REPORT ON THE FOREST INVENTORY IN THE NORTHEASTERN REGION OF PARAGUAY

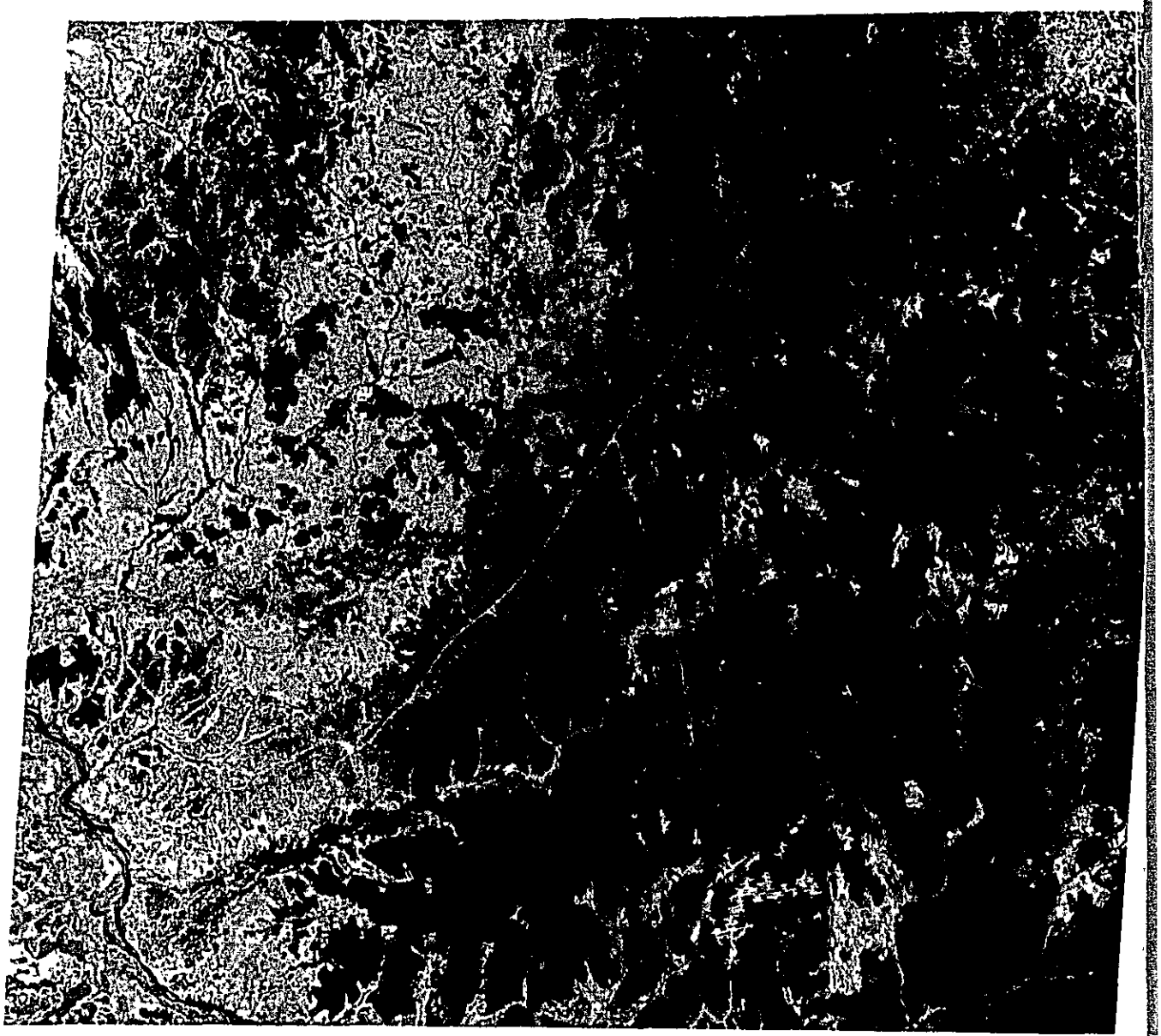
—1983—

GUIDELINE FOR FOREST DEVELOPMENT PLAN

February 1984

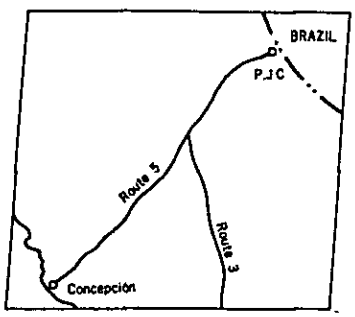
JAPAN INTERNATIONAL COOPERATION AGENCY

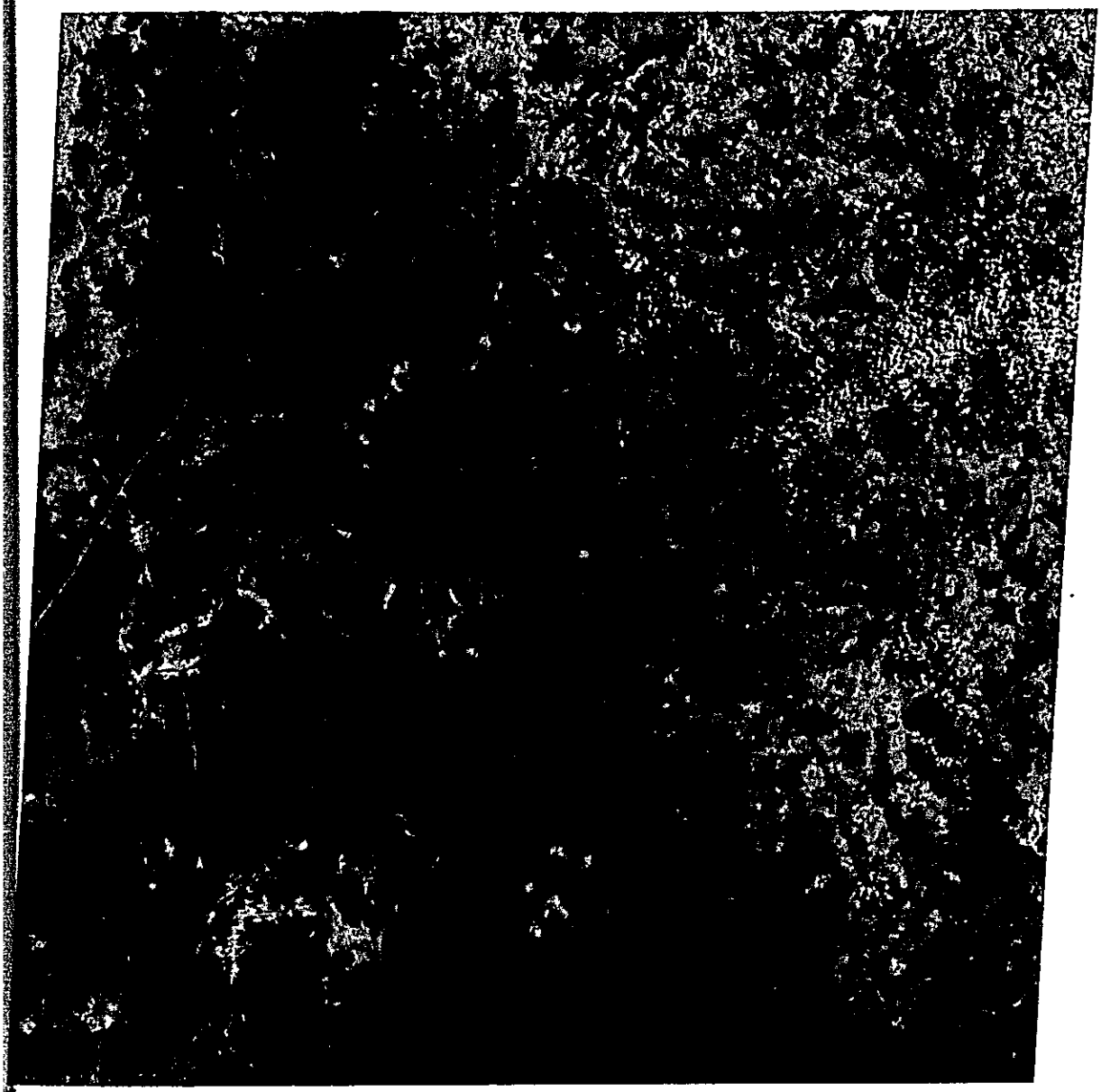
(JICA)



FRONTISPIECE 1

INFRARED-COLOR IMAGE BY LANDSAT (MARCH, 1981) (Scale, 1/million)





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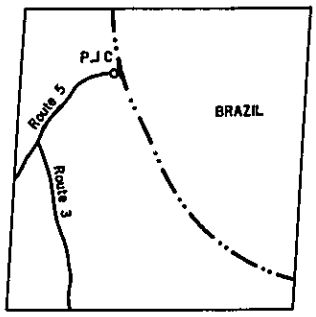

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FOREWARD

The Forestry Inventory of the Northeastern Region of the Republic of Paraguay has been implemented for four years since 1980 on the basis of the Scope of Work concluded in June 1980.

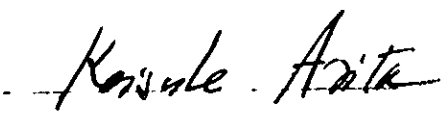
The purpose of this survey is to provide basic data and information for the establishment of a forest management plan covering the region to ensure conservation and sound utilization of Paraguay's valuable forest resources. During the initial three year perio through 1982 aerial photographs were taken, and they were analysed and utilized for further forest surveys. During 1983 guidelines for the preparation of a forestry development plan were compiled based on the survey results of the preceding three years.

This report summarizes the activities undertaken in 1983.

I hope that this report will serve for a sound forestry development in the Northeastern Region of Paraguay and enhance the cooperative relationship between Japan and Paraguay.

Our thanks are due to all the people involved in this survey, in particular, to the officers of the Agriculture and Livestock Ministry and the National Forest Service of the Republic of Paraguay.

February 1984



Keisuke Arita
President
Japan International Cooperation Agency

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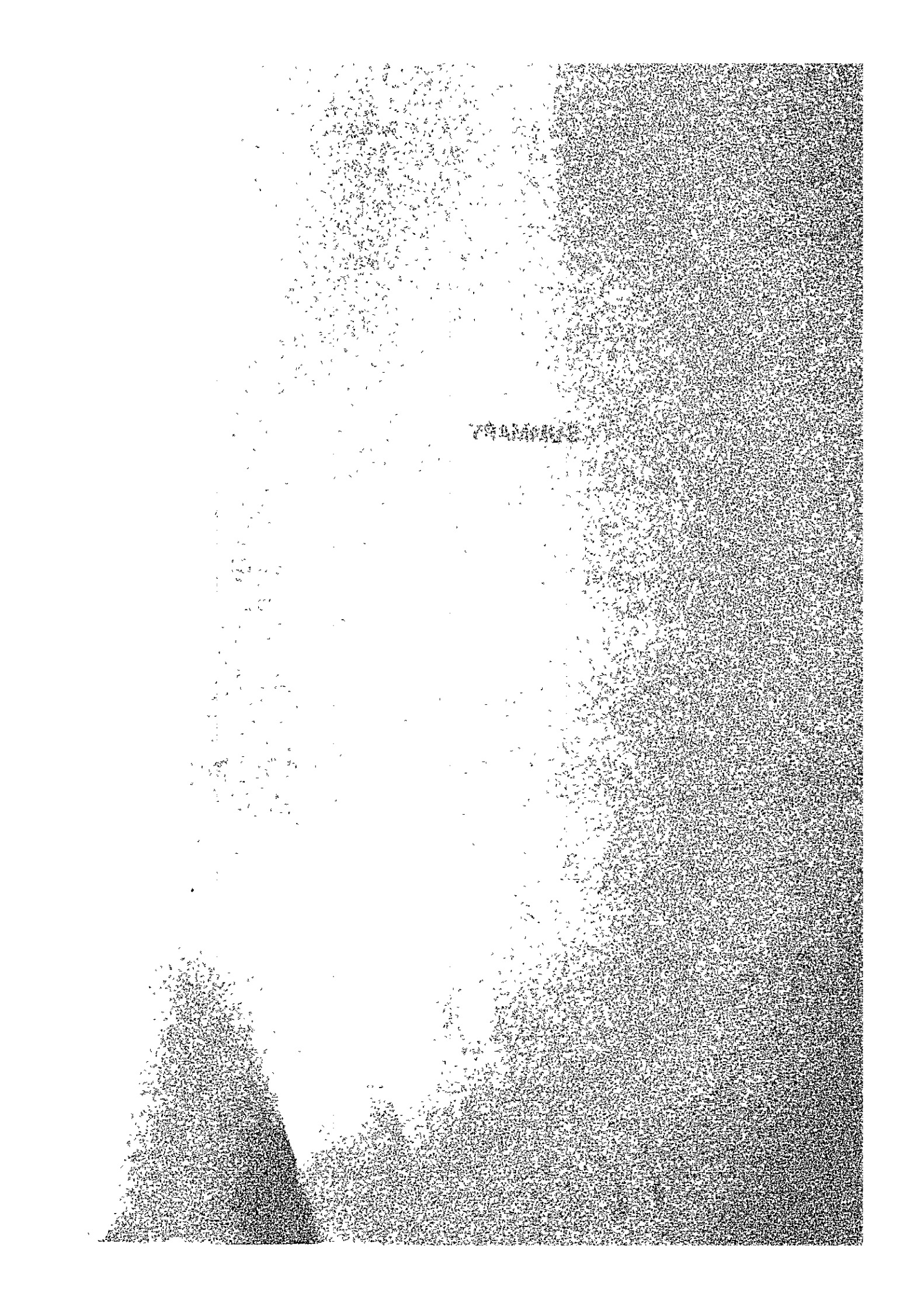
SUMMARY



INTRODUCTION

1. OBJECTIVE AND BACKGROUND OF SURVEY

Paraguay has a land area of approximately 407,000 km^2, with forest being approximately 163,000 km^2 to constitute 40% of the total land area; 23% of the forest is located in the east region.

Despite of its small proportion, the forest in the region has large stock and useful species, and, together with its favorable economic/social environment, has been developed in early time. Particularly, in the northeast region, which is a subject of this survey, the uncontrolable development has been progressed without clear understanding of the existing condition of the forest resources, and led to a situation to be harmful from the standpoint of resource securing and land conservation.

To cope with this situation, the survey such as preparation of aerial photograph map, forest resources survey and soil in investigation were carried out in the past three years, starting from 1980, and from which the condition of the forest resources and the characteristics of the wood land were revealed.

On the basis of the results of such surveys, this survey is to prepare a guideline for forest development plan in the northeast region, and thereby to look into the economy and society of Paraguay toward 21st century and to clarify a direction of public policy on forest resources and industry on comprehensive and long term basis.

2. LIST OF SURVEY TEAM AND PERIOD OF FIELD SURVEY

List of survey team and period of Field survey

Classification	Responsibility	Name	Period of field survey
Basic study for forest development plan	Team leader	Yasuo Muramatsu	24/VI/1983~07/VIII/1983
	Economic/Social analysis	Kuniyasu Wakamori	"
	Land plan	Katsutarou Kato	"
	Forest plan	Atsushi Hisamichi	"
Field consultation	Leader Development plan	Yasuo Muramatsu	25/XI/1983~24/XII/1983
	Land use plan	Kuniyasu Wakamori	"
	Forest management plan	Atsushi Hisamichi	"

List of National Forestry Service of Paraguay (SFN) director, deputy director, chief district forest

Title	Name
Eng. Agriculture & Forestry, Director	Pedro. F. Calabrese
Eng. Agriculture & Forestry, Chief Department of National Parks, Forest and Preserves	Hilario Moreno
Eng. Agriculture, Chief District Forest, Amambay	Milciades Valdes

List of counterpart in Paraguay Forest Service (SFN)

Responsibility	Title	Name
Basic study for forest development plan	Eng. Agr.	Luciano Cabral
	Eng. Agr.	Carlos Barboza
	Tech, Ft.	Carmelo Rodriguez
	Tech. Ft.	Raul Alonso
	Tech. Ft.	Rosalino Vargas
Field consultation	Eng. Agr.	Luciano Cabral
	Eng. Agr.	Milciades Valdes
	Tech. Ft.	Carmelo Rodrigues

3. DESCRIPTION OF THE SURVEY AREA

3-1 Geographical location and land area

The survey area is located in northeast part of Paraguay, bounded by 22° and 24° South Latitude, and 55°30' and 56°30' West Longitude, and contains the Department of Amambay and a part of three adjacent departments, Concepción, San Pedro and Canendiyu, covering approximately 15,000 km^2.

3-2 Topography and geology

The area is made up of Amambay Mountain Range, which has a dividing ridge along an international border with Brazil, and undulating landscape with gentle hills in southwest side continued from the mountain range. The elevation of the area is ranged from 200 m to 600 m.

Watershed of the area belongs to branch system of Paraguay river, and each branch stream flows in east-south direction to join into the main river; the area constitutes the upper riverhead of the river system.

Geology of the area consists of debris type consolidated sediment made up of sandstone, mud stone, shale and conglomerate, and of basalt extrusion.

3-3 Stand condition

The forest in the area is mainly comprised of natural/sub-tropical broad leaved forest with an insignificant extent of planted forest. Peroba constitutes approximately 19% of total stock in the natural forest, to be the most found species. The mix ratio of useful species is as many as 50% of the total stock.

3-4 Climate

Annual mean temperature in P. J. Caballero is 21.3°C, and annual rainfall is 1,537 mm. Rainy season is between October through March, with monthly average rainfall within the range of 150 mm–180 mm.

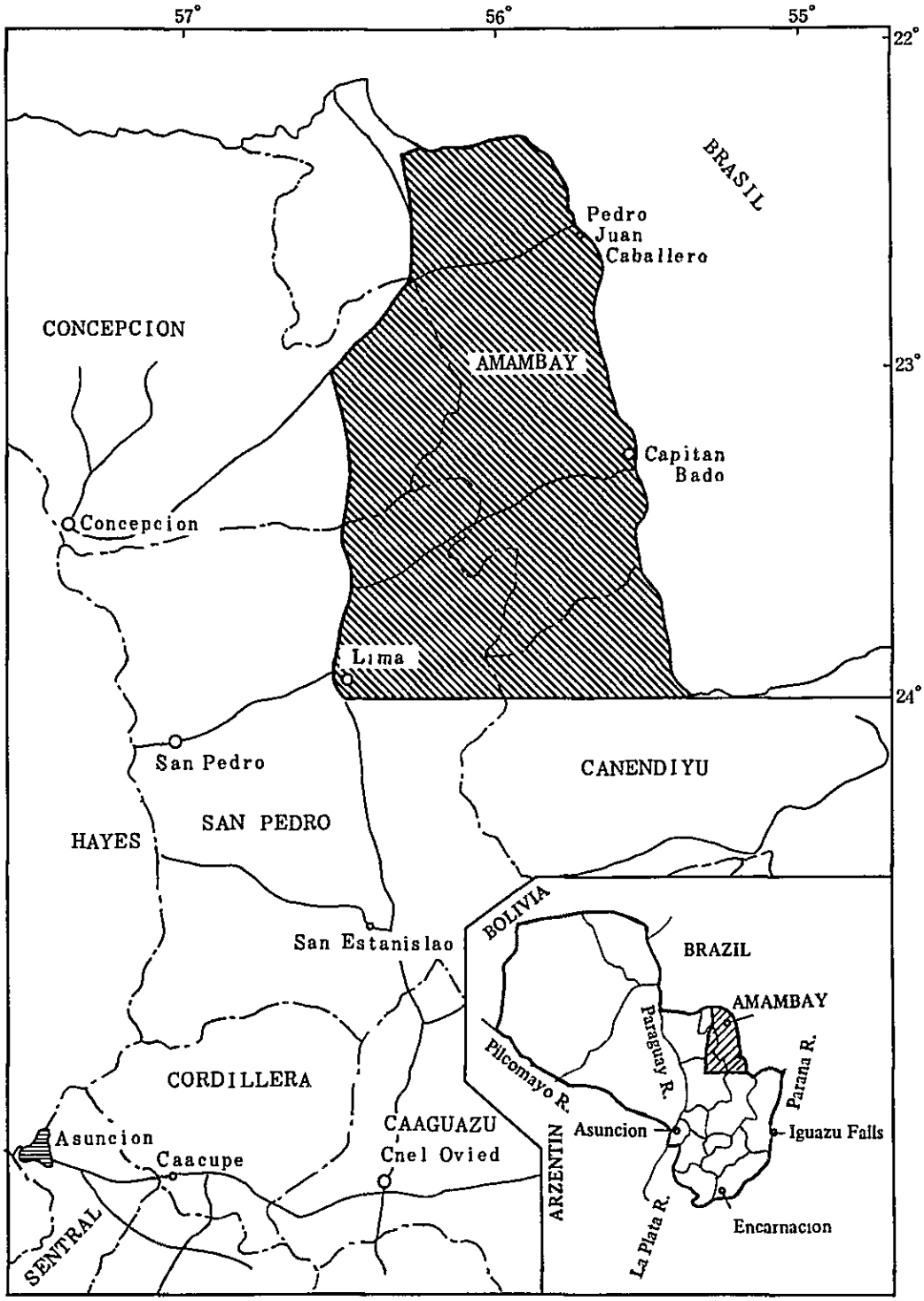


Fig. 0-0-1 Location map of survey area

PART 1. GUIDELINE FOR FOREST DEVELOPMENT PLAN

1. BASIC PRINCIPLE

1-1 Characteristics of the Forest

The characteristics of the forest in the area, which is a subject of the present plan, are discussed in detail in the reports on forestry resources survey carried out in past three years since 1980 as well as in this report, "PART 2 BASIC SURVEY". This section is to summarize the characteristics of the forest for elements which are directly related to preparation and implementation of the guideline for the forest development plan in the subject area.

Element	Characteristics
(a) Geographical Location and Land Area	a) The survey area covers the Department of Amambay and a part of adjacent three departments, Concepción, San Pedro and Canendiyu in northeast parts of Paraguay. b) The area has a land area of approximately 15,000 km^2.
(b) Topography, Geology and Climate	a) The area is located in undulating landscape with gentle hills continued from a dividing ridge in northeast along an international border with Brazil. Topography is generally open and level with elevation ranging from 200 m to 600 m; high in the east and low in the west. b) The area belongs to Paraguay river system, to constitute upstream head-waters area for the branch streams. c) The area is made up of consolidated sediment containing sandstone, mud stone, shale and conglomerate as well as basalt extrusion. d) The area has annual mean temperature of 21.3°C and annual rainfall of 1,537 mm with rainy season between October through March
(c) Stand Condition and Forest Resources	a) Forest coverage constitutes approximately 60% of the total area, with high forest to cover 35%. b) The forest is of natural/subtropical broad leaved type with a great variety of species Extent of planted forest is minimal. c) Total stock in the area is approximately 28 million m^3, of which class A + B accounts for 54%, or approximately 15 million m^3, and Peroba accounts for 19%, or approximately 5 million m^3.
(d) Increment in Natural Forest	a) Estimated from a survey result of annual rings of trees cut in the area, increment of all species is 2.13 m^3 per ha. b) Increment of class A + B and Peroba is 0.55 m^3 and 0.21 m^3 respectively. c) The rate of the increment for all species is estimated at around 3.3% annually.
(e) Natural Regeneration	a) Determined from a result of a survey on sapling growth in the natural forest, the number of sapling for each forest type is as follows:

Forest type	Tree height 0.3m ~ 1.3m		DBH ~4cm		DBH 5cm ~ 9cm	
	Peroba	A + B	Peroba	A + B	Peroba	A + B
A_1	1,083	750	83	250	0	0
A_2	333	944	111	167	56	0
M	0	200	100	0	0	0
M_2	125	542	125	42	0	0
DA_2	1,556	611	444	167	56	56
DA_3	2,000	375	625	250	250	125

b) From the number of sapling for classified size, 67–92% of Peroba sapling disappears before reaching diameter breast height (DBH) of 4 cm, and over 83% of decrease rate for 5–9 cm class, while 67% and 91% for same classes in A + B class.
This indicates that a majority of saplings produced disappears before reaching diameter breast height of 4 cm.

c) A tendency is observed in the number of saplings to decrease with crown density of upper trees in excess of a certain degree. This seems to be attributable to luminous intensity in the forest to be affected by the crowns.

(f) Soil Condition in the Forest

a) From a result of profile survey, the soil in the forest is classified into sand (Type S), sand/loam (Type S·L), loam (Type L), clay loam (Type CL), clay (Type C) and gley soils (Type C).

b) Type S soil is good for natural regeneration and have potential for reforestation, albeit low productivity. Type S·L, L and CL soil is suitable for reforestation, particularly type L soil has the highest productivity.

c) Type S and S·L soil are highly subject to decreasing fertility and top soil erosion after cutting, to require careful treatment.

(g) Disappearance of the Forest

a) According to a result of Landsat data analysis, the forests have disappeared at annual average rate of around 1.3% in five year period between 1972 and 1977.

b) This tendency is progressing faster recently. The analysis results of the same data in the latest two years from March 1981 to March 1983 indicate that 2.6% of the forest disappear each year, and the contents of remained forests are becoming poorer affected by selection cutting of bulky trees.

1-2 Economic and Social Characteristics of the Area

Economic and social characteristics of the area is discussed in Part 2 of this report 'Basic Study' which has been produced on the basis of a result of basic study for forest development plan carried out in this year. The summary of the basic characteristics is listed as follows:

Item	Major Characteristics
(a) Concern about forest and forestry	a) Level of recognition on rapid decrease of forest resource as well as Forest Act is generally low.
	b) Strong governmental assistance and guidance are required to promote reforestation project.
	c) Desperate demand for stable employment opportunity is voiced among residents in the area.
(b) Population	a) The eastern region contains 98% of the total population, with population density of 18.6 persons/km^2. The population growth rate in the region is 2.5% in the recent years, in contrast to the world average of 1.4%.
	b) The total population in the planning area is approximately 100,000 with the growth rate of 0.5%, along with conspicuous trend of being concentrated into urban areas.
	c) The total working population in the planning area is estimated 40,000–50,000 with considerable high growth rate to be estimated.
(c) Gross National	a) Gross National Product of the country is amounted to US$ 4,110 million, being ranked 9th in South America.
	b) The country has shown a steady rate of growth, more than 10% on the annual average between 1977–1980 and relatively stable growth after 1981.
	c) In terms of sectoral composition, agriculture;livestock farming; forestry sector constitutes a share of 30.3%, to be a dominant sector in Paraguay economy; among which forestry section constitutes 3.2% of the total GNP.
(d) External Trade	a) Balance of trade recorded a deficit of US$ 2.1 billion in 1981.
	b) The trade structure is typically of primary product export and industrial product import. According to export record in 1981, wood products constitute 12.5%, and vegetable oil, mainly consisting of oil paulownia, 7.6% and Quebracho extract 1.9%, as forest related products.
	c) Dominant share of external trade is done within LAFTA (Latin American Free Trade Association), particularly a large share by Brazil and Argentina.
(e) Forestry Production	a) Forestry sector constitutes 21.4% of the total export value in 1980 and 12.5% in 1981, to be a major export item of the country.
	b) Domestic consumption is largely of firewood for household and industrial fuel, 2.8 million tons produced in 1981.

c) Production of logs has been rapidly growing in recent years, to reach 1.5 million tons for industrial logs.
d) As to overseas market, a large share of export from the north-east region goes to Brazil.

1-3 Objective of Forest Development Planning Guideline

The planning area contains vast forest, 60% of the total area, to form a largest forest zone in the eastern part of Paraguay. Recently cutting and development of the forests in the area is progressed rapidly, and it is urgent matter to formulate forest development plan so as to conserve and nurture the forest resource under orderly development and to aim for intensive land use

The area is estimated to contain approximately 100,000 population, around 3% of the total population of Paraguay. The population is in process of being concentrated in urban areas, and level of recognition on forest and forestry is still low.

On the other hand, Paraguay economy continues a relatively stable growth among neighboring countries which are subject to inflation, being led by agriculture/livestock farming/forestry sector which constitutes about 30% of Gross National Product.

Forestry sector constitutes over 3% of Gross National Product, but has a share of 22% in 1981 export value, mainly wood products and forestry related products, and coupled with supply of firewood for household and industrial use as well as production of industrial and agriculture/livestock farming logs the sector occupies a very important position in the national economy.

Neverthless, a most of export of wood product is done in the form of lumber or sawed timber, with low degree of processing. As it is advantageous for an inland country like Paraguay to maximize the degree of processing so as to export high value added wood products, it is necessary to promote wood consuming industries such as furniture, woodcraft, pulp and paper manufacturing by effectively utilizing abundant forest resource, water resource and electric power in the country.

This forest development planning guideline has been prepared on the basis of peculiar characteristics of the area in terms of economic and social structure and forest resource, as well as the study results to the previous year, to aim for conserving and fostering forest resource with consideration to coordination with total land use planning, to aim for regional development and improvement of local people welfare by means of continuous and stable supply of forest products such as woods and increase of employment opportunity, and to aim for conservation and strengthening of public functions of forest such as soil conservation, fostering of water resource, and conservation and creation of natural environment.

1-4 Basic Principles on Forest Development Planning Guideline

In order to efficiently achieve the above objectives, basic principles on preparing guideline for forest development planning are established as follows;

(1) To clarify define land use classification and to aim for intensive use of land
(2) To clarify define forest management classification and to aim for standardization of forest management
(3) To attempt to estimate and maintain appropriate cutting volume and to aim for conservation and fostering of forest resource

(4) To promote reforestation and thereby to develop forest resource in active manner
(5) To aim for intensive use of forest resource such as use and development of unused materials
(6) To aim for conservation and upgrading of public functions of forest such as soil conservation, fostering of water resource and conservation and creation of natural environment
(7) To aim for coordination with other industries, particularly agriculture and livestock farming

2. LAND USE CLASSIFICATION

2-1 Present Land Use and Its Problem

According to information on the present land use and potential area for each land use classification in the east region, presented in the document prepared by the Forest Service, Ministry of Agriculture and Livestock (TCP/PAR/8902), in 1979 agricultural and livestock farming land have already exceed their potential area, while forest land is 1.2 million ha less than its potential area, to indicate that unused forest land has been already developed and used as agricultural and livestock farming land.

This means that at present inbalance between land uses is existing as a result of excessive development of potential forest land. Moreover, the inbalance will be increasingly widened due to further development of present forest land when found very suitable for agricultural and livestock farming land, and likelihood of this situation is very high. As such inbalance will have a considerable impact on economy and society in this region, it is considered to be an important subject on economic and social development that rational land use plan be formulated on the basis of overall and long term viewpoint in the region and will be appropriately implemented.

2-2 Principle and Definition of Land Use Classification

On classifying land uses, an attempt was made to bring about optimum classification which is based upon trend of land use pattern and natural, economic and social characteristics of the region, while taking into consideration the integration with overall land use plan, trend and function of the forest as watershed protection, and present land use pattern. Also, the consideration was given to comprehensive land use which should cover agriculture, livestock farming and forestry.

Under above principles, a whole part of the area was classified into the following seven zones:

a. Urban zone
b. Agricultural zone
c. Livestock farming zone
d. Forest zone
e. Mixed zone
f. Conservative zone
g. Swamp and others

2-3 Method of Land Use Classification

(1) Unit of Classification

Forest planning map was equally divided into 15 sections in both vertical and horizontal direction to construct meshes, and which were used as unit of classification.

Dimension of each mesh is 2 minutes of Longitude by 2 minutes of Latitude, with average area of approximately 1,248 ha (approximately 3,420 m x 3,650 m).

(2) Criteria for classification

The following table of land condition index was prepared by using productivity and gradient of land, to be used as criteria for classification in terms of natural condition:

Table 0-1-1 Table of land condition index

Gradient / Productivity of land	1 ~3°	2 3°~6°	3 6°~9°	4 9°~12°	5 12°~	Remarks
1 Type L	1	2	3	4	5	Incl. type CL
2 Type S-L	2	3	4	5	6	
3 Type S	3	4	5	6	7	
4 Type others	4	5	6	7	8	Type C,G and Others

(3) Description of land use classification

Land in each mesh was classified into the following classes in accordance with the table of land condition index, with consideration to present land use pattern and future trend, distance from urban and village settlement, and other economic and social condition.

a Urban zone

Urban zone includes an area mainly consistaing of urban and other major settlement and their surrounding areas which should be integrated in overall development, improvement and conservation.

b Agricultural zone

Agricultural zone includes an area having land condition index of 2 or less or agricultural land of more than 50% of the total area.

c Livestock farming zone

Livestock farming zone includes an area having land condition index of 3—4 or livestock framing land or more than 50% of the total area.

d Forest zone

a) Forest zone includes an area having land condition index of 5 or more or forest land of more than 50% of the total area.

b) Also the zone includes an area which is suitable for forest land in need for securing and upgrading the various functions of forest such as land conservation and water source conservation.

e. Mixed zone

Mixed zone includes an area in mixture of land condition index suitable for agriculture, livestock farming or forest, or mainly consisting of multiple land use for agriculture, livestock farming and/or forestry

f Conservative zone

Conservative zone includes an area mainly consisting of national park, reserved land for conservation of natural environment or other public use, and conservative land required by laws or for specific use.

g Swamp and others

These include an area mainly consisting of swamp, wildland, lakes and marshes, and others which are not an object of ordinary land use.

2-4 Result of Land Use Classification

In accordance with the above criteria, a whole part of the planning area was classified into the zones, and the result was presented in accompanied Forest Plan Map.

Area for each land use classification and geographical distribution of the zones are as presented in Table 2 and Fig. 1 respectively

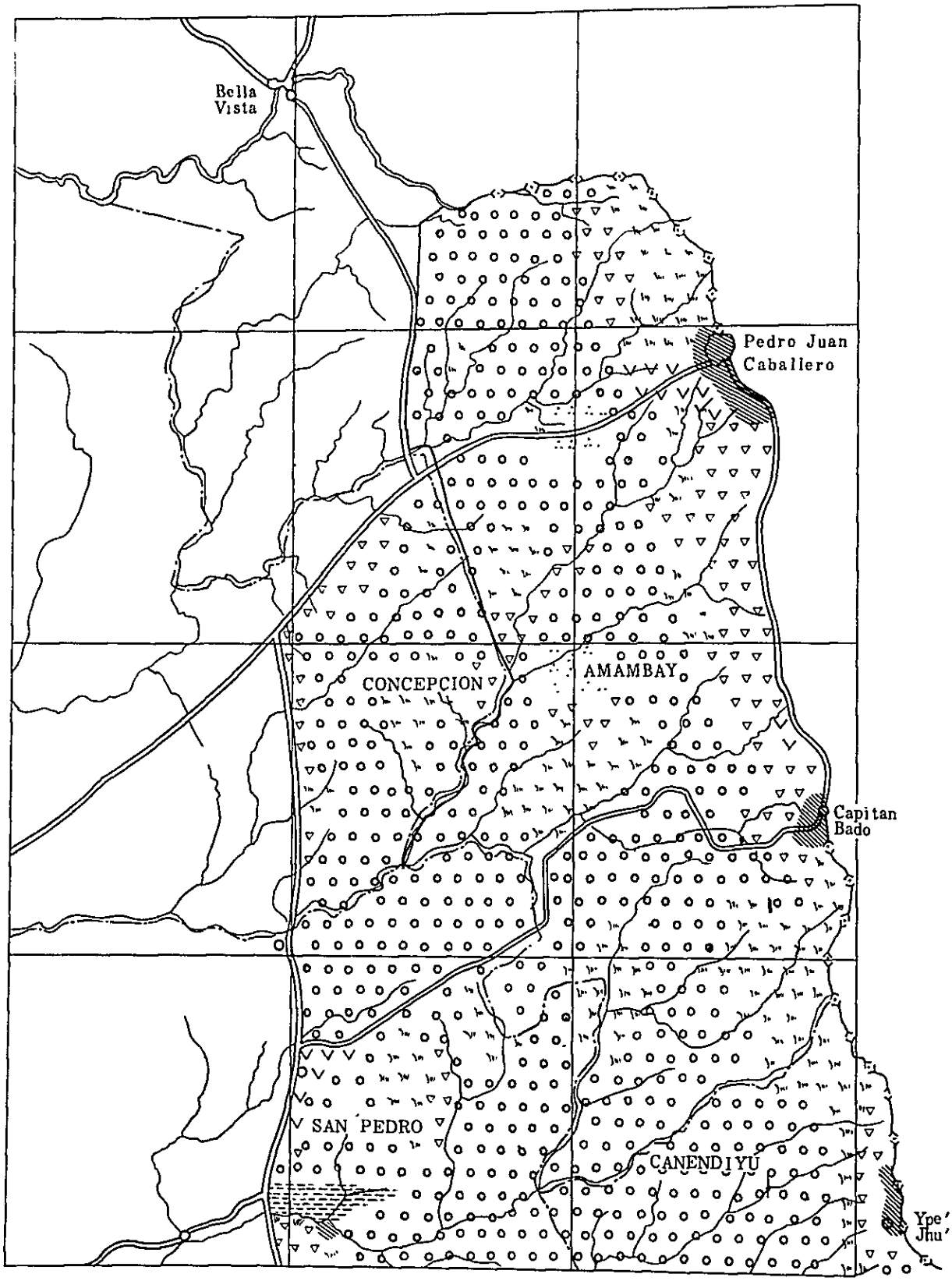
In addition, comparison was made between area by the above land use classification and by the present land use (see 1982 report), as shown in the table below.
Direct comparison between two figures are not very meaningful, since purpose of classfication and definition of land uses are different between two data. However, when the comparison is used for understanding of general trend of land use, this land use classification is thought to be appropriate for the purpose.

Table 0-1-2 Area by land use classification and department

Department / Land use classification	AMAMBAY		CONCEPCIÓN		SAN PEDRO		CANENDIYU		Total	
	Area		Area		Area		Area		Area	
	ha	%	ha	%	ha	%	ha	%	ha	%
Urban Zone	8,700	1			3,300	1	3,700	2	15,700	1
Agricultural Zone	26,200	3			6,600	2			32,800	2
Livestock Farming Zone	218,400	25	34,600	19	29,500	9	27,700	15	310,200	20
Forest Zone	436,800	50	111,000	61	242,900	74	148,000	80	938,700	60
Mixed Zone	148,500	17	36,400	20	32,800	10	5,600	3	223,300	14
Conservative Zone	35,000	4							35,000	2
Swamp and Others					13,100	4			13,100	1
Total	873,600	56	182,000	11	328,200	21	185,000	12	1,568,800	100

Table 0-1-3 Comparison between land use classification and present land use pattern

Type of data / Land use classification	Land use classification		Present land use pattern		Remarks
	Area		Area		
	ha	%	ha	%	
Urban Zone	15,700	1	2,373	(02)	Built-up area
Agricultural Zone	32,800	2	78,928	5	Agricultural land
Livestock Farming Zone	310,200	20	338,167	22	Pasture
Forest Zone	938,700	60	955,404	61	Forest
Mixed Zone	223,300	14	—		
Conservative Zone	35,000	2	—		
Swamp and Others	13,100	1	50,226	3	Swamp
	—		143,705	9	Cut-over area
Total	1,568,800	100	1,568,803	100	



	Urban zone	▽	Mixed zone
V	Agricultural zone	∴	Conservative Zone
	Livestock farming zone		Swamp
○	Forest zone		

Fig. 0-1-1 Geographical distribution of land use classification

2-5 Summary of Land Use Classification

(1) General distribution of zones

a. Urban zone

The urban zone is located in built-up area of P.J. Caballero and Capitan Bado and their vicinities as well as settlements at Lima and Ypé Jhú and their vicinities, with the area being around 1 % of the total area.

b. Agricultural zone

The agricultural zone is located in the area surrounding the city of P. J. Cabblero, hill area along national road route 5, and Colonia Rio Verde in the State of San Pedro, with the area being around 2% of the total area. In addition, significant portion of agricultural land is included in mixed zone.

c. Livestock farming zone

The livestock farming zone is widely distributed in the area extending in adjacent to the border with Brazil from P. J. Caballero to Estrella in the north, the area along the border from Capitan Bado to Ypé Jhú, and the area along national road route 3, and 11.

The zone constitutes 20%, of the total area, with extensive use in general.

d. Forest zone

The forest zone constitutes 60% of the total area, and 62% when the conservative zone is included. Recently, however, the forests have disappeared in the area with easy access to transportation including around urban areas and along roads as a result of rapid rate of development.

e. Mixed zone

The mixed zone is located in the entire eastern part from P. J. Caballero to Capitan Bado, in the areas along national road route 3 and 5, and transitional area between livestock farming zone and forest zone.

The zone constitutes 14% of the total area. Among the observed forms of land use mix, namely agriculture – livestock farming, livestock farming – forest and agriculture – livestock – forest, the form of livestock farming – forest is most common at present.

f. Conservative zone

The conservative zone is located in Cerro Cora and Cerro Guazú, to constiture 2% of the total area.

The zone in Cerro Cora includes national park area and reserve for its future expansion which covers approximately 8,500 ha. The zone in Cerro Guazú is a proposed national park under this plan, covering approximately 21,000 ha.

g. Swamp and others

The zone is located in low swamp land around Aguaray – Guazú river extending to the east of Lima, to constitute around 1% of the total area. Although the zone is not likely to be used for the time being, it will become important in future for the purposes of the recreational use along with the forest zone, and academic research and conservation of natural environment such as protection of wild animal and vegetation.

(2) Problem and future direction of land use

Looking into change in forest area in a whole part of four departments directly related to the planning area, including the Department of Amambay, for three year period between 1976 and 1979, approximately 130,000 ha of the forest have disappeared.

The annual rate of the disappearance is as many as 2% , with further accelerated rate in recent years.

If this trend continues in future, in due course not only a shortage of wood for domestic demand, including construction material and firewood, will be created but also serious deterioration of the forest will have an adverse effect on conservation of the land and its natural environment such as flood prevention and top soil protection; to be anticipated as serious obstacles to economic and social development of Paraguay.

Henceforth, in the planning area effective programmes should be promoted for maintaining and securing of the forest under comprehensive land use plan.

3. FOREST PLAN

3-1 Forest Classification

3-1-1 Classification and definition of forest

Upon overall examination of present condition of the forest, present situation of forest development and future trend, it is considered to be most appropriate to do classification of forest and woodland in the area in accordance with Paraguay Forest Law (Law No. 422).

The forest and woodland in the area are classified into the following three classes, as in Article 4 of the Law.

a. Productive forest
b. Protective forest
c. Special forest

(1) Productive forest

Productive forest is defined as forest and woodland which is expected to generate annual or regular earnings through a certain degree of work. (Article 5 of the Law)

(2) Protective forest

Protective forest is defined as forest and woodland which are reserved or established to serve the following purposes (Article 6 of the Law):

a) Control of water resource (water system)
b) Protection of soil, agricultural activity, livestock farming activity, roads, rivers and streams, lakes and marshlands, water channels, and reservoirs.
c) Prevention of soil erosion, flood, wind damage and drying
d) Protection of wild animal and vegetation
e) Securing of public health
f) Securing of other public purpose

(3) Special forest

Special forest is defined as forest and woodland which are required for protection on account of their high academic, educational, historical, aesthetic, environmental or recreational values. (Article 7 of the Law)

3-1-2 Method of forest classification

Forest classification was made for forest zone, mixed zone, and conservative zone in accordance with the aforementioned land use classification, taking into account integration with present condition and future image of land use in a whole part of the area. Each forest and woodland was classified, on the basis of forest type classification, through analysis of its natural and socio-economic condition in present and future, to be as follows:

(1) Productive forest

① Productive forest is defined as forest and woodland, other than protective forest and special forest, including high forest (forest type A_1, A_2, A_3, (medium forest (forest type M_2, M_3), forest under cutting (forest type E), mixed forest (forest type M), and a part of low forest (forest type B_2).

② The forest includes cut-over area and other land which are expected to be an object of forestry management in future.

(2) Protective forest

① Protective forest is defined as forest and woodland which are required for serving the purposes described in 3-1-1 (2).

② The forest includes forest and woodland which are expected to serve the same purposes in figure.

③ The forest includes forest and woodland which are not appropriate for productive forest due to natural condition. (most of mixed forest type M, low forest type B_1 and B_2)

(3) Special forest

① Special forest is defined as forest and woodland which are required of conservation for the benefit of the effects described in 3-1-1 (3).

② The forest includes forest and woodland which are expected to generate the above effects in future.

③ The forest includes forest and woodland which have present and future need for other special purposes.

(4) Forest type and classification

Management of forests should be established on the basis of natural condition pertaining to each forest, including climate, topography, geology and soil condition, along with overall and long term viewpoint related to economic and social condition (objective) as described in 3-1-1

On preparing this plan, as discussed to this point, adequate classification was made on the basis of forest type which is mainly representation of the natural condition, by means of analyzing each forest for its natural, economic and social condition in present and future. To establish criteria for forest classification by arranging above interrelations, a general association between forest types and forest classifications was made into the following table.

Table 0-1-3 Forest type and forest classification

Forest type / Forest classification	High forest	Mixed forest	Medium forest	Low forest	Forest under cutting
	A_1 A_2 A_3	M	M_2 M_3	B_1 B_2	E
Productive forest	——	- - - -	——	- - -	——
Protective forest	- - - - -	——	- - - - -	——	- - - -
Special forest	- - - - -	- - - -	- - - - -	- - - - -	- - - - -

Note: —— mostly associated
- - - Partly or specially associated

3-1-3 Result of forest classification

In accordance with the above principles, forest classification was made for forest zone, mixed and conservative zone in land use classification, and forest plan map (accompanied) was prepared.

As a result of the classification, the area of each forest classification is assessed as follows:

Table 0-1-4 Area of forest by classification and department (ha)

Department / Forest classification	AMAMBAY		CONCEPCIÓN		SAN PEDRO		CANENDIYU		TOTAL	
	Area ha	%	Area ha	%	Area ha	%	Area ha	%	Area ha	%
Productive forest	306,800	71	76,600	77	183,200	85	98,200	73	664,800	75
Protective forest	98,900	23	23,200	23	32,800	15	35,900	27	190,800	22
Special forest	24,800	6							24,800	3
	430,500	49	99,800	11	216,000	25	134,100	15	880,400	100

3-2 Standard of Management Method

3-2-1 Management standard

Forest management in the planning area was studied for each unit of forest on the basis of forest classification and type, and thereby to establish the appropriate standard of management method, as presented in the following table:

Table 0-1-5 Management standard table

Forest classification	Forest type group	Area	Tree species	Cutting system	Regeneration	Final cutting age
Productive Forest	$A_1 \sim A_3$ M_2, M_3	316,000 ha 324,500 (640,500)	Broad leaved tree Parana pine Elliottii pine	Selective cutting Shelter wood cutting Clear cutting	Natural seeding A_1, A_2, M_2 –Supporting work Clear cutting–Planting	DBH 40 cm ~ (90 years)
	E	'24,300	Parana pine Elliottii pine Eucalyptus Broad leaved tree	Clear cutting	Artificial planting	Pine 20 years Eucalyptus 15 years
Protective Forest	$A_1 \sim A_3$ M_2, M_3	7,600 11,400 (19,000)	Existing species	Light selective cutting	Natural regeneration Supporting work as required	DBH 40 cm ~
	M	84,800	Existing species	Postponent of cutting Light selective cutting for high/mixed forest with consideration to conservation	Natural regeneration	DBH 40 cm ~
	B_1, B_2	87,000	Existing species	Postponent of cutting Light selective cutting or clear cutting for similar to M_2 forest for protection purpose	Natural regeneration Clear cutting–Planting	
Special Forest	All forest type	24,800	Existing species	Prohibition of cutting Scenery improvement cutting	Natural regeneration Scenery improvement cutting	

3-2-2 Productive forest

(A) Forest type $A_1 - A_3, M_2, M_3$ group

(1) Tree species

In principle, natural forest with broad leaved trees will be fostered. The present composition of species has a great variety, including 135 species to be found in the present study. In future, fostering of useful species should be attempted through such forest management as cutting, regeneration and tending, thereby aiming for gradual conversion to the forest with high mix ratio of useful species and high productivity.

(2) Cutting

Cutting will be done by selective cutting system. Particularly single tree selective cutting system will be principally used, as one-site collection by large type machines will be relatively easy on gentle landscape to be found in most of the planning area. Shelterwood cutting or clear cutting system will be used in the location where succeeding trees of useful broad leaved trees are abundant to promise stable regeneration or reforestation by planting.

(3) Regeneration

Regeneration will be principally done by natural seeding of useful broad leaved trees, except for the forest type A_1, A_2, and M_2 on which compensatory planting will be done as required by growing condition of sampling.

Species and planting method for cut-over area or newly reforested area will be in accordance with those of reforestation.

(4) Final cutting age

In principle, final cutting age is determined at an age when diameter breast height reaches 40 cm, taking into consideration the increment process of trees and use value of products. A result of the present study indicates that the age is generally within the range of 90–100 years. The age is thought to be shortened by 20–30 years if the growth accelerating measures, such as cutting of upper trees and improvement of tending, will have been provided.

(B) Forest type E group

(1) Tree species

For this group, Elliottii pine, Parana pine, Eucalyptus and other broad leaved species will be fostered.

(2) Cutting

Clear cutting system will be used, with due consideration to effective use of saplings of Peroba and other useful species.

(3) Regeneration

Regeneration will be done by artificial planting of desired species, with maximum retaining and fostering of saplings of useful species, thereby to aim for development of healthy forest.

(4) Final cutting age

With consideration to trend of increment and use value of products, final cutting age for Parana pine and Elliotti pine is determined at 20 years, and Eucalyptus at 15 years.

3-2-3 Protective forest

(A) Forest type $A_1 - A_3, M_2, M_3$ group

(1) Tree species

The existing species of the natural forest will be mainly fostered for the time

being. An attempt should be made to gradually improve it to species and forest composition suitable for the purpose of protective forest.

(2) Cutting

The forest is required of fully providing its important functions, namely water resource control, soil conservation, erosion and flood prevention, protection of wild animal and vegetation, and securing of public health. These functions should be maintained and improved by means of management suitable for each purpose.

To do this, light selective cutting will be done in need for maintaining healthy forest, along with careful management to aim for conversion to a desired type of forest.

(3) Regeneration

Regeneration will be done by natural regeneration of the existing species, with saplings of useful species through regeneration and tending as well as supporting work when required.

(4) Final cutting age

Target diameter for final cutting should be more than 40 cm.

B Fores type M group

(1) Tree species

In principle, the existing species of the natural forest will be fostered, with gradual conversion to the composition suitable for the purpose of protective forest.

(2) Cutting

The cutting will be postponed until the composition of the forest will have been improved. Light selective cutting should be permitted where conservation effect will not be obscured by cutting because of mixed growth of upper trees, or regeneration will be required for achieving conservation purpose.

(3) Regeneration

For selective cut-over area, regeneration will be made by natural regeneration of the desired species, as well as artificial planting of the species suitable for conservation purpose

(C) Forest type B_1, B_2 group

(1) Three species

Natural regeneration of the existing species will be done for improvement of the composition of the forest.

(2) Cutting

Cutting will be postponed. Where required, cutting other than for the purpose of caring will be prohibited.

For the forest, which type is B_2 as a result of selective cutting but originally similar to M_2, light selective cutting will be done within the limit to require for regeneration or clear cutting will be done to improve forest type when required for conservation purpose.

(3) Regeneration

Regeneration will be done principally to improve the composition of the forest.

3-2-4 Special forest

(1) Tree species

In principle, the existing species will be fostered. At the same time conversion to the species suitable for conservation purpose should be done.

(2) Cutting

The forest with high academic or historical value will be strictly protected by prohibition of cutting.

Scenic management or scenery improvement cutting will be done in the forest for scinic purpose or recreational use, taking into account the present condition.

(3) Regeneration

Regeneration will be done by natural regeneration of the existing species, with scenery improvement planting where required.

3-2-5 Standard of forest composition by purpose

On establishing the standard of forest management method in the planning area, improvement of the functions of the forest together with coordination among the functions was intended for the purpose of maximizing such functions, irrespective of tangible or intangible, in total and sophisticated manner. At the same time maintenance and development of sound forest resources were intended through implementation of appropriate forest management.

The followings are the standards of desired forest composition in need for maximizing the various functions under given condition of the forest within the planning area.

(1) Wood conserving function

The forest with large increment, consisting of trees with good shape and quality while maintaining appropriate stand density.

(2) Water resource fostering function

The forest of fast increment, high crown closure rate, and sufficient development of roots, having soil with well developed crumbled structure and abundant macropore.

(3) Soil conserving function

The forest having deeply and widely developed roots, litter layers, and well developed undergrowth aided by appropriate sunlight.

(4) Public health/scenery conserving and recreational function

The forest having high scenic value in combination with lakes, marshlands and valleys, consisting of many species and stand types to have a variety of light and shade as well as color tone, having high environmental value peculiar to the area, and being suitable for recreational activity.

The forest in vicinity of urban areas, having stable stand type with local species are majority, and having high effect on living environment conservation such as weather alleviation and noise absorption.

3-3 Standard Cutting Volume

On the basis of forest stock obtained in resource survey, standard cutting volume was calculated by using a result of increment survey in the natural forest; Annual standard cutting volume in the planning area was estimated at 924,000 m^3.

3-3-1 Base stock and increment

The followings are stock and increment which are basis of estimation of standard cutting volume.

Increment was calculated from base stock multiplied by increment rate of all species.

Tree species	Base stock	Increment rate	Increment
Total increment	27,845,025 m^3	3.3 %	918,886 m^3
A + B	14,963,651		493,800
Peroba	5,236,869		172,817

3-3-2 Estimation of standard cutting volume

(1) Formula for estimation of cutting volume

The following formula was used to estimate the cutting volume to this plan·

V_W . . . . . .Actual volume in total
Zw . . . . . .Average increment in total
u . . . . . .Rotation

(2) Rotation

As indicated in a result of increment survey of the natural forest in the planning area, increment period of 90–100 years is generally required before the major species reach their expected diameter class of 40 cm. Accordingly in this plan the final cutting age of the natural forest was determined at 90 years. However, as most of the forests in the area is aged, a conscious effort will be required to increase forest production by means of positive improvement of the natural forest along with reforestation to a possible extent.

On implementation of such programmes, indiscrete implementation will result in damage or deterioration of the forest rather than improvement, thereby to adversely affect securing and development of forest resources in future.

Thus, in this plan it is considered to be reasonable to establish an improvement period, equivalent to around two third of the final cutting age, so as to promote improvement and replenishment of forest composition. The improvement period of 60 years was used for rotation (U) in the formula to estimate the standard cutting volume.

(3) Standard cutting volume

Using the above factors, standard cutting volume in this planning area was estimated as follows.

Standard cutting volume 924,000 m^3
Including A + B 496
Peroba 174

Summary of estimation of standard cutting volume is tabulated as follows:

Table 0-1-6 Summary of estimation of standard cutting volume

Tree species	Actual stock (Vw)	Increment (Zw)	Improvement period (U)	Standard cutting volume (Ew)
All species	27,845,025m^3	918,886m^3	60 years	923,527m^3
A + B	14,963,651	493,800		496,294
Proba	5,236,869	172,817		173,690

As clearly seen in the above table, estimated standard cutting volume mostly agrees with the increment in the area; same result as estimated by increment method. Thus the standard cutting volume is proven to be generally reasonable from testing result by increment method as well.

3-4 Cutting Plan

3-4-1 Cutting budget

On the basis of the standard cutting volume, annual cutting budget in the planning area was determined with overall consideration to actual cutting volume and living environment factors such as population and life style, and presented as follows:

Table 0-1-7 Annual cutting budget

	Lumber	Firewood & charcoal	Total
Cutting budget	800,000 m^3	100,000 m^3	900,000 m^3
(Useful species)	500,000 m^3		500,000 m^3

The above cutting budget will be controlled as of the total volume, and allowable cut of useful species in ( ) is listed for reference only.

3-4-2 Cutting system

(A) Selective cutting work

Selective cutting work will be applied to a most of productive forest. As such forest will serve as a base of forest production in the area, appropriate management should be designed for improvement of the forest composition to be converted into highly productive forest.

(1) Cutting system

a. The forest with high tree density

Single tree selective cutting will be done for this type of forest in light of growing condition of saplings in lower story and residual stand crop.

b. Ordinary forest

This is the forest other than ones with high tree density and dispersed one. For this type of forest, group selective cutting will be mainly done in the woodland with high production rate and good environmental condition, while taking into account working condition such as shrubbery. On the other hand, light single tree selective cutting will be done in the woodland with less favorable environment for the time being, so as to maintain the existing forest.

c. Dispersed forest

This is the forest with low density of high trees and crown dispersal. For this type of forest, efficient cutting, including surface treatment by large type machines, will be done in the woodland with good environmental condition. Light single tree selective cutting will be done in other woodland as required for fostering a healthy forest.

(2) Criteria for tree selection

Selection of tree for cutting work will be done by totally analyzing the forest composition, such as its density. shape and quality of trees, diameter class, and condition of succeeding trees so as to maintain healthy residual stand crop and to increase production in future.

(3) Cutting rate

Cutting volume in an unit of continuous forest will be limited to 50% of the total volume.

(B) Light selective cutting work

For forest type A_1-A_3, M_2, M_3 in protective forest and protective tree zone in productive forest, light selective cutting will be done to foster healthy forest, to maintain and improve its protective functions, and to increase total production in the forest by means of producing usable woods at the same time.

Cutting method will be generally based on the following criteria:

(1) Protective forest and protective tree zone

① To primarily cut damaged trees and large diameter trees highly susceptible to wind broken (overmatured tree and decayed tree)

② To retain trees for main roof materials and trees along rivers to a maximum extent

③ To mainly do single tree selective cutting, and to limit cutting rate to around 30% with variation in accordance with density, diameter and species.

④ To cut protective tree zone, which is mainly used for securing of natural scenery, with due consideration to local condition and purposes.

(2) Steep slope area, wet land, and stone and gravel land

① To primarily cut damaged trees, overmatured trees, decaying trees, tilted trees of large diameter which are likely to induce erosion of woodland.

② To protect healthy trees of small or medium diameter to a maximum extent

③ To mainly do single tree selective cutting, and thereby to avoid drastic change in forest composition.

(3) National park and other special forests

① To do minimum cutting when required for securing and improving the functions of forest to achieve the purpose such as securing of natural scenery.

② To primarily cut damaged trees, decaying trees and overmatured trees so as to prevent forest deterioration.

③ To mainly to light single tree selective cutting, and thereby to avoid drastic change of forest composition.

C. Shelterwood cutting work

Shelterwood cutting work will be done for the forest which has high potential in being developed as productive forest of good growing forest type, has mostly completed regeneration, and contains saplings and small diameter tree of useful species in undergrowth. Upper story group will be cut to stimulate increment of undergrowth group, and thereby to develop the forest with high productivity.

(1) The forest with confined undergrowth

For the forest where normal growth of lower trees is hampered by higher trees of medium or large diameter, two step cutting will be done to avoid drastic change of environment for benefit of protection and fostering of undergrowth group, and to foster healthy succeeding forest type.

The first cutting will be primarily done for damaged trees, diseased trees, and aged trees of large diameter, but healthy middle aged trees to be retained, while caring for growing condition of undergrowth group. Cutting rate will be between 40–60 %.

The second step cutting will be done 10–20 years after the first cutting with consideration to growing condition of undergrowth group and residual stand crop. The cutting method will be in accordance with that for dispered forest described in the next section.

(2) Disperesed forest

Most of higher trees will be cut to stimulate the increment of undergrowth group, retaining useful species of medium diameter to a possible extent.

(D) Clear cutting work

Clear cutting will be done for a part of forest type $A_1 - A_3$, M_2, M_3 group of productive forest which are highly feasible in being developed as reforestration by artificial planting, and for forest type E group, and thereby to aim for improving species and stand type.

(1) Cutting method

On cutting and transporting of trees, the area where group of sapling of useful species is growing to become matured woodland will be carefully retained to make an effective use of natural ability and to allow the sound growth of new planted forest.

(2) Protective tree zone

Protective tree zone will be established for protection of planted forest, prevention of soil erosion, maintaining of soil fertility, conservation and creation of natural environment, under the following criteria:

① The zone will be provided along ridges and rivers where required for wind protection, forest fire prevention, prevention of soil erosion and maintaining of soil fertility.

Also, the zone will be provided in wide slope or flat land where one cutting area is large, at about 1,500–2,000 m interval with consideration to predominant wind direction and surrounding condition.

Width of protective tree zone will be 100 m for each side of a ridge and river, or 200 m in total, and 200 m for flat land, with variation in accordance with local condition.

② The zone will be provided for the recreational area along roads or an area along roads with heavy traffic, to be mainly required for conservation of natural environment. The width will be more than 100 m on each side, with variation in accordance with local condition to reflect surrounding landscape, scenery and intensity of land use.

③ Management of protective tree zone will be in accordance with that of protective forest and others.

3-5 Regeneration and Seed/Seedling Plan

3-5-1 Natural regeneration

(1) Required number of saplings for regeneration

① On the basis of dense crown forest survey which is a part of the forest resource survey, the number of saplings per ha required for completion of regeneration in natural forest was determined at 1,000 for all species, 300 for useful species and 200 for Peroba.

② At the same time, as generated natural saplings evidently show high rate of decrease before growing to matured trees. The following formula was tentatively determined as a base for estimating the required number of saplings for regeneration.

$$n_1 (1-K_1) + n_2 (1-K_2) + n_3 (1-K_3) \geqq N$$

whereas,

- n_1 Number of saplings with tree height of 0.3m ~ 1.3m
- n_2 Number of sapling with tree height of more than 1.3m and DBH of less than 4 cm.
- n_3 Number of sapling with DBH of 5 cm ~ 9cm
- k_1 Decrease rate of sapling for n_1 = 0.67
- k_2 Decrease rate of sapling for n_2 = 0.30
- k_3 Decrease rate of sapling for n_3 = 0.10
- N The number of saplings required to complete regeneration

③ From the above formula, the number of useful species required for natural regeneration was calculated for each size class, as presented in the table below; the

number of useful saplings at a regeneration point could be calculated by summing up the number of useful species which correspond to observed number of saplings for each size class.

Table 0-1-8 Number of useful species for natural regeneration

(per ha)

Observed No. of sapling	n_1 (1 - k_1)	n_2 (1 - k_2)	n_3 (1 - k_3)	
100	33	70	90	Saplings which grow within spacing of less than 2m should be counted as one sapling.
250	82	175	225	
500	165	350	450	
750	247	525	675	
1,000	330	700	900	
1,250	412	875	1,125	
1,500	495	1,050	1,350	
1,750	577	1,225	1,575	
2,000	600	1,400	1,800	
2,500	825	1,750	2,250	

(2) Natural regeneration supporting work

When the number of generated saplings does not reach one required for completion of regeneration, natural regeneration supporting work will be proceeded as follows:

① Planting, Saplings of Parana pine, Elliotti pine, Euacalyptus, Paraiso and other natural growing species will be planted in quantity as twice as required for completion of regeneration.

② Cutting

Weeding of ground floor vegetation will be done for areas where growth of succeeding saplings are hampered by such ground floor vegetation.

3-5-2 Reforestation

(A) Species for reforestation

The following species are selected with due consideration to the criteria ①suitability to natural condition, ② fast increment rate and healthy condition, and③high use value when produced.

(1) Area mainly for wood production; productive forest, protective forest and a part of special forest

ⓐ Coniferous
Parana pine
Elliottii pine
Caribbean pine

ⓑ Broadlead tree
Eucalyptus
Paraiso
Others

ⓒ Naturally growing species

On reforestation of useful trees that grow naturally like Peroba, we determined to run experimental reforestation for the time being, while concurrently and actively promoting the research and development of reforestation techniques, such as, abundancy of seeds, storage, nursery practive, reforestation, and tending or protection, in order to assure steady supply for the future.

(2) Area mainly for conservation function; protective forest where natural growing species are particularly suitable for the purpose, and a part of special forest;

Yvyrá-pytá	Peroba
Trebol	Yvyrá-ró
Lapacho	Other useful species
Cedro	

(B) Method of reforestation

(1) Planting (sowing) time

Adequate planting (sowing) time is in winter season between May–August, particularly between July–August.

(2) Number of plantings

Number of plantings will be in accordance with the following standard, with decrease/increase as required, (per ha)

Pines	1,600 ~ 2,000 seedlings
Eucalyptus, Paraiso	2,000 ~ 2,500 seedlings

(3) Tending

Tending such as weeding, pruning and thinning will be done. Tending time and frequency will be principally based on the following silviculture system, with adjustment to local condition.

(C) Protection

(1) Forest fire prevention

The fire fighting system will be improved by reinforcing fire prevention measures such as installation of fire lines and watching/patrol in dangerous season, and by building up fire extinguishing equipments and carrying out fire fishing drill.

(2) Prevention of ant damage

Patrol in reforestated areas and early extermination by chemicals will be carried out. At the same time, effective extermination methods will be researched and developed.

(3) Prevention of damages by disease and insect

Systems for detection at an early stage and prompt action will be provided, and research and development of prevention technique will be carried out.

3-5-3 Seed/seedling and nursery

For the time being, seeds and seedlings for reforestation in the area will be directly produced and used by governmental organizations or distributed to planters. At the same time, research, development and extension/guidance on nursery practice technology will be carried out by public organizations.

(1) Nursery

The existing nursery in the City of P.J. Caballero, managed by Amambay forest district office, will be improved to be a central nursery in the northeast region.

(2) Seed

Although seeds of superior grade species by breeding will be used in the long run, seeds collected from healthy seed trees of good shape/quality and fast growing will be used for the time being.

Imported seeds acquired from reliable sources will be used.

Seed orchard will be provided in nursery site for pines and Eucalyptus of selected individual with superior grade species. For natural growing species, healthy stand with good shape/quality and growing condition will be designated as seed collecting stand.

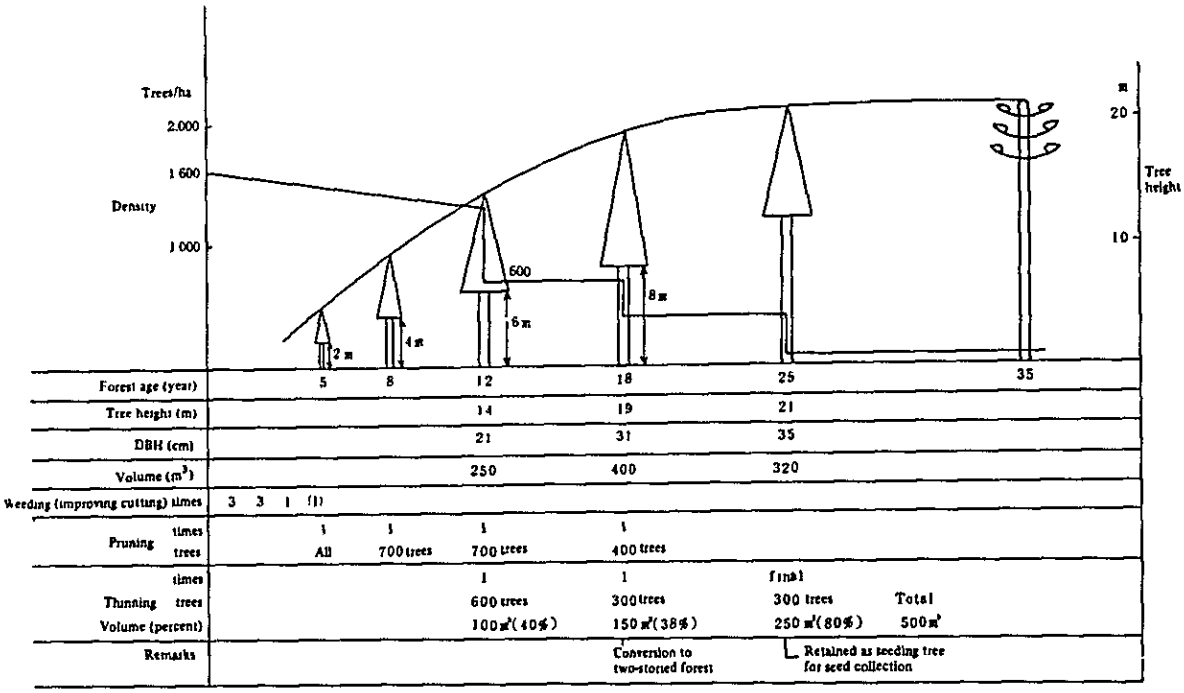


Fig. 0-1-2 Silvicultural system for Parana pine

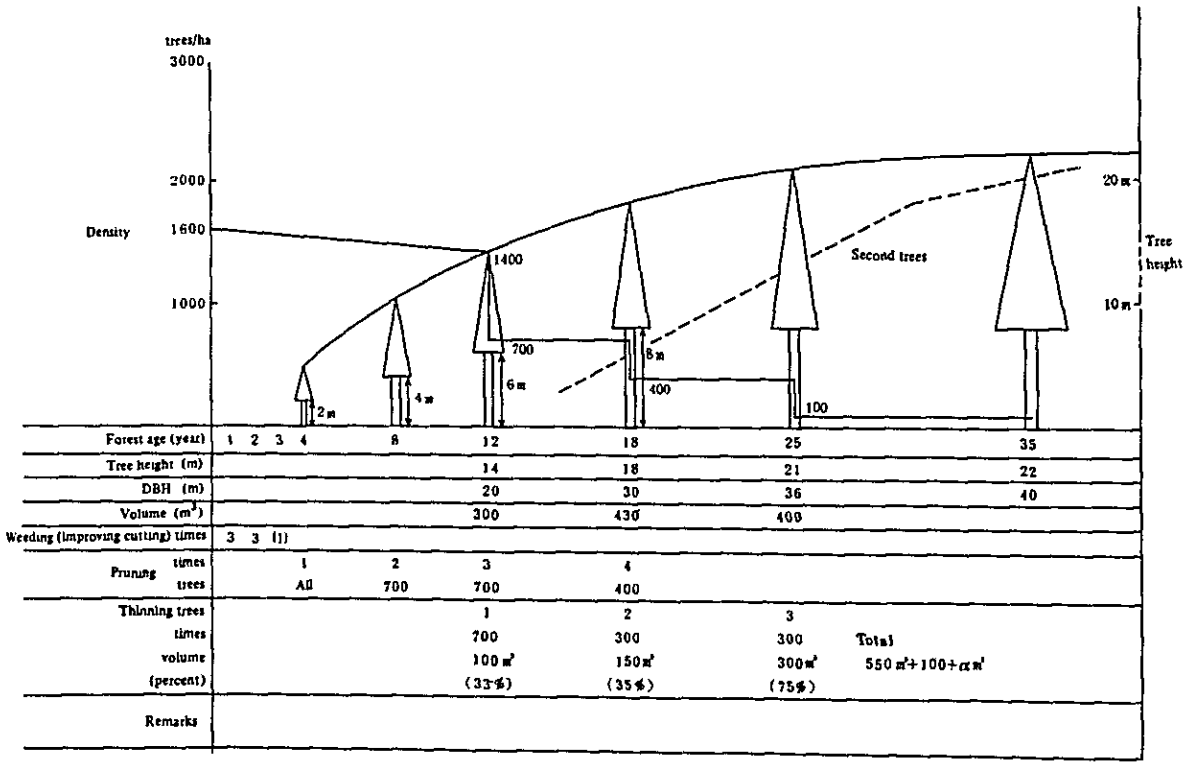


Fig. 0-1-3 Silvicultural system for Elliottii pine

(3) Sowing and nursery practice

① Parana pine; Seeds will be collected between April–May, and sowed by July. Germination occurs in 60 days after sowing and out-planting is done in four months after germination.

② Elliottii pine; Sowing will be done by using wood box or pot, with one grain per pot. Survival percentage of seedlings is generally 20,000 per 1 kg of seeds.

③ Eucalyptus; Sowing will be done between July and October, and seedlings could be used for out-planting in 4 months after sowing. Survival percentage of the seedlings is 25,000 – 30,000 per 1 kg of seeds.

④ Other species; For natural growing species, observation, experiment and research will be done on seeds' yield, collection, sowing and cultivation of seedlings to develop the nursery operational techniques.

(4) Nursery management and facility

① For the time being, nursery will be managed by a chief of Amambay forest district office, with assistants to be assigned to the nursery on full time basis. At the same time, guidance and extension of techniques to the private nurseries will be carried out.

② Nursery facility; For the central nursery, buildings such as administration office and warehouse, and water supply/irrigation facilities will be provided.

③ Temporary nursery in the forest of Cerro Cora will be administered by utilizing organization and facility of national park office, except for water supply and irrigation facilities to be newly provided.

3-5-4 Establishment of experiment/research facility

An experiment/research facility will be established by using a part of the existing nursery site to cover a whole part of the northeast region. This facility is to carry out research, development, extension and guidance on technology in the whole range of forestry and forest related industries, including seeds/seedlings, reforestation, compound management of agricultural/livestock farming/forestry, and use of forest and wood.

3-6 Forest Road and Conservation Plan

3-6-1 Forest road plan

Under the existing road transport condition, it is very difficult to formulate a comprehensive forest road plan in the planning area, while a significant effect could not be expected.

Therefore, when needs for preparation of area forest road plan arise, such a plan will be done in accordance with forest road plan for the model areas, instead of formulating a forest road plan to cover a whole part of the planning area.

3-6-2 Conservation plan

(1) Conservative area

① Cerro Cora National Park and its expansion; Conservation will be implemented in accordance with the sections of the model area (4.2).

② Proposed Cerro Guazú National Park; This is the largest mountain forest zone in the planning area, with a great variety of wild life and vegetation. This plan intends that the area will be designated as a national park principally aiming at conservation of natural environment including wild life and vegetation, and thus prompt procedure for the designation is expected in consideration of progress of forest development in the surrounding areas And it is desirable to designate the area of around 20,000 ha which includes peripheral buffer (controlled) zone.

(2) Protective forest

In this plan, the forest area of around 191,000 ha, 22% of the total area, was classified as protective forest. It is expected that the designation will be done by clearly delineating the subject areas, and functional classification and treatment standard of each forest will clearly defined to implement really effective management.

(3) Protective tree zone

Protective tree zones will be retained in forests area including natural forest. The zones will be developed in an area where forests have been disappeared to required such zone, in accordance with that of the model area (4.1).

4. FOREST DEVELOPMENT PLAN IN MODEL AREAS

4-1 Pedro Juan Caballero Model Area

The area has been used and developed as agricultural and livestock farming land from old times because of its location and land condition; at present livestock farming land constitutes 69% of the total area, while forest land constitutes 22%.

Under this circumstance, the model area was selected to focus on treatment of forests in livestock farming development zone and intensification of land use by compound management of livestock farming and forestry.

4-1-1 General description onf the area

(1) The model area is located in the Department of Amambay, bounded by 22°22'30" and 22°30' South Latitude and 55°45' and 55°52'30" West Longitude, with a lnad area of 17.502 ha.

(2) The area is made up of a plateau-like hill area in Amambay Mountain Range, with an elevation between 400 m−710 m, and constitutes the headstream of upper branch rivers of Rio Aquidabán

The soils are generally sandy or sandy gravel, with relatively low productivity.

(3) Land use distribution of the area is 69%livestock farming land and 22%by forest, which is scattered in a part of the southern hill area and along streams, from of small forest.

4-1-2 Forest classification

Protective forest constitutes 84% of forests which are subject to forest classification.

4-1-3 Standard for management

The appropriate management will be done in accordance with the following management standard. Details of the management standard will be in accordance with 3.2.

4-1-4 Cutting plan

(A) Selective cutting work
(B) Light selective cutting work
(C) Shelterwood cutting work
(D) Clear cutting work

Cutting plan for the above will be in accordance with 3-4 'Cutting Method.'

4-1-5 Reforestation plan

(A) Productive forest

(1) Species for reforestation

Fast increment species to produce easily marketable and profitable woods will be selected. The following species will meet such requirements;

ⓐ Coniferous tree	Parana pine	ⓒ Naturally growing species
	Elliottii pine	On reforestation of useful trees that grow naturally like Peroba, we determined to run experimental reforestation for the time being, while concurrently and actively promoting the research and development of reforestation techniques, such as, abundancy of seeds, storage, nursery practice, reforestation, and tending or protection, in order to assure steady supply for the future.
	Caribbean pine	
	Etc.	
ⓑ Broadleaved tree	Eucalyptus	
	Paraiso	
	Etc.	

Table 0-1-9 Management standard table

Forest classification	Forest type group	Area	Tree species	Cutting system	Regeneration	Final cutting age
Productive Forest	$A_1 \sim A_3$ M_2, M_3	62 ha	Broad leaved tree Parana pine Elliottii pine	Selective cutting Shelter wood cutting Clear cutting	Natural seeding A_1, A_2, M_2 –Supporting work. Clear cutting–Planting	DBH 40 cm ~ (90 years)
	E	62 ha	Parana pine Elliottii pine Eucalyptus Broad leaved tree	Clear cutting	Artificial planting	Pine 20 years Eucalyptus 15 years
Protective Forest	$A_1 \sim A_3$ M_2, M_3		Existing species	Light selective cutting	Natural regeneration Supporting work as required	DBH 40 cm ~
	M	661 ha	Existing species	Postponent of cutting Light selective cutting for high/mixed forest with consideration to conservation	Natural regeneration	DBH 40 cm ~
	B_1, B_2		Existing species	Postponent of cutting Light selective cutting or clear cutting for similar to M_2 forest for protection purpose	Natural regeneration Clear cutting–Planting	

(2) Method of reforestation

a. Planting period

Planting on forest land will be done in winter season between May and August.

b. Number of plantings

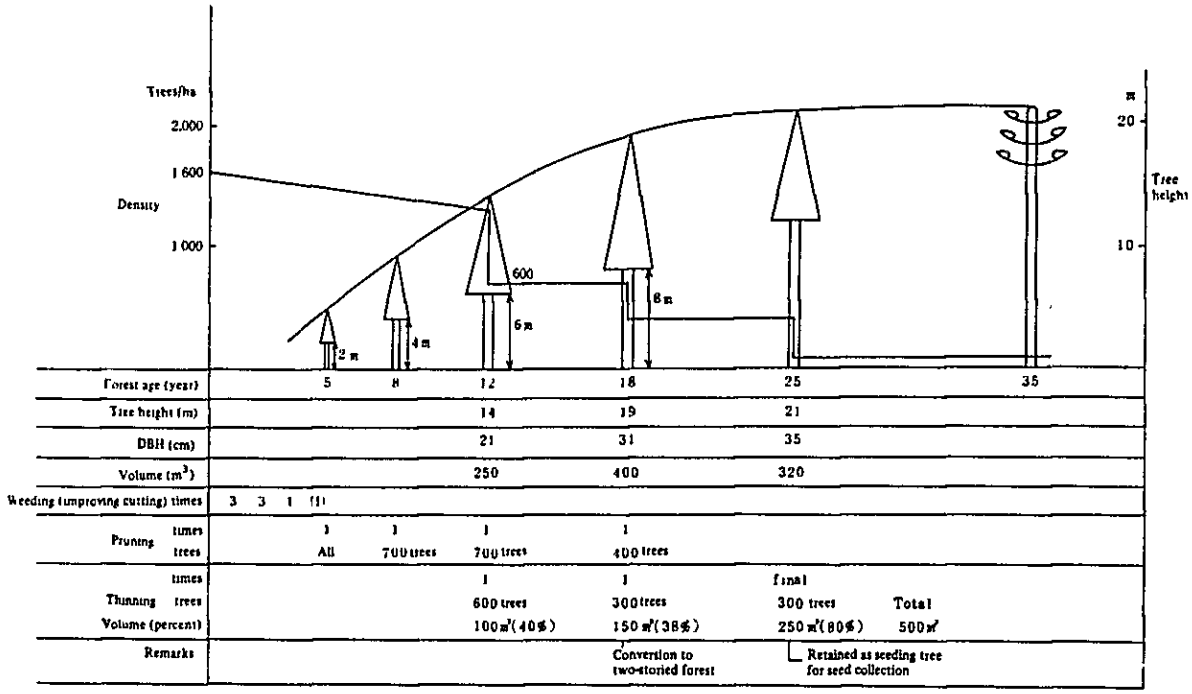
The number of plantings will be determined in accordance with the following standard, with decrease/increase as required by local condition and purpose of reforestation;

Table 0-1-10 Standard number of plantings by species

Tree species	Number of planting
Parana pine	1,600 ~ 2,000 trees/ha
Elliotti pine	1,600 ~ 2,000
Eucalyptus	2,200 ~ 2,500

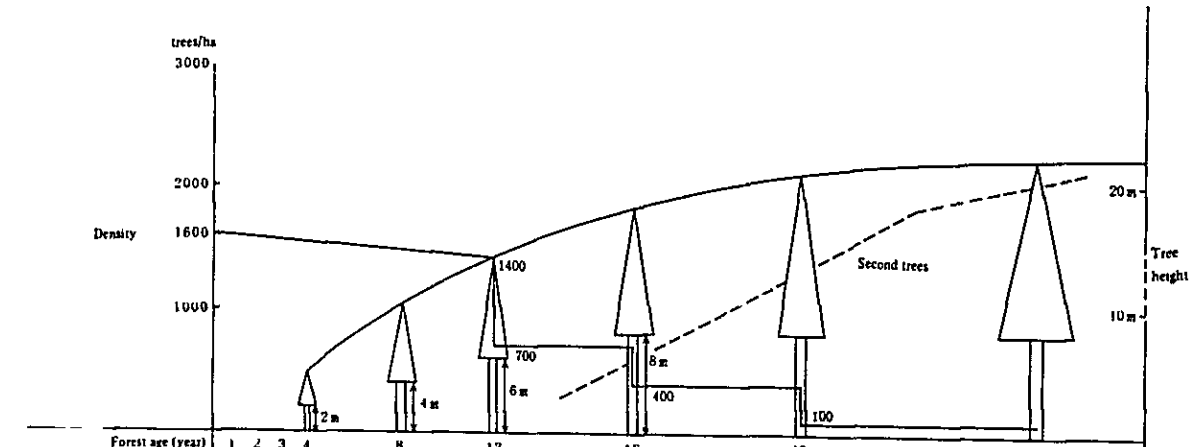
(3) Tending and protection

Tending, such as weeding, pruning and thinning will be done after planting. Silviculture systems for Parana pine and Elliottii pine are presented in the following diagrams.



Forest age (year)	5	8	12	18	25	35
Tree height (m)			14	19	21	
DBH (cm)			21	31	35	
Volume (m^3)			250	400	320	
Weeding (improving cutting) times	3	3	1	(1)		
Pruning times	1	1	1	1		
Pruning trees	All	700 trees	700 trees	400 trees		
Thinning times			1	1	final	
Thinning trees			600 trees	300 trees	300 trees	Total
Volume (percent)			100 m^3(40%)	150 m^3(38%)	250 m^3(80%)	500 m^3
Remarks				Conversion to two-storied forest	Retained as seeding tree for seed collection	

Fig. 0-1-4 Silvicultural system for Parana pine



Forest age (year)	1 2 3 4		8	12	18	25	35
Tree height (m)				14	18	21	22
DBH (m)				20	30	36	40
Volume (m^3)				300	430	400	
Weeding (improving cutting) times	3	3	(1)				
Pruning times		1	2	3	4		
Pruning trees		All	700	700	400		
Thinning trees				1	2	3	
Thinning times				700	300	300	Total
Thinning volume				100 m^3	150 m^3	300 m^3	550 m^3+100+α m^3
(percent)				(33%)	(35%)	(75%)	
Remarks							

Fig. 0-1-5 Silvicultural system for Elliottii pine

(B) Protective forest

Natural forests which exist in along side of major rivers and streams in the area will be conserved to a possible extent In wayside of such rivers and streams with no natural forest, reforestation will be actively done to aim at conservation of water quality,prevention of soil erosion and conservation of riverside.

(1) Species for reforestation

① Fast increment species with high use value will be primarily considered, Parana pine, Elliottii pine and Eucalyptus.

② For areas with high risk of fire, e.g , in adjacent to pastures, fast incremet species with great fire resistance will be selected, Eucalyptus, Paraiso.

③ For detriorated areas to require prompt revegetation, fast growing species with high breeding potential, such as Yvyrá-pytá will be selected.

(2) Reforestation, tending and protection

Method of reforestation, tending and protection for protective forest will be in accordance with that of productive forest

(3) Target area for reforestation

Wayside area (100 m wide on each side) of rivers and streams with high risk of erosion, e.g., slopes around swamps, deteriorated areas and their surroundings which are susceptible to deterioration, catchment or flood storage areas and surrounding slopes.

(C) Recommendations on promoting reforestation

The area was once a vast forest land having a sizeable stock of forest resources, and has been developed as livestock farming and agricultural land from old times because of its location and environmental condition. As a result, forest area has decreased to 22% of the total area with decreasing quality On the other hand, the area is located in proximity to the City of P.J. Caballero, a center of wood consumption in the northeast region, and thus has a great locational advantage of wood production, marketing and use.

On the basis of this background, the following recommendations were made on promotion of reforestation in the area,

① To actively convert the existing natural forests, where suitalbe, to planted forests.

② To actively implement reforestation in agricultural and livestock farming land with low intensity of use.

③ To implement reforestation in livestock farming land by establishing the zoning, and thereby to promote compound management with forestry through improving of grazing capacity and maintaining of soil fertility while securing forestry production.

④ To actively develop protective tree zones in accordance with the corresponding plan, and at the same time to aim for increasing forestry production.

⑤ To carry out public education on need and importance of reforestation as well as research, development and guidance on reforestation technology by means of utilizing planted forests in this area (refer to 3.5.4).

4-1-6 Protective tree zone

When forests are cut and converted to other uses or planted forests are developed in a large area, forests should be retained in band or group. Also, an area where such extensive clear cutting has been done should be developed of forest zone.

(1) Specific area to retain and develop forest

Protective tree zones will be established in the following types of landscape,

① Steep slope area

The forests will be retained or developed on slope areas with following grades which correspond to different soil types;

Soil type	Grade
S type	more than 6°
S L type	more than 9°
L type	more than 12°

② Ridges and convexed part

③ Alongside of swamps and streams

(2) Size of forest to be retained or developed

A certain size of forest, preferably continuous, will be required to fully show the various protective functions. It is recommended that strips of forest zone will be retained or developed in grid pattern, with the following dimension;

① Width of a forest zone	200 m
② Length of a forest zone	more than 200 m
③ Spacing between forest zones	around 2 km

(3) Management of protective tree zone

a. Spacies

When protective tree zones are newly developed, useful species with great fire resistence will be selected, in consideration of values as economic forest and burning in agricultural and livestock farming land.

As pines are easily combustible, care should be taken by priotizing Eucalyptus species or arranging broadleaved species such as Eucalyptus around pines to form fire break tree belt.

In addition, planting of unique species on a large area will be avoided where possible, and healthy forests such as mixed forest and multi-storied forest will be developed.

b. Cutting and regeneration

① Cutting and regeneration in natural forest will be done in accordance with that of protective forest, to attempt the conversion to healthy tree zones with high protection effect.

② Protective tree zones in planted forest will be converted to multi-storied forests by two-storied forest management or selective cutting method, or regenerated by alternate strip clear cutting method.

(4) Protective tree zone development plan

a. Specific area to be developed

Major ridges, wayside area of rivers and streams, and on lines connecting them.
Details are as presented in Model Area Forest Plan Map.

b. Dimension

200 m wide strips

c. Size of development

Size of the development by type of area is as follows,

Major ridges	600 ha
Wayside of rivers and streams	655 ha
Others	847 ha
Total	2,162 ha

d. Development cost

Development cost for protective tree zones (Parana pine, as of 1981; Mr. Komiya) is estimated as in the following table.

According to this, development cost per ha is 120,000 Gs, to be totaled to approximately 259 million Gs, and approximately 158 million Gs for major ridges and wayside area of rivers and streams.

Example

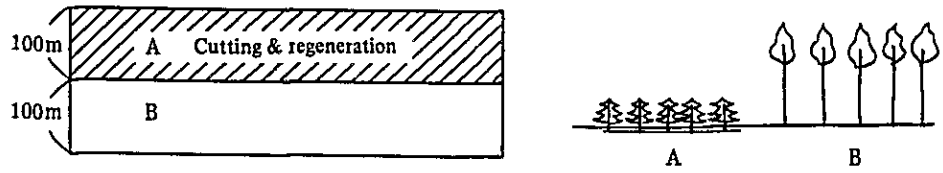


Fig. 0-1-6 Regeneration by alternate strip clear cutting

Table 0-1-11 Development cost estimated for protective tree zones

Item	1st year	2nd year	3rd year ~Tending period	Total
Grand clearance	30,000	—		30,000
Planting/compensatory planting	31,000	2,000		33,000
	12,000	9,000	12,000	33,000
Ant extermination	8,000	4,000		12,000
Others	8,000	2,000	2,000	12,000
Total	89,000	17,000	14,000	120,000

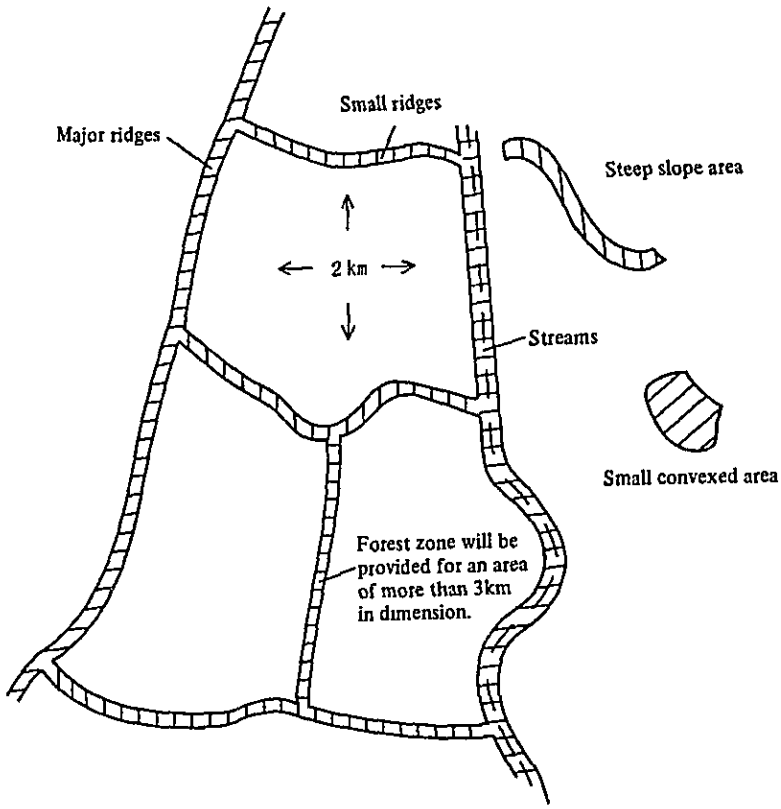


Fig. 0-1-7 Example of retained/developed forests in large clear cutting area

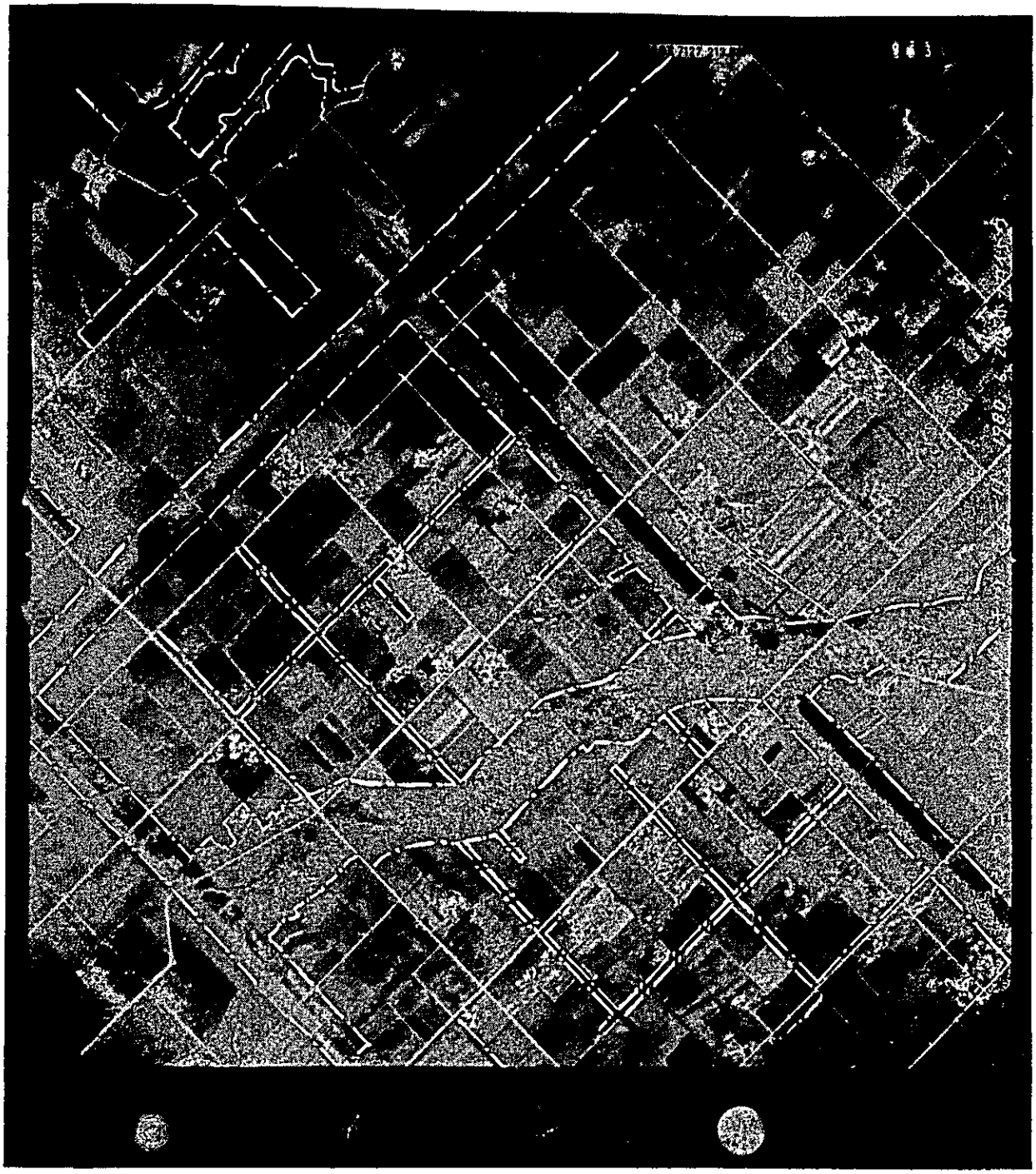


Photo 0-1-1 Protective tree zone (Aerial photograph)

4-1-7 Forest road plan

(1) Basic principle

By using existing roads which surround north, south and east side of the mode area as a basic road system, the forest road plan was prepared to serve as a multi-purpose road to establish and manage protective tree zones and to manage other forests and livestock farming land.

The forest road system will be managed directly by the government, its representative or any other appointed organizations, and opened to general traffic within a specified range.

(2) Types and width of forest roads and their proposed length

	Wide	Length	Length/ha
Main forest road	4 m	29,080 m	1.7 m
Branch forest road	3 m	26,400	1.5
Total		55,480	3.2

4-2 Cerro Cora Model Area

The area contains Cerro Cora National Park (total area of 5,538 ha) which is used for public recreation and other activities.

As an expansion of the national park is proposed in this plan, the area is selected as conservative zone in main part.

4-2-1 General description of the Area

(1) The model area is located in the Department of Amambay, bounded by 22°37'30" and 22°45' South Latitude and 56°00' and 56°07'30" West Longitude, with a land area of 17,522 ha.

(2) The area is made up of flat or gentle sloped hilly landscape on the west side of Amambay Mountain Range, with an elevation between 260 m–550 m. The area also contains Cerros which stand out at 100 m–200 m height.

The soils are generally sandy, with a relatively low land productivity.

(3) The forests in the area consist mainly of medium forest and mixed forest, with low forest in a part.

(4) Land use distribution in the area is 55% by forest, 22/ by livestock farming land, 8% by agricultural land and 14% by cut-over area which appears to have been converted to livestock farming land.

4-2-2 Forest classification

A result of the forest classification is 43% by productive forest, 19% by protective forest and 38% by special forest.

Special forest consists of Cerro Cora National Park and its proposed expansion.

4-2-3 Standard for management plan system

The appropriate management will be done in accordance with the following management method. Details of the management standard will be in accordance with 3.2

Table 0-1-12 Management standard table

Forest classification	Forest type group	Area	Tree species	Cutting system	Regeneration	Final cutting age
Productive Forest	M_2, M_3	3,980 ha	Broad leaved tree Parana pine Elliottii pine	Selective cutting Shelter wood cutting Clear cutting	Natural seeding A_1, A_2, M_2 –Supporting work. Clear cutting–Planting	DBH 40 cm ~ (90 years)
	E	562 ha	Parana pine Elliottii pine Eucalyptus Broad leaved tree	Clear cutting	Artificial planting	Pine 20 years Eucalyptus 15 years
Protective Forest	M	1,135 ha	Existing species	Postponent of cutting Light selective cutting for high/mixed forest with consideration to conservation	Natural regeneration	DBH 40 cm ~
	B_1, B_2	898 ha	Existing species	Postponent of cutting Light selective cutting or clear cutting for similar to M_2 forest for protection purpose	Natural regeneration Clear cutting–Planting	
Special Forest	All forest type	3,931 ha	Existing species	Prohibition of cutting Scenery improvement cutting	Natural regeneration Scenery improvement cutting	

4-2-4 Cutting plan

In accordance with P. J C. model area

4-2-5 Reforestation plan

(A) Productive forest

In accordance with P. J. C. model area

(B) Protective forest

In accordance with P.J. C model areax

(C) Protective tree zone

Protective tree zones will be provided for the areas along rivers and streams which have no forest and thus high risk of soil erosion and outflow.

Approximately 516 ha should be reforestated for development of protective tree zones.

4-2-6 Forest plan for national park area

(1) Cutting plan

Although cutting will be prohibited in principle, scenery improvement cutting and minimum extent of cutting required for appropriate maintenance of the park may be carried out.

(2) Reforestation plan

In principle, the reforestation will be done by natural regeneration of existing species so as to maintain the ecological system.

(3) Forest road plan

Although new roads are not planned, existing roads will be improved to secure convenience and safety of users.

(4) Facility and administration plan

① Existing national park office will be effectively used as road management facility to improve the administration.

② Existing nursery will be improved to secure saplings for reforestation. Irrigation facilities will be provided for this purpose.

③ Forest fire watch stations and fire extinguishing equipments should be provided.

④ General facilities should be provided to prepare for increase of future needs.

⑤ Education facilities, including historic museum, botanical garden and camping school, should be provided to prepare for the future need

(5) Recommendations on treatment of forests in the national park area

① An expansion of the national park area of 9,342 ha (680 ha in the model area) is proposed in this plan As a result, the total national park area will become ha. For this proposed expansion, it is desirable to take a necessary action for being designated as national park in the earliest time.

② The national park area should be clearly classified into a zone for conservation of natural environment and a zone for recreational use, to aim at planned and high intensive use of the area.

③ It is desirable to take necessary actions for prompt reforestation of areas in the park where trees have been artificially eliminated, except for areas required for recreational use.

4-3 Lima Model Area

In the model area, the forests are conserved in relatively good condition because of its location and land condition, with balanced arrangement of city/settlement, agricultural land and forest.

In this plan, the model area was selected in the plan to focus on agricultural area includ-

ing settlements and forest area.

4-3-1 General description of the area

(1) The model area is located in the Department of San Pedro, and bounded by 23°45' and 23°52'30" South Latitude and 56°22'30" and 56°30' West Longitude, with a land area of 15,767 ha.

(2) The area is located in a landscape with a little relative height difference at an elevation of 120 m–200 m, and forms a mid-stream area of Rio Aguary–Guazú and contains a large marsh land.

The soils are generally of loam type or sandy soil.

(3) The forest in the area consists of medium forest, with high forest to constitute 12%, and the forest composition is relatively poor as a whole. In addition, mixed forest, 15% of the total forest area, is distributed around marsh land.

(4) Existing land use distribution is 46% by forest, 13% by agricultural land, and 6% by livestock farming land, to show larger share of agricultural land than other areas.

In addition, marsh land and others account for 33%.

4-3-2 Forest classification

Productive forest constitutes 92% of the total forest area, and 83% of which (76% of the total forest area) is medium forest. An improvement of the forest will be an important task to increase forest production.

In addition to productive forest, protective forest, 8% of the total area, is found along Aguary – Guazú river.

4-3-3 Standard for management plan system

The appropriate management will be done in accordance with the following management method. Details of the management method will be in accordance with 3.2.

Table 0-1-13 Management standard

Forest classification	Forest type group	Area	Tree species	Cutting system	Regeneration	Final cutting age
Productive Forest	$A_1 \sim A_3$ M_2, M_3	849 ha 4,218	Broad leaved tree Parana pine Elliottii pine	Selective cutting Shelter wood cutting Clear cutting	Natural seeding A_1, A_2, M_2 –Supporting work. Clear cutting–Planting	DBH 40 cm ~ (90 years)
Protective Forest	M	462 ha	Existing species	Postponent of cutting Light selective cutting for high/mixed forest with consideration to conservation	Natural regeneration	DBH 40 cm ~

4-3-4 Cutting plan

In accordance with P. J. C. model area

4-3-5 Reforestation plan

In accordance with P. J. C. model area

4-3-6 Forest road plan

(1) Existing condition and future policy

Transport in the area mostly depends on national road route 3 and agricultural/livestock farming roads to connect route 3 and settlements.

In this plan, it is proposed that an agricultural/livestock farming road which branches out from route 3 and passes almost the center of the area in east-west direction will be expanded and improved to make a main forest road, and from which branch forest roads will be constructed in north-south direction.

(2) Proposed length

Main forest road	12,000 m	Length per ha	0.8 m
Branch forest road	13,400 m		0.8 m
Total	25,400 m		1.6 m

5. FUTURE OUTLOOK OF FOREST RESOURCES AND CUTTING VOLUME

5-1 Forest Area

(1) The future forest area was estimated.

As a result, the future forest area in the area was estimated at 970,000 m^3, or forest ratio of 62%.

(2) On the basis of the above forest area data, the area by forest class was estimated as follows:

Table 0-1-14 Future outlook of forest area

Forest classification	Areal composition	Estimated area by forest class
Productive forest	75 %	727,600 ha
Protective forest	22	213,400
Special forest	3	29,100
Total	100	970,100

Henceforth, the forest area in the future is estimated at 970,000 ha, with productive forest to be around 730,000 ha.

5-2 Stock and Increment

5-2-1 Stock

(1) On the basis of a result of the dense crown forest survey, the targeted volume of natural forest was determined as follows:

Targeted volume of natural forest (per ha)

All species 130 m^3

Useful species 85 m^3

Average volume of the present forest for selective cutting work is 69 m^3 per ha.

(2) Targeted volume of planted forest was calculated for Parana pine and Elliottii pine as index, and was determined in terms of usable volume as follows:

Targeted volume of planted forest (per ha).

245 m^3

(3) Composition of natural and planted forest in productive forest was determined as follows:

Natural forest	90%	655,000 ha
Planted forest	10%	73,000 ha

(4) The stock of forest classes other than productive forest, which were assumed to maintain the present condition, was determined at 50 m^3 per ha.

(5) Under the above assumptions, the total stock in the area was calculated to obtain the following estimate.

Total stock 84,906,000 m^3

5-2-2 Increment

(1) On the basis of a result of the basic survey, an increment of natural forest was

estimated, by using a increment rate of 5%, as follows:

Increment of natural forest 3,193,000 m^3

(2) The increment of planted forest, on Parana pine and Elliottii pine as index species, was estimated at 25 m^3 per ha, and which was modified by the use rate to obtain the final estimate as follows:

Increment of planted forest 1,278,000 m^3

(3) The increment of forest classes other productive forest, which were assumed to maintain the present condition, was estimated by using the increment rate of 3.5% as follows:

Increment of other forest classes 424,000 m^3

(4) Altogether, the total increment in the area was estimated as follows:

Total increment 4,895,000 m^3

5-3 Cutting Volume

On the basis of an annual increment of the forests while taking into account purposes of establishing protective forest and special forest, the total cutting volume in the future was estimated as follows:

Total cutting volume

Natural forest	3,193,000 m^3
Planted forest	1,278,000 m^3
Other forest classes	140,000 m^3
Total	4,611,000 m^3

5-4 Summary on Future Outlook of Forest Resources and Cutting Volume

To this point, estimates were made on forest area, stock, increment and cutting volume in the area, to be summarized as follows:

Table 0-1-15 Summary on future outlook of forest resources and cutting volume

Forest classification		Type of forest	Area	Stock	Increment	Cutting volume	Remarks
			1,000ha	1,000m³	1,000m³	1,000m³	
Estimate	Productive forest	Natural forest	655	(41,756) 63,863	(2,088) 3,193	(2,088) 3,193	( ) – useful species
		Planted forest	73	8,943	1,278	1,278	
		Sub-total	728	72,806	4,471	4,471	
	Protective forest		213	10,650	373	123	
	Special forest		29	1,450	51	17	
	Total		970	(41,756) 84,906	(2,088) 4,895	(2,088) 4,611	
Present (a)			970	(20,460) 46,166	(1,023) 3,051	(1,023) 2,912	
Existing forest (b)			955	(14,964) 27,845	(494) 919	(496) 924	Increment – estimate Cutting volume – standard cutting volume
Ratio	(a)/(b)x100		102	(137) 166	(207) 332	(206) 315	

According to the above table, a result of a comparison between the future outlook and the present condition of the forests, for reference, indicates that the stock will increase by around 1.7 times and the increment and cutting volume will increase by around three times.

5-5 Present Cutting Volume and Future Outlook

(1) Present allowable cut of forest and actual cutting volume

① The actual cutting/logging volume in recent years was estimated at around 697,000 m³, which is only logging volume for saw-logs, and 75% of which, or 523,000 m³, appears to be of Peroba.

② By using above results, the allowable cut (standard cutting volume) and the actual cutting volume of the forests were compared as in the table below, to indicate that the actual cutting volume exceeds the allowable cut by 1.4 times for useful species and by three times for Peroba.

Table 0-1-16 Allowable cut and actual cutting volume

Species	Allowable cut ⓐ	Actual cutting volume ⓑ	ⓑ/ⓐ x 100
	1,000m³	1,000m³	
Useful species (A+B)	496	697	141
Peroba	174	523	301

(2) Exploitable years under present cutting volume

① By using the present stock and increment of the forests, the exploitable years were calculated from the above actual cutting volume to be as follows:

Exploitable years under present cutting volume.

Useful species	33.2 years
Peroba	12.0 years

② Naturally, as the forest resources becomes closer to exhaustion to deteriorate the quality of forest products and to move the cutting work to remote areas, the cutting volume gradually decreases. Thus, it is not conceivable that all the forests are disappeared in the exploitable years. Nevertheless, it is obvious that the situation will go toward exhaustion of the forest resources, deterioration of the quality of wood products and increase of production cost at accelerated rate, so far as the present cutting practice continues. Since an ominous sign of such situation is clearily observed, prompt actions should be taken.

6. PROPOSAL FOR THE IMPLEMENTATION OF GUIDE LINE FOR FOREST DEVELOPMENT PLAN

In order to achieve the purposes of this Forestry Development Plan Guideline, it is necessary to provide proper management of the existing forests and to aggressively carry out forestry development according to the provisions of the Guideline.

Since the details of the guideline have specifically been given according to each item, we would like to discuss herein those matters that are considered necessary in the implementation of the guideline.

(1) Expansion of the measures for national forestry and forest development

a) Introduction of a forestry management plan system

Forestry and forest measures should be formulated on the basis of a long-range and integrated thinking.

For this purpose, it is necessary to prepare a systematic forestry plan incorporating state and regional forestry and to carry out the forestry development in an orderly and integrated manner. It is therefore desirable that the introduction of a logical forestry plan system will be studied as early as possible.

b) Proposal for forest conservation and definition of method for implementation

It is expected that the areas for reserved forests as classified under this plan shall be defined in each region and the guideline measures be provided, as well as forestry management standards shall be established in order to effectively achieve the purposes of the guideline, and effective measures be provided.

c) Accurate control of cutting rules and cutting volume

In order to ensure accurate control of cutting rules and cutting volume, such measures as provided in the following should be studied and implemented as early as possible.

① To adopt a license system or an application system for cutting so as to be able to grasp the cutting volume, and ensure an orderly forest exploitation, and control or adjust the total cut.

② To strengthen the existing control stations and a full-time watch system with respect to the checking on cutting and transporting logs, and to carry out mobile checkings as well at loading points or on roadways in order to improve the rate of seizure of illegal cuts, and to expand forestry district offices if necessary.

③ To consider to provide control measures over the cutting volume form the aspect of log consumption such as the establishment of goals of consumption limits for each production facility of sawmills, or the adjustment on cutting license (Guia) issuance, etc.

(2) Expansion of facilities to provide basic data necessary for forestry management

a) Preparation of a timber volume table

In order to provide an adequate direction to the forestry development, it is first necessary to establish the criteria of measurement, which is a basis of forestry. So, it is necessary to prepare quickly a timber volume table.

b) Expansion of experimental and research facilities for forestry management

Presently, there are several experimental areas for natural forests. But, these sould be further examined with respect to the size and condition of the areas and the method of observation.

Experimental areas should be established and observation activities should begin as

early as possible for the collection of basic data including the increment, harvest, development, etc. of natural forests.

c) Putting other data in order

In order to promote the development of reforestation, it is essential to conduct a systematic soil research and to put other basic data in order including the preparation of forestry harvest tables, etc. But, we only emphasize the importance of this activity at this time.

(3) To take aggressive measures for the development of reforestation

a) Protective and promotive measures for reforestation by private sector

It is necessary to expand and strengthen tax preference measures that are partially enforced under forestry law, and to provide aggressive measures to promote reforestation by private sector, including low interest loans by public funds, reforestation subsidies, etc.

b) To promote a profit-sharing reforestation by national or public organizations

It is absolutely necessary for the promotion of reforestation that national or public organizations take initiatives to promote reforestation and motivate private sector in this endeavor.

In this case, it seems proper that public forest land shall be utilized for reforestation under contract between foresters and land owners, and that the income form cutting or thinning shall be shared (profitsharing reforestation) between the two.

As a part of measures for reforestation a profitsharing reforestation method should be studied.

(4) To promote and propagate the research and development of reforestation technique

It is necessary to positively promote the research and development of reforestation technique according to the provisions of this plan, and to propagate such technique to those who wish to engage in reforestation.

It is also necessary to provide the facilities for that purpose and train technical personnel as soon as possible.

(5) To promote measures for the development of wood-related industries.

One of the preconditions to promote reforestation is to secure stable marketing channels for wood.

To increase the value of wood through the promotion of the use of untapped wood material and a higher utilization of natural wood is extremely important for the improvement of regional economy as well as for the enhancement of job opportunities for local population.

For that purpose, it is necessary to positively promote or induce wood-consuming industries including woodchip industry, pulp industry, plywood industry, furniture industry, wood-working industry, paper industry, etc.

(6) To promote the use of untapped wood material and the development of wood technology

It is necessary to draw the creativeness of private sectors in close cooperation with CEDEFO, and to aggressively promote the development of techniques for the use of wood.

For that purpose, it is necessary to expand faiclities and train technical personnel.

(7) To educate people on the importance of forestry and propagate such education

Denudation of tropical and subtropical forests is occurring on the global magnitude. The advancing desert and the changing climate are the subject of great concern. And this region is no exception.

It is, therefore, important to positively promote the educational and propagative activities on the importance of "green resources" with state or public organization taking the leadership, so as to heighten the enthusiasm of people for reforestation.

(8) To promote the intensive use of land for higher and integrated land utilization

Many of the land areas in this region are carelessly used except for certain areas.

As mentioned in the forestry development plan in the model area, the establishment of reserved forest area will be necessary in this region in order to regain the productive capacity of land through reforestation by a classified forestry system and to promote an intensive use of land. It is, further, a great task toward the 21st century for this region to promote a higher and integrated use of land through complex land management, which incorporates cattle-breeding and forestry, or agriculture and forestry.

PART 2. BASIC SURVEY

1. FOREST SURVEY

1-1 Progress and Result of Previous Surveys

(1) Pointed to controlled forest development, forestry promotion and development of regional economy in northeast region of Parguay, forestry resources servey, including preparation of aerial photography map, forest resources survey and soil investigation, was carried out in past three years starting from 1980, which clarified the existing condition of forest resources and characteristics of the forest. In this section, outline of previous surveys including their progress and result was summarized, to reveal a whole part of forestry resources in the region.
Progress of the surveys are as follows:

Table 0-2-1 Progress of the surveys

Item of survey \ year	1980	1981	1982
General survey	Landsat data analysis		
Forestry resources survey	Aerial photographing (northern part)	(southern part)	
	Forest preliminary survey		
		Air photo interpretation	
		Forest regular survey (northern part)	(whole area) 1st 2nd
			Dense crown forest survey
			Soil investigation

(2) These survey results, after necessary analysis and study, were compiled to the following reports:

March, 1981 Report on The Landsat Analysis, The Forest Resources Inventory in The North-eastern Region, The Republic of Paraguay

March, 1982 Report on The Forest Inventory in The Northeastern Region, The Republic of Paraguay in 1981

March, 1983 Inventario Forestal, Zona Noreste de la Region Oriental Republica de Paraguay

1982 report (March, 1983) was compiled from study results between 1980–1982.

1-2 Landsat Data Analysis

(1) The Forest Type and Land Use map (1 : 500,000) was prepared from a result of Landsat data analysis.

(2) Looking over yearly change of the forest, it has disappeared at annual average rate of about 1.3% during five year period between 1972 and 1977. A result of analysis on a specific area indicates that disappearance rate of the forest for 12 years is 27.5% for high forest and 17.2% for low forest, with annual average rate of 2.3% and 1.4% respectively.

Particularly, fast declining trend is observed in recent five years between 1970 and 1980.

1-3 Forest Resources

General description of the forest resources on the basis of sampling survey is as follows:

(1) The area of the region by land use and stratum is as follows:

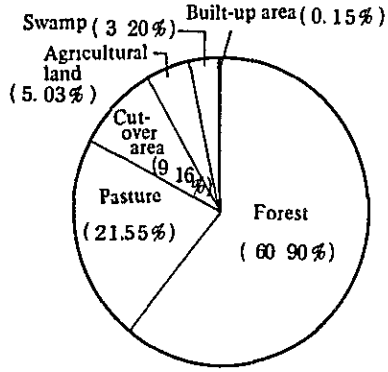


Fig. 0-2-1 Composition of area by land use

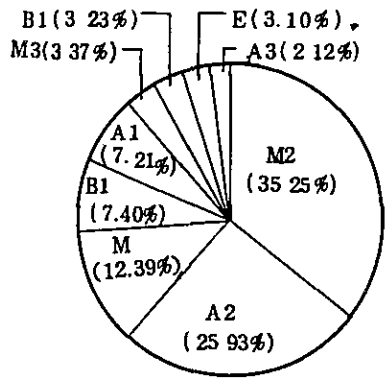


Fig. 0-2-2 Composition of area of the forest by stratum

(2) 135 species with diameter breast height (DBH) of more than 41 cm were found in the area, among which Peroba constitutes 22% of total volume.

(3) Total stock in the study area (diameter breat height of more than 41 cm, without bark, defective trees excluded) is:

Total stock (m^3) = 27,845,025 ± 2,314,944, while total stock of class A + B and Peroba is:

A + B (m^3) = 14,963,651 ± 1,731,470

Peroba (m^3) = 5,236,869 ± 1,462,447

to constitute 53.7% and 18.8% of total stock respectively.

Stock of major species is: Cedro 457,000 m^3, Lapacho 876,000 m^3; and Peroba 5,237,000 m^3.

Stock by department, in which the Department of Amambay constitutes around 50%, is as follows:

Table 0-2-2 Stock by department

Department	Area (ha)	Stock		(1,000m³)
		Total stock	A + B	Peroba
AMAMBAY	477,445	14,148	7,615	2,782
CONCEPCIÓN	105,503	3,121	1,682	581
SAN PEDRO	231,221	6,642	3,589	1,205
CANENDIYU	141,235	3,934	2,078	669
TOTAL	955,404	27,845	14,964	5,237

(4) Volume of Peroba per ha by diameter class, in which the volume of 80 cm diameter class constitutes around 27%, is as follows:

Table 0-2-3 Volume of peroba per ha by diameter class

Species \ Diameter class (cm)	10~20	21~30	31~40	41~50	51~60	61~70	71~80	81~90	91~100	101~	Total
Peroba (m^3)	0.45	0.71	1.01	0.97	1.31	1.16	1.14	0.56	0.56	1.42	9.29
(%)	4.9	7.6	10.9	10.4	14.1	12.5	12.3	6.0	6.0	15.3	100
	23.4			24.5		24.8		27.3			100

1-4 Forest Soil

Followings are the characteristics of soil in the survey area:

① Very deep soil layer
② Strong reddish color such as dark red brown, and dark red
③ Unclear boundary of stratums in most part
④ Stone and gravel not contained in soil layer
Probable presence of conglomerate in the depth between a few meters and several tens of meter.
⑤ Moderately moist soil mostly found, with rare dry soil.

Type and characteristic of forest soil in the area are as follows:

(1) Sand type soil (Type S)

This is a deep sandy soil containing a variety of sand size from very fine grain to relatively large grain. Fine sandy soil is largely contained, without stone and gravel.

This type of soil is generally good for natural regeneration, but productivity of the forest is not high.

Reforestration is feasible with a certain degree of growth to be expected. However, as this type of soil is subject to rapid wash-out after forest cutting and to resultant reduction of fertility, care will be required on forest development.

(2) Sand/Loam type soil (Type S.L)

This is an intermediate type between sand type soil and loam type soil, and widely distributed in flat land of the area. Many of this is of fine sand or very fine sand. This either contains less cohesive clay in its layers or has a relatively cohesive layer in bottom part of B layer

The productivity of this soil is higher than the preceding type, to be sufficiently feasible for development of planted forest.

Care should be taken for this type of soil because of a large impact by wash-out, fertility reduction and top soil erosion when becoming open land.

(3) Loam tupe soil (Type L)

This is largely distributed in high land forest area of undulating landscape with slope, similar to indicator Ferralissols of dark red color.

Growth of saplings on this soil is satisfactory, with abundant vegetation.

This has the highest productivity among all the types in the area, to be feasible in developing high growing planted forest if properly managed.

(4) Clay/loam type soil (Type CL)

This contains many clay in the layer. Management of the forest on this type of soil is generally in accordance with that for loam type soil

(5) Clay type soil (Type C)

This is heavy cohesive soil found in upper plateau of undulating landscape. As the productivity of the forest on this type of soil is low, developing of planted forest should be avoided.

(6) Gleysols (Type G)

This is found at gentle slopes in lower part of slope and at low swamp.

Vegetation on this type of soil includes wet grass land, shrub, and low forest. Because of low productivity of the forest on this soil, this could not be an object of forestry production

2. FOREST MANAGEMENT SURVEY

2-1 Increment of Natural Forest

To estimate the in crement of the natural forest, annual ring survey of stumps and others was carried out for 102 trees of useful species including Peroba, and stand increment was calculated.

(1) Survey method

① The number and width of annual rings on cross section of stumps, felling trees and bottom end of logs were measured to calculate basal diameter for each age grade. (Annual growth ring survey)

② From relationship between calculated basal diameter and diameter breast height, diameter breast height for each age grade was calculated.

③ From relationship between calculated diameter breast height and stem volume, stem volume for each diameter class was calculated.

④ Increment was calculated by using stem volume for each diameter class, and was divided by passing year to calculate annual average increment for each diameter class. This calculation procedure could be expressed in the following formula:

$$Zd = \frac{Vd_2 - Vd_1}{n}$$

Whereas, Vd_1 : Stem volume for a given diameter class

Vd_2 . Stem volume for a diameter class higher than Vd_1 by one class

n . The number of years required for passing from Vd_1 to Vd_2

⑤ Increment per ha for each diameter class was calculated by multiplying the number of tree per ha for each diameter class by increment and was totaled to obtain increment per ha.

(2) Calculation of stand increment

As a result of calculation of the increment in the natural forest of the planning area, stand increment of all species in the area (total volume per ha) is as presented in Table 0-2-4, to be 2.13 m^3 per ha.

At the same time, stand increment for A + B group and Peroba is 0.55 m^3 per ha and 0.21 m^3 per ha respectively.

Also, increment rate of stem volume was calculated by dividing stand increment of all species by stand stem volume per ha, being estimated at around 3.3%.

Table 0-2-4 Stand increment

Species	Type \ Diameter class cm	10~20	21~30	31~40	41~50	51~60	61~70	71~80	81~90	91~100	101~	Total
All species	Trees/ha	1901	740	296	123	59	29	18	0.7	0.4	03	3180
	Annual average increment m^3/trees	00036	00071	00124	00180	00232	00275	00326	00377	0.0416	00461	
	Increment m^3/ha	06844	05254	03670	02214	01369	00798	00587	00264	00166	00138	2.1304
A + B	Trees/ha	24.2	125	80	48	28	16	1.0	0.5	0.3	03	560
	Annual average increment m^3/trees	00031	0.0071	00119	00173	0.0241	00305	00373	00458	0.0513	00568	
	Increment m^3/ha	00750	00888	0.0952	00830	00675	00488	00373	00229	0.0154	00170	05509
Peroba	Trees/ha	102	3.7	2.1	11	10	06	04	0.1	01	0.2	195
	Annual average increment m^3/trees	00031	00071	0.0133	0.0199	00295	00395	0.0508	0.0632	0.0768	0.0896	
	Increment m^3/ha	0.0316	0.0263	00279	0.0219	0.0295	0.0237	0.0203	0.0063	00077	0.0179	0.2131

Incrementrate $P(\%) = Z/V \times 100 = 2.1304 / 64.60 \times 100 = 33$

Whereas, stem volume per ha $(V) = 6460\ m^3$

2-2 Natural Regeneration

Natural regeneration survey was done in the forest of the planning area for ①relationship between forest type and number of sapling, ②sapling increment change in number of growing stand and ③relationship between sapling and upper tree. General description of the survey results is as follows.

(1) Number of saplings for each forest type

Peroba is found in forest type D more than any other forest types. A + B group with diameter (DBH) classes of up to 4 cm is found similarly in forest type A and D, and for diameter class of 5 – 9 cm more in forest type D.

Number of saplings for each forest type is as presented in the following table:

Table 0-2-5 Number of saplings by forest type

Forest type	Tree height 0.3m ~ 1.3m		DBH ~4cm		DBH 5cm ~9cm	
	Peroba	A+B	Peroba	A+B	Peroba	A+B
A_1	1,083	750	83	250	0	0
A_2	333	944	111	167	56	0
M	0	200	100	0	0	0
M_2	125	542	125	42	0	0
DA_2	1,556	611	444	167	56	56
DA_3	2,000	375	625	250	250	125

(2) Sapling growth and change in number of growing stand

Looking over change in number of for each class size, Peroba decreases by 67 – 92% before reaching diameter of 4 cm, and by more than 83% in diameter class of 5 – 9 cm, in all forest type except for type M_1 and M_2.

On the other hand A + B group decreases by more than 67% before reaching diameter of 4 cm, and by more than 91% in diameter class of 5 – 9 cm, in all forest types except for type DA_3. This indicates that most of generated saplings disappears before reaching diameter of 4 cm.

(3) Number of Peroba seed tree and sapling

From survey result, the number of saplings tends to decrease with an increase of Peroba seed trees, albeit not strong association.

This is thought to be affected by its relation with the following crown density.

(4) Upper tree density and number of saplings

In this relation, number of saplings tends to decrease with an increase of upper tree in a forest.

This implies that generation and growth of sapling are affected by luminous intensity which is determined by crown density of the upper trees.

2-3 Seedling and Planted Forest

(1) Seedling and reforestation

Amount of seeding, germination rate, planting time and seed spacing were surveyed for Parana pine, Elliottii pine and Eucalyptus

① Amount of seeding is 60 – 90 kg (direct seedling) per ha with 7,900 – 11,700 grains for Parana pine, and 500 kg per ha for Eucalyptus.

② Parana pine is planted between April and May by direct seedling or in pot, Elliottii pine is planted between June and August in wood box or pot, and Eucalyptus is planted between July and October in seedbed.

③ The number of plantings per ha by species is tabulated as follows:

Table 0-2-6 The number of plantings

Tree species	Yamazoe report[2) 3) 4)]	Forest service report[1)]	Komiya report[8)]	Remarks
	trees/ha	trees/ha	trees/ha	
Parana pine	2,500 ~ 3,000	* 2,250	1,600	* Forest age – 4 years
Elliottii pine	1,700	3,000	2,200 ~ 3,000	
Eucalyptus	2,200 ~ 2,500	2,500		

④ Site levelling and ant extermination are required for Eucalyptus planting, and fire prevention for Elliottii pine planting.

⑤ Adequate time of planting in nursery is between July and August, and adequate time of planting in woodland is between May and August as well as in winter season.

(2) Increment of planted forest

Characteristics of species and increment in planted forest were surveyed mainly on the basis of the various reports.

① Cutting period appears to be appropriate to be around 20 – 25 years for Parana pine and Elliottii pine, and 10 – 15 years for Eucalyptus.

② Annual increment of planted forest by species and forest age are tabulated as follows

Table 0-2-7 Increment of planted forest

Tree species	Forest age	Alto Parana Forestry Center report	Forest Service report	Komiya report	CEDEFO report
Parana pine	10	145 m^3	14.3 m^3	20.8 m^3	
	20		185 m^3	27.8 m^3	
	25			22.8 m^3	
Elliottii pine	10	22.6 m^3	281 m^3	25.0 m^3	
	20		31.4 m^3	29.4 m^3	
	25			26.0 m^3	
Caribbean pine	10		27.2 m^3		
	20				
	25				
Eucalyptus	10		25~30 m^3		
	20		33 m^3		
	25				
Cedro	25~27				1.71 m^3
Peterevý	25~27				2.43 m^3
Lapacho	25~27				0.59 m^3
Peraiso	10				
	20				
	25				

Annual increment of Parana pine increases until forest age reaches 20 years, and decreases thereafter.

Elliottii pine shows larger annual increment than Parana pine in each forest age. Caribbean pine, Eucalyptus and Paraiso show relatively large annual increment, and particularly Eucalyptus and Paraiso show larger annual increment than coniferous trees such as Caribbean pine.

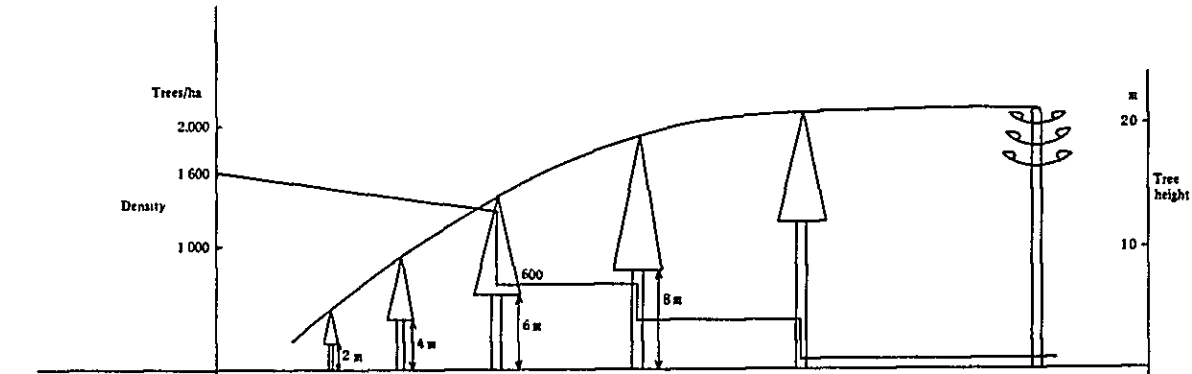
③ Comparing increment between local and planted species, planted species such as Parana pine and Eucalyptus show much larger increment than local species such as Cedro, Peraleb and Lapacho, as seen in the table of 0-2-7.

(3) Silvicultural system

The detail of silvicultural system is illustrated in the following diagrams. Weeding will be done for Parana pine and Elliottii pine, three times annually up to forest age of 4 years.

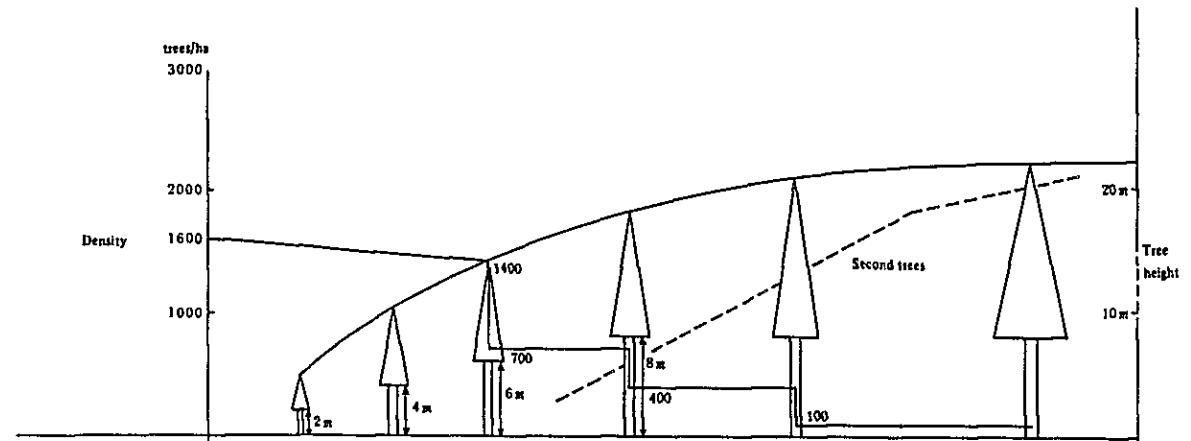
Pruning will be done for all trees at forest age of 5 years, for 700 trees at 8 years and 12 years, and for 400 trees at 18 years.

Thinning will be done for 600 trees and 100 m^3 at forest age of 12 years, and for 300 trees and 150 m^3 at 18 years. Silvicultural systems for Parana pine and Elliottii pine are illustrated as follows:



Forest age (year)	5	8	12	18	25	35
Tree height (m)			14	19	21	
DBH (cm)			21	31	35	
Volume (m^3)			250	400	320	
Weeding (improving cutting) times	3	3	1	1		
Pruning times	1	1	1	1		
Pruning trees	All	700 trees	700 trees	400 trees		
Thinning times			1	1	final	
Thinning trees			600 trees	300 trees	300 trees	Total
Volume (percent)			100 m^3(40%)	150 m^3(38%)	250 m^3(80%)	500 m^3
Remarks				Conversion to two-storied forest	Retained as seeding tree for seed collection	

Fig. 0-2-3 Silvicultural system for Parana pine



Forest age (year)	1 2 3 4	8	12	18	25	35
Tree height (m)			14	18	21	22
DBH (m)			20	30	36	40
Volume (m^3)			300	430	400	
Weeding (improving cutting) times	3 3 (1)					
Pruning times	1	2	3	4		
Pruning trees	All	700	700	400		
Thinning trees			1	2	3	
Thinning times			700	300	300	Total
Thinning volume			100 m^3	150 m^3	300 m^3	550 m^3+100+α m^3
Thinning (percent)			(33%)	(35%)	(75%)	
Remarks						

Fig. 0-2-4 Silvicultural system for Elliottii pine