B class trees, so that it ought to be protected by prohibiting logging.

5. Forest Plantation Survey

(1) Growth and Yield

    1) Survey of forest plantations selecting 30 sample plots was conducted in the following three areas, Capiibary, Stroessner and Province of Misiones in Argentina, and at the same time, stem analysis of 13 number of Elliottii pines (Pinus elliottii) and three number of Parana pines (Araucaria angustifolia) was conducted as well.

    2) Stem volume table and anticipated yield table of Elliottii pine were prepared as shown in the following tables.

(2) Forest Productivity Map

Forest productivity map, using data of Elliottii pine, was prepared through interpretation of forest productivity factors.

(3) Planting Species

Suitability of tree species for forest plantations was investigated taking into consideration the natural conditions of Capiibary area and the future trend of timber demand and supply. It is concluded that the following species would be suitable for forest plantations:

Stem Volume Table of Elliottii Pine (m³)

Tree height (m) \ d.b.h (cm)	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
2	0.0024																		
3	0.0029	0.0049																	
4	0.0033	0.0060	0.0083	0.0127															
5	0.0037	0.0068	0.0101	0.0154	0.0203	0.0279	0.0367	0.0570	0.0708										
6	0.0040	0.0076	0.0117	0.0180	0.0248	0.0341	0.0448	0.0671	0.0833	0.1013									
7	0.0043	0.0082	0.0132	0.0203	0.0292	0.0401	0.0527	0.0770	0.0956	0.1162	0.1390								
8	0.0045	0.0088	0.0147	0.0226	0.0335	0.0460	0.0605	0.0868	0.1077	0.1310	0.1565	0.1845							
9	0.0048	0.0094	0.0161	0.0247	0.0378	0.0518	0.0681	0.0964	0.1197	0.1455	0.1739	0.2049	0.2386						
10	0.0050	0.0099	0.0174	0.0268	0.0420	0.0576	0.0757	0.1059	0.1315	0.1598	0.1911	0.2252	0.2621	0.3020					
11	0.0053	0.0104	0.0187	0.0288	0.0461	0.0632	0.0832	0.1153	0.1431	0.1740	0.2080	0.2452	0.2854	0.3288	0.3753				
12	0.0055	0.0109	0.0200	0.0307	0.0502	0.0689	0.0906	0.1246	0.1547	0.1881	0.2249	0.2650	0.3085	0.3554	0.4057	0.4594			
13	0.0057	0.0114	0.0212	0.0325	0.0543	0.0744	0.0979	0.1339	0.1662	0.2020	0.2415	0.2846	0.3313	0.3817	0.4357	0.4934	0.5548		
14	0.0059	0.0118	0.0224	0.0344	0.0583	0.0799	0.1051	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	0.0122	0.0235	0.0361	0.0623	0.0854	0.1123	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		0.0126	0.0247	0.0379	0.0662	0.0908	0.1195	0.1611	0.2000	0.2432	0.2907	0.3425	0.3988	0.4595	0.5245	0.5940	0.6678	0.7462	0.8290
17			0.0258	0.0396	0.0701	0.0962	0.1266	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			0.0268	0.0412	0.0740	0.1016	0.1336	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			0.0279	0.0429	0.0779	0.1069	0.1406	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				0.0445	0.0818	0.1122	0.1475	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				0.0460	0.0856	0.1175	0.1545	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				0.0476	0.0894	0.1227	0.1613	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					0.0932	0.1279	0.1682	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					0.0970	0.1331	0.1750	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						0.1382	0.1818	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						0.1434	0.1885	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							0.1952	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							0.2019	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 (m³).

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	
	cm	m	m³		m³	m³	m³
1							
2							
3	4.5	3.3					
4	6.8	4.7					
5	9.3	6.3					
6	11.8	8.1	0.0758	953	72		19
7	14.3	9.9	0.1144	953	109	62	21
8	16.6	11.7	0.1620	953	154		24
9	18.7	13.6	0.2177	953	207		27
10	20.8	15.3					
11	22.8	16.9	0.2818	535	151		30
12	24.6	18.4	0.3532	535	189	118	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.

(2nd site class)

Stand age	Mean			Per hectare			Mean increment
	d.b.h. cm	Height m	Volume per single tree m³	No. of trees	Volume m³	Thinning volume m³	m³
1							
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	1272	82	37	13
10	15.4	11.3	0.0890	1272	113		15
11	16.8	12.5	0.1164	1272	148		17
12	18.2	13.6	0.1461	1272	186	73	19
13	19.5	14.6	0.1779	862	153		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 back.

. <u>Species for Afforestations</u>

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

Broad-leaved trees: Eucalyptus spp.

. <u>Species for Research Afforestation</u>

Broad-leaved trees: Paraiso (Melia azedarach),
Cedro (Cedrela sp.),
Lapacho (Tabebuia sp.),
Peterevy (Cordia trichotoma),
other tree species, and fodder
tree species.

(4) <u>Silviculture System</u>

Based on the anticipated yield table, silviculture system of Elliottii pine plantations was investigated.

The following diagrams show the results of investigations:

First row labels / columns:

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 (m³)		134	269	369	440
Weeding (cleaning) (times)	3 3 3 1				
Pruning (times)		535	362		
Thinning (times)		768 62m³(46%)	418 116m³(44%)	173 119m³(32%)	
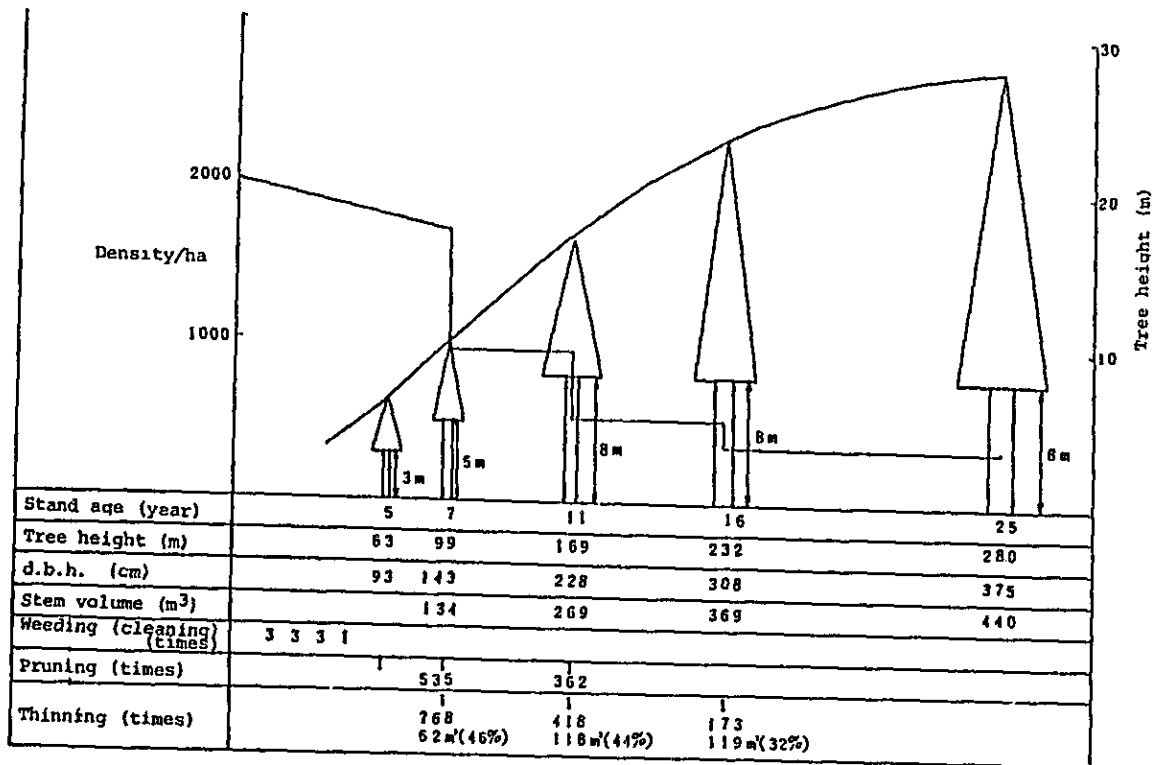
Elliottii Pine Silviculture System (on 1st site class)

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 (m³)		117	226	305	343
Weeding (cleaning) (times)	3 3 3 1				
Pruning (times)		862	629本		
Thinning (times)		559 37m³(31%)	410 73m³(32%)	233 82m³(27%)	
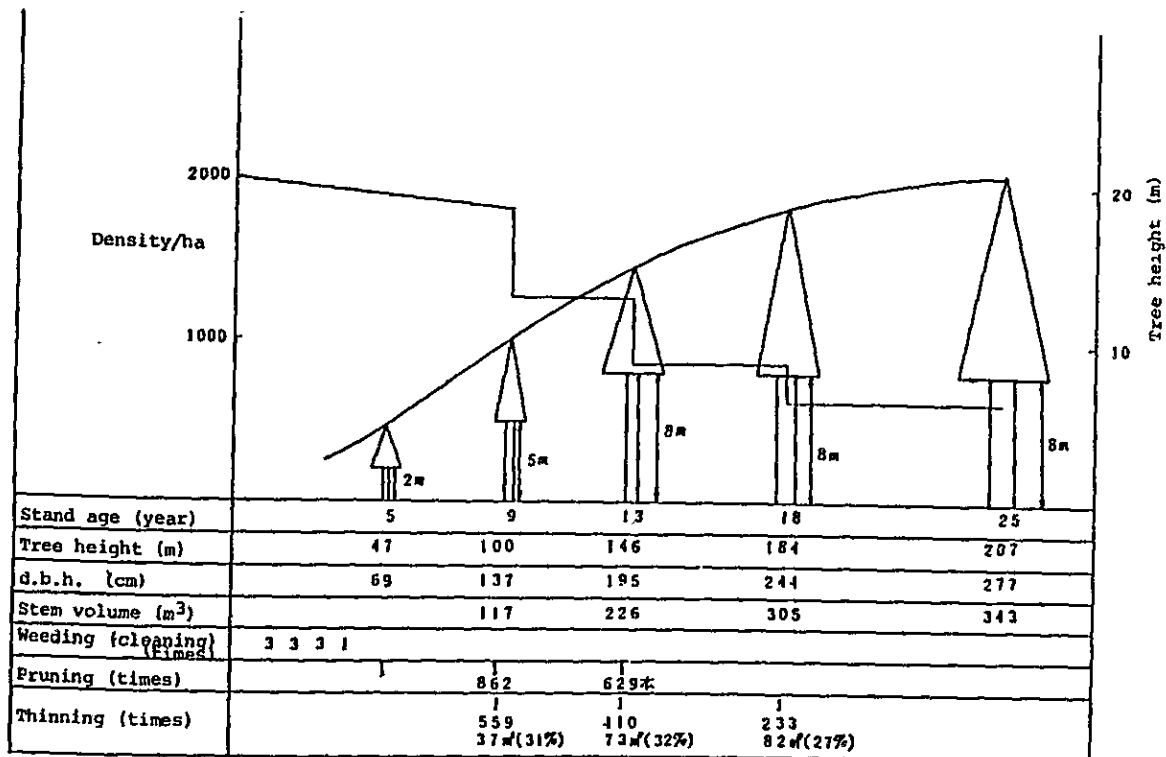
Elliottii Pine Silviculture System (on 2nd site class)

6. Natural Regeneration Survey

The survey was conducted on the growth of infant trees and growth of natural forests. A review of research methods on natural regeneration was also undertaken.

As for growth of infant trees, a small plot of 1 m by 20 m was set up at three spots in the front, middle and rear of each sample plot for the inventory survey, and the number of infant trees with DBH of less than 10 cm was counted by species classifying them into three categories of: (1) tree height less than 1.3 m (but above 0.3 m), (2) tree height 1.3 m or more (DBH 4 cm or less), and (3) tree height 1.3 m or more (DBH between 5 cm to 10 cm).

The average number of infant trees per hectare in the study area was 15,600 (16 trees per m^2) for all species classes combined, about 900 (5.7% of all infant trees) for A + B classes, and about 2,400 (15.2% of all infant trees) for A + B + C classes. The number of infant trees was found to be quite small; even with C class trees included in the count, it was only 0.24 tree per m^2, or at the rate of one tree for every 4 m^2.

Regarding natural regeneration, available case studies are scanty, and the appropriate regeneration techniques have not yet been elucidated. In view of the situation, it would be necessary to first set up an experimental area on regeneration to obtain and accumulate data rather than immediately starting the regeneration work at a full scale.

SECTION IV

SOCIO-ECONOMIC SURVEY

1. General Conditions

(1) Population

    The total population of Paraguay is 3.03 million,
and population density 7.4 persons/km² (National Census,
1983).

    Percent distribution of employed workers by
occupation in 1983 shows that workers in primary industry
such as agriculture, livestock and forestry account for
41.3% of the total, thus constituting the mainstay of the
labor force. Change in the percent distribution during the
decade between 1973 and 1983 however indicate 10% decline
in the share of agriculture, livestock, forestry and mining
with compensatory increases in the shares of manufacture,
commerce and other secondary and tertiary sectors.

(2) Politics and Religion

    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. As
for local administration, the capital and 18 departments are
established.

    The freedom of faith is assured under the consti-
tution, though Catholicism is the national religion.

(3)　Economy of Paraguay

.　General Condition

Paraguay's GNP and its per capita are US$4,970 million and US$1,630 respectively in 1981.

The average annual growth of GDP during the decade from 1965 to 1975 was 5.2% a year. Particulary during the 1977 - 1980 period, a growth of more than 10% was achieved.

Although its pace of economic growth has slowed down since 1981, Paraguayan economy is continuing to grow relatively steadily despite the serious recession and rampant inflation that plagues the neighboring countries.

Breaking down GDP by sector, the production sector accounted for 54.1% of GDP in Fiscal Year 1981, just sligtly over the 45.9% by the service sector.

Of the production sector, the agricultural sector accounted for 20.5% of GDP, followed by the manufacturing sector with 16.6%. The forestry sector earned 3.2%. The combined share of agriculture, livestock and forestry was 30.3%, but compared with 35.7% in 1975, their weight is on a declining trend.

In terms of the 1981 production indices with 1977 as a base year at 100, that of agriculture was 135, livestock 116, and forestry 145 against 148 for total production.

.　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. The
deficit in 1981 reached US$210 million.

2) Import and export items

Paraguay is a typical exporter of primary
products and importer of industrial products,
almost all of its export being accounted for by
agricultural, livestock and forestry products. Of
the 1981 total exports of US$296 million, textile
goods accounted for 43.0%, 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%).

Imports are largely accounted for by ma-
chineries, fuels and so on which are indispensable
for the economic development of Paraguay.

Imports of paper, paper board and proces-
sed paper products amounted to about US$10 million
in 1981, accounting for 1.9% of the total imports.

3) Export destinations and import sources

As for export, inter-regional transactions
within LAFTA (The Latin American Free Trade Asso-
ciation) are the largest. Particularly, the shares
of Brazil and Argentina are high.

The 1981 actual exports by destination
were Argentina (23.2%), Brazil (13.6%), West
Germany (11.1%), Japan (8.4%), and the United
States (5.2%).

Import sources are Brazil (25.9%),
Argentina (19.8%), the United States (9.7%), Japan
(8.3%) and West Germany (8.1%).

. An Economic Outlook

An economic outlook is as follows according to the
document prepared by the Paraguayan Government:

1) GDP is expected to reach 518 billion Gs in 1985
   against 391 billion Gs in 1981. During these
   years, 7% increase is expected a year on average.

2) The growth of exports will be 11.1% and imports
   10.6% on average.

3) The growth of primary industry sector is expected
   at 7.8% a year on average in future. This sector
   will occupy 30.6% of GDP in 1985.

4) Secondary industry sector is also expected to grow
   at 8.1% a year on average, and it will occupy 24.5%
   of GDP in 1985.

5) The main service sector will also grow at 10.4% a
   year on average, and the share will be 6.5% of GDP
   in 1985.

6) The growth of other services will be 6% a year on
   average, but the ratio in GDP will be reduced to
   38.2% in 1985 from 40.1% in 1981.

For Paraguay's economic development, it is indispensable to proceed with industrialization projects on the one hand, such as the construction of hydraulic power plants in Itaipu and Yacyreta and the construction of Acepal Steel Mill, and on the other hand, to improve quality of agricultural, livestock and forestry products and raise their productivity.

Particularly, considering the favourable environment and resource conditions of this country, the development of forestry and forest industry is indeed an extremely important prerequisite for the economic development of Paraguay.

2. Socio-Economic Conditions in Capiibary Area

. Socio-Economic Conditions in the Department of San Pedro

1) Area: 20,002 km²

2) Population: 191,812 persons, 9.6 persons/km²
(as of 1982)
In the year 2000 the working
population will be 1.8 times as many
as present.

3) Agricultural production:

Crop	Harvesting area (1979)
Cash crops:	66,300 ha
Cotton	31,600
Soybean	16,200
Wheat	8,300
Others	10,200

Crop	Harvesting area (1979)
Subsistence crops:	51,100 ha
Maize	31,300
Manioc	10,500
POROTO (bean)	6,200
Others	3,100
Total	117,400

Production values: Gs 4,659,000, or 8.1% of national agricultural production

4) Forest area:

Year	Forest area (thousand ha)	% area of Department	% total forest area of Paraguay
1945	859.4	43.0	12.6
1976	540.0	27.0	12.9

• Socio-Economic Overview of Capiibary Area

1) General conditions

Although the study area administratively belongs to the City of San Estanislao, Department of San Pedro, it is more appropriate to consider it as part of the socio-economic sphere that extends from Capiibary to Mbutuy in the Department of Caaguazu.

In recent years the upgrading of National Highway No. 2 between Capital City Asuncion and Stroessner and the completion of National Highway No. 3 which branches off from the Highway No. 2 and

runs north to Mbutuy have given Capiibary area easy access to the National Highway No. 2 via Mbutuy along which the wood-based industries are concentrated.

It was against such a background that the timber company FINAP had acquired about 100,000 ha of forest and had engaged in sawmill operation for about a decade between 1968 and 1979. By this undertaking, the population of the area increased and villages were formed. When FINAP's business was closed, part of the employees remained and engaged themselves in animal husbandry, and with the entry of other farmers who settled to cultivate the land there, the villages continued to exist to date.

2) Population in Capiibary area

The population in the central part of Mbutuy and its surroundings is 13,380 persons.

The population in and around the survey area is roughly estimated at 5,000 persons.

3) Industries and livelihood

The inhabitants in this area are mainly engaged in animal husbandry. The average land holding per family is around 20 ha, of which cultivated land is about 4 ha.

The major crops are cotton and tobacco besides such subsistence crops as peanuts, soybeans, manioc and maize. Livestocks raised are cattle, horse, swine, sheep, chicken, etc. but as

their numbers are small, the degree of their contribution to the family budget is small.

Of the 50 families living in the study area, 25 families are former FINAP employees.

The former FINAP employees are small scale farmers with average size family of seven and average land holding of 11 ha, of which 6 ha is for cropping cotton, 3 ha for tobacco, 1 ha for maize, 0.5 ha for manioc, 0.5 ha for pimentoes and bananas and for raising chicken and swine.

3. Wood Based Industries

(1) Demand for Timber

. Production Values

The share of the forestry sector in GDP was small at 3.2% in 1981 but its exports accounted for 12.5% of Paraguay's total exports in 1981 and 21.4% in 1980, thus constituting an important export item for the country.

The largest end use of timber in domestic consumption is fuelwood for household use and industrial fuel. Annual production of fuelwood was 2.8 million tons in 1981.

The 1981 production of logs grew more than twice that of 1974. Above all, the quantity of logs for industrial use was large at 1.5 million tons, but this presumably included the large demand for the construction of the Itaipu Dam.

. <u>Timber Demand Pattern</u>

The following generation may be made on the characteristics of the timber demand pattern in Paraguay.

1) About 70% of the sawn timber is used for building, while the balance is used for furniture and interior works.

2) End-uses of construction timber are - in the order of larger usage volume - structural timber (ridge piece of roof and ceiling, beam, girder, roof sheathing, etc.), furniture (major tree species used are Lapacho and Cedro) temporary work materials and interior work materials.

3) The domestic market is concentrated in Asuncion which accounts for 70 to 80% of domestic demand.

The above are representative fields of timber utilization, but in Paraguay, there is another field of timber demand, and that is for pasture fence and for fuel-wood and charcoal production.

Although Paraguay's wood-based industries and lumber production are regarded as important industries for the economic development of the country, it is hard to say that they are achieving steady expansion and development. Rather, they seem to be faced with the need to:

1) develop new demands for forest products in the home market,

2) improve and upgrade production facilities and production technology in the wood-based industries in order to improve export quality and competitiveness of forest products,

3) improve the infrastructure for timber production.

In other words, the forestry sector of Paraguay is reading the stage where it is bound to bring about a rapid development of wood-based industries and infrastructure for timber production.

. Direction of Demand in the Private Sector

The demand for temporary work materials for building construction and for housing cannot be expected to grow much in view of the traditional building methods and the life style in Paraguay. However, the mounting interest in wooden houses of late is worthy of attention.

Particularly noteworthy of the application fields of wood in Paraguay is wooden furniture.

Next in importance to furniture are the manufacturing and marketing of window frames, doors, cabinets fixed to the wall and other interior decorating wood products.

. Forecast of Demand for Timber

Compared with 1982 demand, the quantity of demand for timber in year 2000 is forecasted to increase by 1.8 times for sawlogs, by twice for charcoal production, by 1.9 times for agricultural uses, etc., all adding up to an aggregate demand quantity of 9,239,000 m^3 or 1.6 times the 1982 demand of 5,915,000 m^3.

(2) Demand for Fuelwood

. Demand Pattern for Fuelwood

The demand for household fuelwood and charcoal is
showing approximately the same trend as the growth of
population. The demand for fuelwood for industrial use is
also important. When the Acepal Steel Mill is completed, it
is estimated that more than 150,000 tons of charcoal will be
consumed annually. Also, the demand for fuelwood for brick
and roof tile industries is considered certain to increase
gradually.

. Direction of Supply of and Demand for Fuelwood in
  Capiibary Area

When studying the supply of and demand for fuel-
wood, it is basic to meet the demand for the industrial
energy for steel making and other industries which are
expected to go into operation or are expected to be promot-
ed.

The required volume of logs to produce the 100,000
tons of charcoal that Acepal Steel Mill would need is
estimated to be around 598 thousand m^3 a year.

(3) Measures to Promote Wood-Based Industries

As soon as it prohibited to export logs in 1972,
Paraguay formulated the "Five Year Basic Program for Streng-
thening Forest Industries" (with total budget of Gs 30
million) in 1977 with the aim of promoting wood-based
industries by implementing various policy measures.

Besides, the Instituto Nacional de Technologia y
Normalizacion (INTN) is engaged in the study of utilizing
the lesser-known species. Also, the Escuela Technica
Forestal (ETF) in Alto Parana and Centro de Desarrollo
Forestal (CEDEFO) are training technicians for forestry and
forest industries. Furthermore, case studies on pulp and
particle board industries are now under way as a technical
cooperation programme of the Association of Latin American
Development Institute (ALADI). Conclusions of the studies
are expected shortly.

In 1981, due to the decline of wood-based products
in exports, the sawmills and wood processing industries were
compelled to cut back gradually on production. In 1983, the
situation seemed to have been seriously aggravated.

Facing this serious situation of the wood-based
industries, the Export Promotion Center of Paraguay has
announced that it is urgent to take adequate measures for
export expansion, as reducing manufacturing cost, improving
the process in techniques and, it would be necessary, in the
future, to secure enough export availability.

4.   Infrastructure

As major infrastructure in Paraguay, the present
situation of the transportation facilities such as roads,
major ports, air transport and railways and of the
communication facilities such as telephone and telex were
investigated.

As for the infrastructure in Department of San
Pedro, telephone, mail, schools, health, waterworks, and
roads were investigated as well. (Refer to the Main Text)

The area around the Capiibary Afforestation Project
Area, however, lacks sufficient infrastructure other than
National Highway No. 10, a telephone line, a small airship
and regular bus services. In this area, roads, airstrip,
schools, hospitals, residences, electricity, water, mail,
telegram, telephone and sawmills were investigated. (Refer
to the Main Text)

5. Agroforestry

In order to clarify the possibility to introduce
agroforestry practices into the Capiibary Afforestation
Project, reports and data on agroforestry systems in Paraguay
were sought, and four agroforestry trial in the country
were investigated. (Refer to the Main Text)

One of the merits to the forestry activities of
introducing agroforestry is the decrease in the costs of
tending, in particular weeding, which are quite substantial
in a country like Paraguay, where grasses grow wildly in
spring and summer.

However, in Paraguay, where the population pressure
on land is low and arable land is relatively abundant, bene-
fits on agricultural side of introducing agroforestry may
not be so great, apart from long-term good effects on lands
such as soil conservation and maintaining land productivity.
This point must be investigated more in detail looking into
local needs of the farmers.

It would probably be needed to first introduce an
experimental agroforestry based on the results of socio-
economic surveys and to investigate, in the meantime, an
appropriate method and possible extension of such agro-
forestry practices.

6. Laws and Regulations Relevant to Afforestation, etc.

(1) Labor laws, (2) planting related lows, (3) investment and major taxes on business firms, etc. relevant to the Capiibary Afforestation Project were investigated. (Refer to the main text)

7. Financial Institutions and Lending Conditions, etc.

For implementing the Capiibary Afforestation Project, Servicio Forestal Nacional (SFN) is contemplating to finance the project by revenues from the disposal of standing trees and by loans from financing institutions.

The lending conditions of relevant financing institutions in and outside Paraguay, who are to be the sources of the project fund, were surveyed based on available data and hearings, and the findings were summarized.

SECTION I

OUTLINE OF STUDY