REPORT ON THE FOREST INVENTORY IN THE NORTHEASTERN REGION, THE REPUBLIC OF PARAGUAY IN 1981

March 1982

JAPAN INTERNATIONAL COOPERATION AGENCY
(J.I.C.A)

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PREFACE

The Forest Inventory in the Northeastern Region of the Republic of Paraguay has been carried out in accordance with the Scope of Work (S/W) signed in June 1980. The Inventory was designed to contribute to forestry planning in Paraguay through cooperation between Japan and Paraguay.

Japan International Cooperation Agency sent a survey team to Paraguay from July 1981 to November 1981, and a field survey and data analyses were carried out by the team in cooperation with the National Forest Service of Paraguay. This report is the result of the team's investigations.

I hope that this report will serve as a basic reference for the forestry development in Paraguay and contribute further to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Paraguay for their close cooperation extended to the team.

March 1982

Keisuke Arita

Keisuke Arita
President,
Japan International
Cooperation Agency

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ABSTRACT

The study area (about 780,000 hectares) was classified and stratified by Landsat-analysis and photo-interpretation (scale 1:20,000). Forest land occupied 54 percent (about 420,000 hectares) in the study area.

A total of 32 sample plots were surveyed on the field, and we estimated a total amount of volume as about 12,113,275 m^3, and a volume of Peroba (Aspidosperma polyneuron) among the total volume was estimated at about 4,980,500 m^3 (41%). This is one feature of the study area; that is, Peroba is the main forest product in the study area as it is exported to Brazil.

However, exploitation for Peroba is excessive now, and we are concerned about the destruction of other commercial species and the forest itself.

In 1982, we will establish the forest inventory for the total study area (1,500,000 ha).

I. INTRODUCTION

Many countries throughout the world are concerned about the declining forest land base. This is especially serious for non-petroleum producing countries at present. As one of them, the government of Paraguay requires the use of available forest management practices for controlling forest products and developing forest industries. This is because forest products and forest industries are very important factors for macroeconomic growth in this country.

However, there is almost no information concerning the distribution of forest stock in the country, especially in the northeastern region.

Our cooperative project with the Paraguayans will take an inventory of forest resources and will establish a methodology of the forest management, which will be transferred to the Paraguayans.

I-1 Purpose

This paper is to analyze results of sample plots, which have already been investigated this year, to estimate the available stock and to establish the procedures of the final investigation of the total study area next year (1982). Last year 1980, we established the size of the sample plot, the methodology of forest measurement and the scope of the field survey.

I-2 The members of the project team

i) The Japanese members

The Japanese field survey team is composed of the following members;

Position	Name	Length of stay	Place
Chief	Hiroshi WATANABE	25 days (9.4.81 to 9.28.81)	Japan forest technical asso.
Crew	Seishiro SHOJIGUCHI	60 " (9.14.81 to 11.12.81)	""
"	Ryoji HATAMURA	60 " (")	"
"	Hiroaki MASUI	70 " (9.4.81 to 11.12.81)	"
"	Michiharu KONDO	60 " (9.18.81 to 11.16.81)	"
"	Atsushi HISAMICHI	60 " (9.14.81 to 11.12.81)	"

ii) Paraguayan team

- National Forest Service
  Agriculture & Forestry Eng. Director Pedro F. CALABRESE
  Agriculture & Forestry Eng. Chief, Hilario MORENO
  Department of National Parks & Forests, and Preserves
- Counterparts
  Eng. Agr. Hugo HUESPE
  Eng. Agr. Luciano CABRAL
  Eng. Agr. Elvio ENCISO
  Tech, Ft. Enlique ORTEGA
  Tech, Ft. Gilberto BAREIRO

I-3 Outline of the forest inventory

The total study area of the forest inventory is about 1,500,000 hectares, located at from latitude 22° south to 24° south and from longitude 55°30' west to 56°30' west. The total study area includes mainly the department of Amambay, and part of the departments of Concepción, San Pedro, and Canendiyu.

The forest resources inventory will be accomplished in four years (1980 to 1983), as in figure-I-1 below, and this year was the second period. The study area of 800,000 hectares was surveyed in the field this year and the total study area of 1,500,000 hectares including the study area of 800,000 hectares will be done next year (1982).

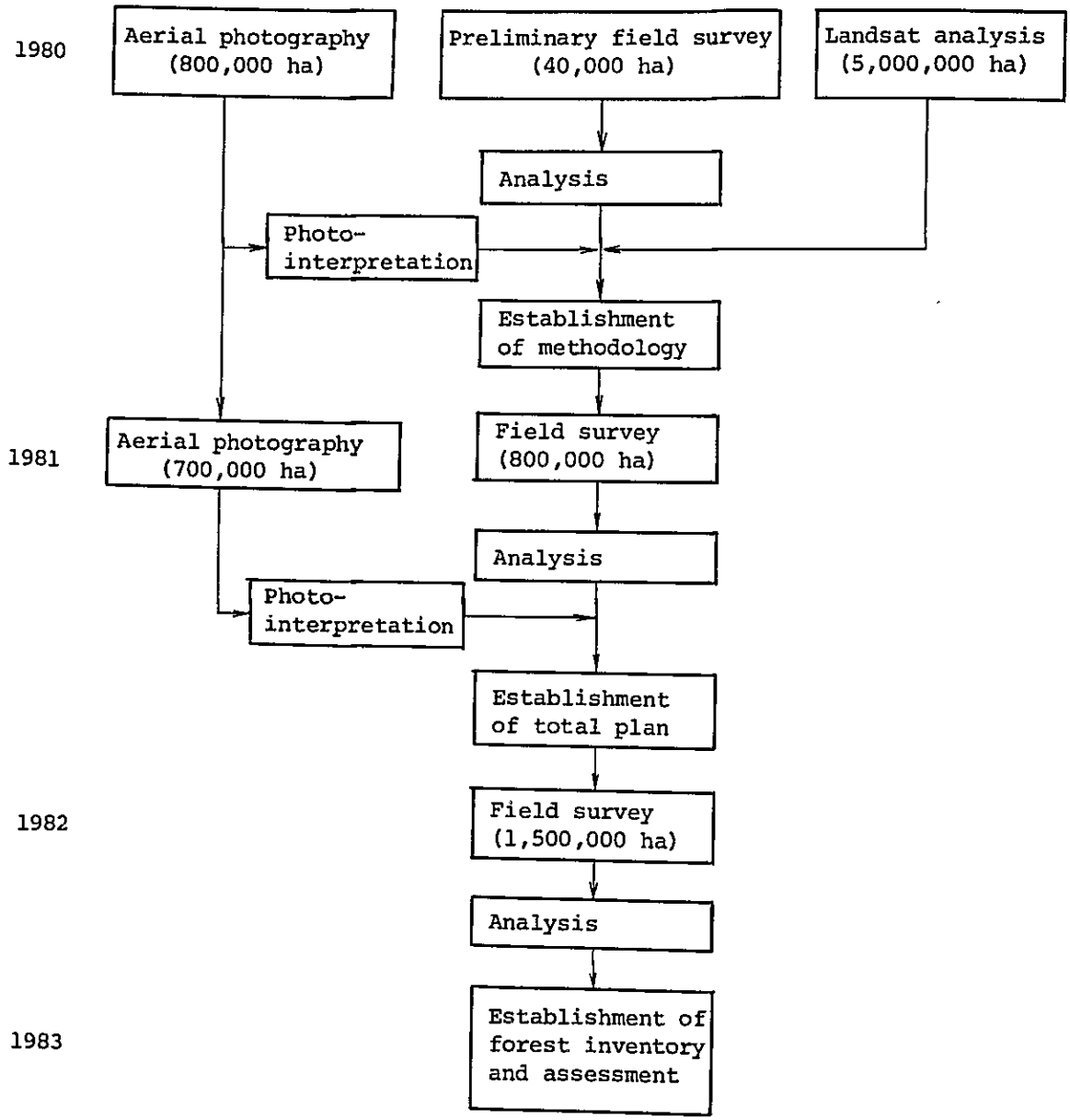


Figure-I-1. Flow-chart of the forest inventory.

This year's work included:

(1) The study area of 800,000 hectares which we had already photographed aerially (scale 1:20,000) was photo-interpreted to classify the forest types.

(2) The field survey was done according to statistics methods (random sampling). (32 plots, each plot is one hectare.)

(3) After analyzing data from the sample plots, the land use was photo-interpreted and the forest inventory in the study area (800,000 ha) were estimated.

(4) Based on these results, a plan for the final forest inventory of the total study area (1,500,000 ha) was established.

I-4 The study area

Location

The study area (about 800,000 ha), which was aerially photographed in 1980, is from latitude 22°15' south to 23°15' south and from longitude 55°30' west to 56°30' west.

Topography

The border between Paraguay and Brazil, which runs from northeast to east, corresponds to a mountain ridge (called CORDILLERA DE AMAMBAY), but is not at so high an elevation (sea level 200 m to 600 m). On the other hand, the northeast of the study area is wavy undulating land where there are sometimes steep hills (called CERRO, elevation 50 m to 100 m) and the southwest area is perfectly flat.

Ecology

All of the forest in the study area is natural hardwood forest, so-called "Sub-tropical hardwood forest". The forest includes many species, but a feature of the study area is that there is much Peroba (Aspidosperma polyneuron)and sometimes pure Peroba stock. The Peroba is the tree most commercially exported to Brazil in the study area. However, we are concerned about the destruction of the forest through excessive exports of Peroba.

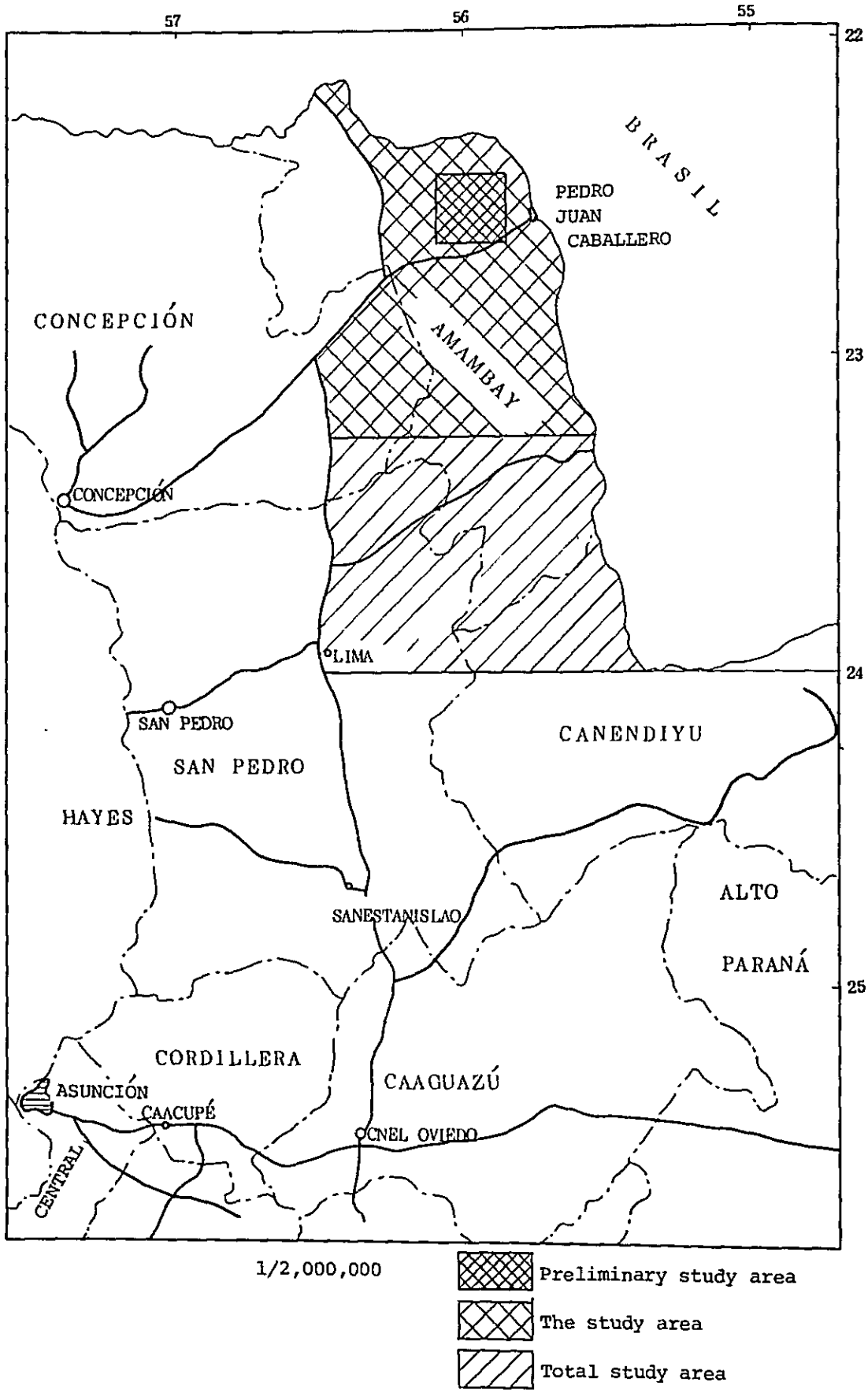


Figure-I-2. The study area.

I-5 Sources of information

The following items were utilized for the forest resources inventory as information sources.

1. A classified map from Landsat analysis (1981)
2. Aerial photographs (1980 or 1981)
   a) Contact prints (scale 1:20,000)
   b) Enlargement prints (scale 1:10,000)
   c) Photo-mosaics (scale 1:20,000)

   (see appendix-1)
3. Topographic maps (scale 1:50,000)
4. The results of preliminary sample plots (1980)
5. The FAO report (1974) (Proyecto de desarrollo forestal y de industrias forestal)

II. DESIGN AND PROCEDURE

The "sampling" method for the forest inventory was adopted, because this method is the best for estimating a vast area like the study area in terms of accuracy, cost and time. In addition, the FAO adopted the "sampling" method for the Forest Inventory of the southeastern region of Paraguay in 1974. Therefore, the two sets of data can be compared after preparing the forest inventory.

The first step of our sampling method was to divide the study area into photo-strata. This is because we classified several forest types by Landsat analysis, and can interpret the aerial photos to classify them more precisely. This is useful in viewing the distribution of forest types and stock in the study area. Beside, in statistics, the accuracy of the estimation for the total stock is higher than in the case of non-photo-stratum. And finally, the volume of the study area will be estimated from the data of sample plots.

Figure-II-1 shows the procedure of work before the field survey on the design of the forest inventory.

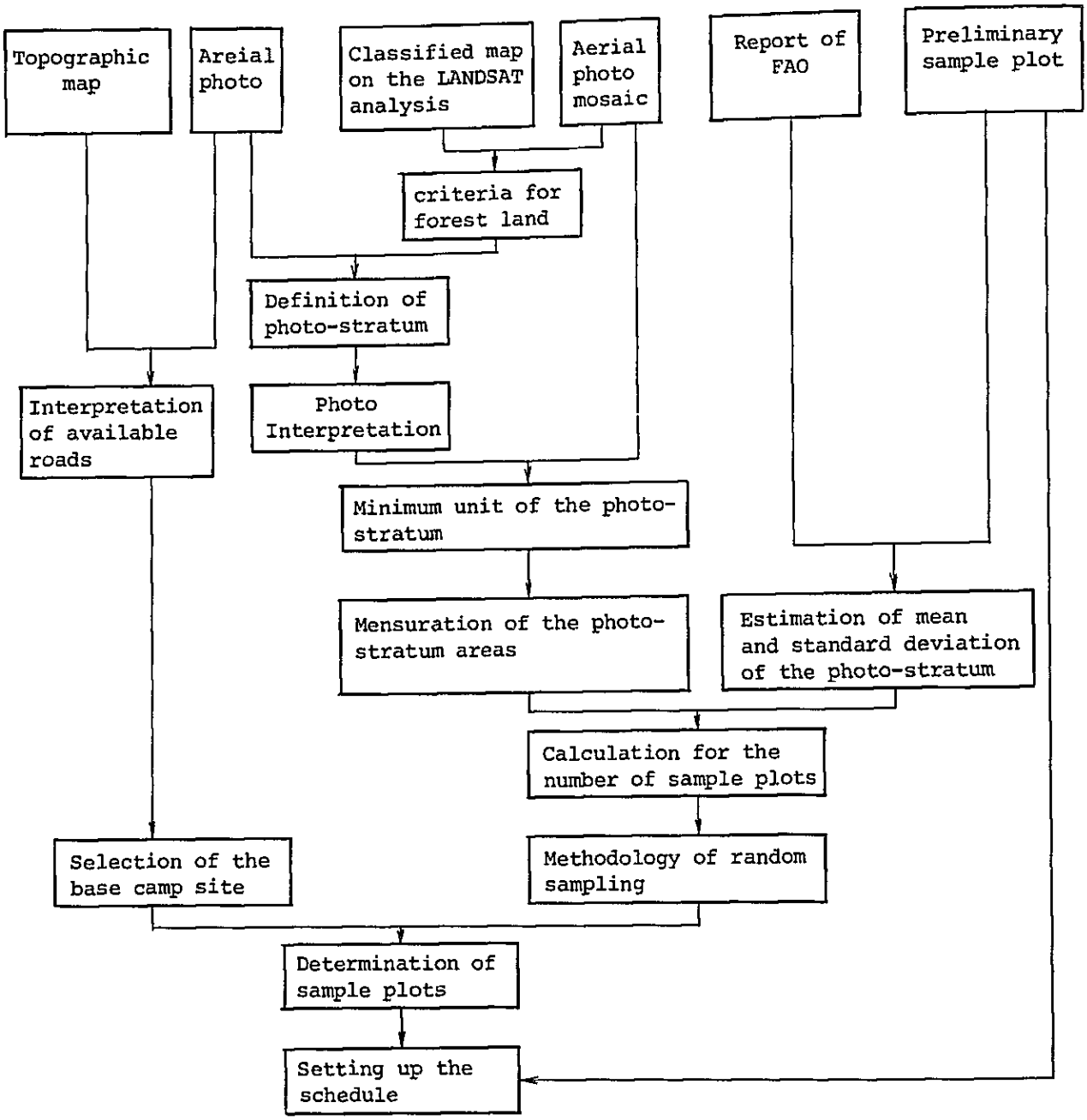


Figure-II-1. Flow-chart for the design of the forest inventory.

II-1 Preliminary interpretation

Preliminary interpretation is the backbone of the design and an important process in establishing the forest inventory. Because these data are not only for calculating a number for sample plots for an estimation of the total volume in the study area, but can also influence the location of the sample plots.

The procedure is as follows;

i) Criteria for forest land
ii) Definition of photo-stratum
iii) Photo-interpretation
iv) Minimum unit of the photo-stratum
v) Mensuration of the photo-stratum areas

i) Criteria for forest land

We decided that a forest less than 4 hectares is not forest land base because it is too small as a total study area, and will require tremendous work in dividing the forest land.

ii) Definition of photo-stratum

a) Landsat computer-analysis

Last year, we made a classified map for forest types and land use for estimation forest and land conditions over 5,000,000 hectares. This map was classified by computer-aided analysis from LANDSAT data. LANDSAT is the name of a USA satellite at an altitude of about 917 km. The Landsat transfers reflected light from the ground to a recording system after passing through filters that select different wavelength intervals of this light, and sends data by radio waves to a ground station.

Therefore, the landsat data are spectral digital information and can be classified by computer-analysis according to the purpose. The details of the theory, method and procedure were explained in last year's report. (see REPORT ON THE LNADSAT ANALYSIS, THE FOREST RESOURCES INVENTORY IN THE NORTHEASTERN REGION, THE REPUBLIC OF PARAGUAY, 1981)

The classified categories were thirteen and the accuracy was as in the following table-II-1;

Category		Tall forest			Medium F.		D.C.F.	M.F.	L.F.	P.C.A.	U.A	N.G.L.	L.G.L	B.B.A	Un-classified
		A	B	C	A	B									
Tall forest	A	35	5	10	20	13	14	5	1	0	0	0	0	0	0
	B	11	19	31	17	3	10	4	5	0	0	0	0	0	0
	C	5	6	60	22	1	3	0	1	0	0	0	0	0	2
Medium forest	A	5	1	6	74	1	13	0	0	0	0	0	0	0	0
	B	4	0	0	1	78	3	14	0	0	0	0	0	0	0
Dense crown forest		9	3	1	20	2	48	12	5	0	0	0	0	0	0
Mixed forest		3	0	0	0	15	16	65	1	0	0	0	0	0	0
Low forest		0	0	0	0	0	3	2	91	0	4	0	0	0	0
Pasture or cultivated A		0	0	0	0	0	0	0	3	71	13	12	1	0	0
Unused area		0	0	0	0	0	0	0	0	10	64	16	10	0	0
Natural grass land		0	0	0	0	0	0	0	0	7	8	84	1	0	0
Low grass land		0	0	0	0	0	0	0	0	0	0	3	97	0	0
Bare or burned area		0	0	0	0	0	0	0	0	0	0	0	0	100	0

Table-II-1. Percentages of the classified probability for the Landsat analysis categories.

b. Criteria for photo-interpretation

It is preferable that criteria for categories of the classified map by Landsat-analysis and categories for the photo's strata correspond, because both results of the classified strata can be compared in the future.

However, some categories are not precisely classified in the Landsat-analysis, for example, tall forests A and B, and Dense crown forest. If these categories can be brought together, table-II-1 would be changed as follows; (table-II-2)

Category	T.F.	M.F.	D.C.F.	M.F.	L.F.	N.F.
Tall forest	61	25	9	3	2	0
Medium forest	8	77	8	7	0	0
Dense crown forest	13	22	48	12	5	0
Mixed forest	3	15	16	65	1	0
Low forest	0	0	3	2	91	0
Non forest	0	0	0	0	0	100

Table-II-2. Percentages for the newly classified categories.

We believe that the accuracy of table-II-2 is satisfactory for the preliminary interpretation process except for the category of dense crown forest. In addition, the tall, medium and low forests can be divided into 3,2 and 2 divisions by which we will interpret the aerial photos (scale 1:20,000) by stereoscope, and the dense crown forest will be included into the tall and medium forests. On the other hand, if we can recognize new logging roads when interpreting the photos of the tall or medium forests, such areas will be kept separate and designated as exploited forests.

The criteria for photo-interpretation is shown by table-II-3

Category	Symbol	Remarks
Tall forest	A1	Upper tree heights over 15 m. The crown density of upper trees is less than 20 percent.
	A2	Upper tree heights over 15 m. The crown density of upper trees is 21 to 49 percent.
	A3	Upper tree heights over 15 m. The crown density of upper trees is more than 50 percent.
Mixed forest	M	Tall and low trees are mixed.
Medium forest	M2	Upper trees and crown density are the same as in A2, but the crown itself is smaller than in the tall forest.
	M3	Upper trees and crown density are the same as in A3, but the crown itself is smaller than in the tall forest.
Low forest	B1	Tree heights less than 15 m.
	B2	Tree heights mostly less than 15 m, but with a few taller trees.
Exploited forest	E	Tall and medium forests which are being exploited at present.

Table-II-3. Criteria for photo-interpretation.

iii) Photo-interpretation

The aerial photos (scale 1:20,000) were interpreted by stereoscope, stratified and were directly drawn with boundary lines. The number of aerial photos is 1,761 and these photos cover about 800,000 hectares. (see appendix-2)

iv) The minimum unit of the photo-stratum

The minimum unit of the photo-stratum was taken as four hectares, for the same reason as the criteria for forest land II-1-i.

v) Mensuration of the photo-stratum area

The results of the photo-interpretation were transdrawn on

photo-mosaics (scale 1:20,000). One sheet of the photo-mosaic was divided by both latitude and longitude into 7 minutes 30 second divisions. (see figure-II-2) We then measured photo-stratum areas with a dot-transparent plate on small scale (1:125,000) of photo-mosaics over all of the photo-strata. The results of the mensuration are approximately as follows;

Category	Symbol	Hectares	Ratio to the study area	Ratio to the forest land
Tall forest	A1	28,789	3.7%	7.0%
	A2	118,542	15.2	28.9
	A3	14,464	1.9	3.5
Mixed forest	M	68,449	8.8	16.7
Medium forest	M2	99,712	12.8	24.3
	M3	17,972	2.3	4.4
Low forest	B1	11,668	1.5	2.8
	B2	34,078	4.4	8.3
Exploited forest	E	15,911	2.0	3.9
Total forest		409,585	52.4	100.0
Non forest		371,366	47.6	—
Total		781,319	100.0	

Table-II-4 . Area (hectare) of preliminary photo-strata on small photo-mosaics (1:125,000).

II-2 Sample plot

It is necessary to estimate the mean and standard deviation (or variance) for each photo-stratum so that the number of sample plots necessary for this investigation can be calculated. Fortunately, we have the FAO report and the results of preliminary sample plots, and consequently we can predict the mean and the

standard deviation from this information. In addition, the ratio (or weight) to the total forest land mentioned in I-1 can be used to allocate the total number of sample plots with each photo-stratum by "OPTIMUM ALLOCATION". Finally, these sample plots will be concretely located.

i) Calculation of the number of sample plots

i)-1 Estimation of mean and standard deviation

In 1974, the FAO prepared the Forest Inventory of the southeastern region with the mean and the standard deviation of volume at each stratum as in the following table-II-5.

Category	Volume per hectare	
	Mean	Standard deviation
Tall forest	$30m^3$	$30m^3$
Mixed forest	15	20
Regeneration of tall forest	10	15
Low forest	2	3

Table-II-5. Mean and standard deviation used by the FAO.

Table-II-5 shows the mean and the standard deviation of volume per hectare at over 42 cm D.B.H. (Diameter of Breast Height). However, these strata do not correspond to the strata of table-II-3 which we interpreted with the 1:20,000 scale aerial photos mentioned before, but we can regard the tall forest, the mixed forest, the regeneration of tall forest, and low forest on table-II-5 used by the FAO as approximately corresponding to the tall and medium forests(A1, A2, A3, M2, M3), the mixed forest (M), the low forest (B1, B2), and a part of the low forest (B1) in table-II-5. (see table-II-6)

Category of the FAO	Category of photo-interpretation
Tall forest	Tall forest and Medium forest (A1, A2, A3, M2, M3)
Mixed forest	Mixed forest (M)
Regeneration of tall forest	Low forest (B1, B2)
Low forest	a part of Low forest (B1)

Table-II-6. Comparison of the strata from the FAO and from photo-interpretation.

Meanwhile, we investigated preliminary sample plots last year (1980), with the following results;

Category	Number of sample plots	Volume of D.B.H. over 42cm	
		Mean	Standard deviation
Tall forest A2	10 (plot)	68 (m^3)	18 (m^3)
Medium forest M2	2	26	3

Table-II-7. Mean and standard deviation of volume investigated in 1980.

Consequently, we expect that the mean of volume at each stratum will be higher than in the FAO report, and the deviation will be lower, because this study area can be expected to be less exploited than the southeast area of the FAO and in addition, more strata have a lower standard deviation in principle. Therefore, we can estimate the mean and the standard deviation as follows;

Category	Symbol	Volume of D.B.H. over 41 cm	
		Mean	Standard deviation
Tall forest	A1	30 (m^3)	25 (m^3)
	A2	70	35
	A3	90	30
Mixed forest	M	15	10
Medium forest	M2	30	20
	M3	40	30
Low forest	B1	2	2
	B2	5	5
Exploited forest	E	30	30

Table-II-8. Mean and standard deviation is estimated for all of the photo-strata for this investigation.

i)-2 Allocation of sample plots

As considering the estimated mean and standard deviation, addition to weight of photo-strata, we decided the number of sample plots for all of the photo-strata as follows;

Stratum	A1	A2	A3	M	M2	M3	B1	B2	E	Total
Number of sample plots	3	10	3	3	5	2	2	2	2	32

Table-II-9. The allocation of sample plots for all of the photo-strata.

ii) Selection of sample plots

In this case, the samples were localized units to prevent local differences and were chosen at random.

In addition, the topographic map (scale 1:50,000) were divided by both latitude and longitude into 15 minute divisions. Also, the topographic map is divided into four equal sections

corresponding with the photo-mosaics. Therefore, we decided that the localized unit for the sampling can correspond to one photo-mosaic. (see figure-II-2.)

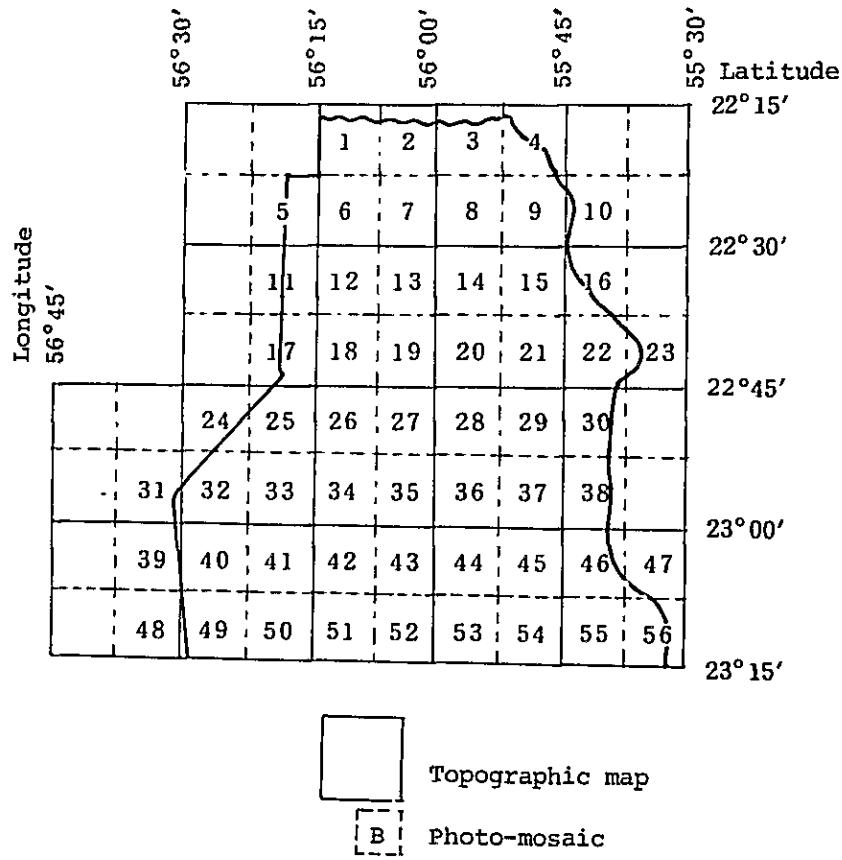
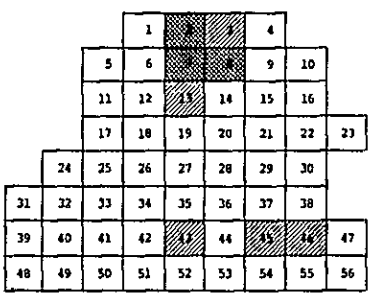


Figure-II-2. The study area and relationship between the topographic maps and the photo-mosaics.

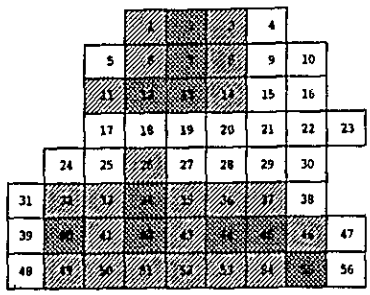
However, only units (or mosaics), having over 1,000 hectares in each photo-stratum, can be considered suitable for sampling. The sample units chosen at random are shown in figure-II-3 and table-II-10.

Symbol of photo-stratum	Number of units as an object for random sampling	Total	Number of sample units chosen at random Total	
A1	2,3,7,8,13,43,45,46	8	3	2,7,8
A2	1,2,3,6,7,8,11,12,13,14,26, 32,33,34,35,36,37,40,41,42, 43,44,45,46,49,50,51,52,53, 54,55	31	10	2,7,12,13,34,40,42, 44,45,55
A3	6,7,13,14,44	5	3	7,13,44
M	2,6,11,12,13,14,18,19,20, 21,22,25,26,27,28,29,30,33 34,35,36,37,38,40,41,42,43 44,45,46,49,50,51,52,53,54 55	37	3	13,18,21
M2	1,6,12,14,18,19,20,21,25 26,27,28,29,30,32,33,34,35 36,37,44,45,49,50,51,52,53, 54,55	29	5	18,19,20,26,36
M3	12,18,25,26,51	5	2	25,26
B1	27,28,35	3	2	27,28
B2	1,5,6,13,19,34,37,41,42,50, 51	11	2	5,34
E	7,27	2	2	7,27

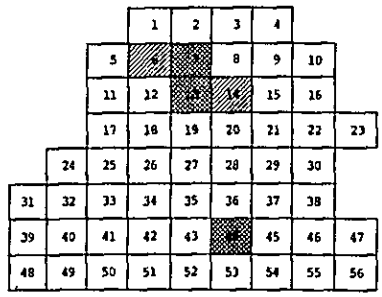
Table-II-10. Number of units as an object and sample units chosen at random.



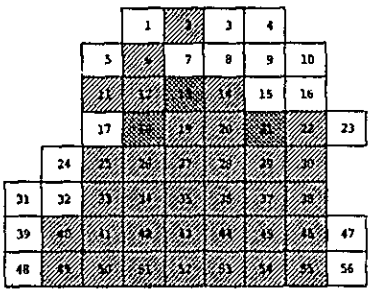
Tall forest A1



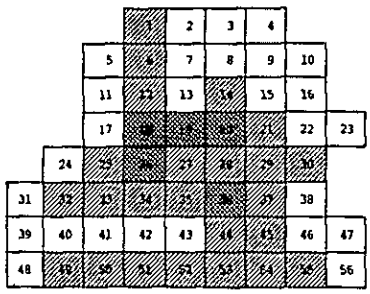
Tall forest A2



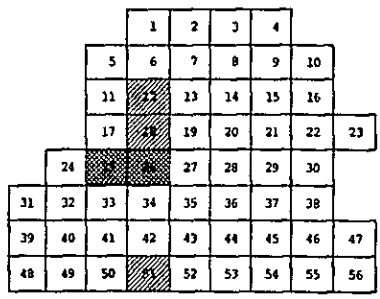
Tall forest A3



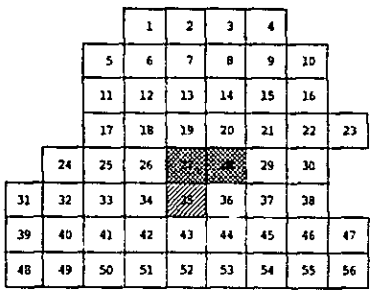
Mixed forest M



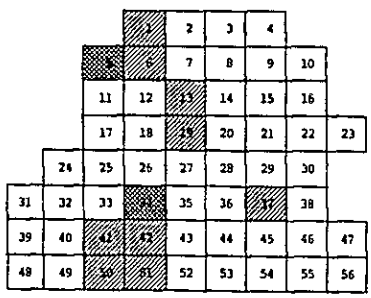
Medium forest M2



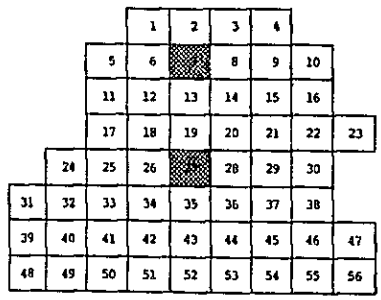
Medium forest M3



Low forest B1



Low forest B2



Exploited forest E

Units having in over 1,000 hectares in each photo-stratum as an object

Sample units chosen at random, consequently

Figure-II-3. Comparison of objects and sample units.

II-3 Preparation process

The first step in the preparation process for the field survey is photo-interpretation of an available access-road to or approaching the sample plot, because the access-roads selected for the sample plots have most influence on the quantity of our field survey. Therefore, the result of the photo-interpretation for the access-roads is transdrawn into the topographic maps and must be examined in detail.

Second, it is necessary to select the base camp site. This is done through phot-interpretation to have the required flat terrain close to a river and safety, and in considering the distance from the sample plots. In addition, available transportation of food, instruments, and labor etc. and ease of communication must be judged from other information.

Finally, we calculated the distance to the sample plots and estimated the period of our field survey from the data of last year's preliminary field survey.

III. FIELD SURVEY

We have done the field survey in a forest which is almost a jungle. We needed to cut shrubs to arrive at the sample plot sites and to clear shrubs in the sample plots to measure trees. In addition there are many insects (mosquitoes, gnats, flies and so on). It was sometimes very bothersome and difficult to work there. However, we were able to do work smoothly because of the discipline of the labor and the helpful suggestions of our Paraguayan counterparts.

The mensuration of trees includes (1) D.B.H., (2) Commercial height, (3) total height of the tree, (4) diameter at 5 m length of commercial logs, and (5) diameter at the commercial height. All of the mensurations were done by our Paraguayan counterparts who were thoroughly trained.

III-1 Methodology

i) Making the sample plots

The size of a sample plot is one hectare which is divided into ten sub-plots. The direction of the sample plot depends on a pin-point site, that is, we photo-interpret distinct points, for example, a big or unique tree, a river bank or road, a corner of a crop-field, or construction. Next, we make sure of them in the field and pin-point more than two of them on the aerial photo and measure the magnetic azimuth angle with a compass.

By the way, we mentioned that the number and the location of all of the photo-strata were decided in II. However, the location of the photo-strata only limits a sample unit (or a photo-mosaic). Therefore, we need to select one of the same photo-strata on the sample unit, which was decided in II, closest to the pin-point. Then we calculate the magnetic azimuth angle from the pin-point to the center of the photo-stratum. We then decided that the sample plots must be more than 200 m from the boundary line of the forest type (or photo-stratum), because the photo-stratum near the boundary line may not perfectly correspond to the photo-stratum itself, but this is not an ecological reason. (see figure-III-1.)

ii) Mensuration

We observe and measure trees as follows;

(1) Identifying species
(2) D.B.H.
(3) Commercial height
(4) Total height of the tree
(5) Diameter at 5 meters length of the commercial log
(6) Diameter at the commercial height
(7) Observation of irregularities

The D.B.H. (2) means Diameter of Breast Height which is about 1.3 meters, and is measured by a diameter tape. However, with the D.B.H., there are sometimes some irregular situations,

for example, a forked tree, a knobby tree, or a buttress tree at the breast height. In these cases, we measure lower or higher than the breast height. (see appendix-3 in detail.)

The commercial height (3) means that part of the stem that is almost a straight log. The total height of the tree (4) is the height from the ground to the top of the crown. The commercial height and the total height of the tree are measured by eye.

The diameter at 5 meters length of the commercial log (5) is measured with a 5 meters pole by a "Penta Prism", and the diameter at the commercial height (6) is also measured by the "Penta Prism". The "Penta Prism" can be measured without level distance because of parallel view.

The observation of irregularities (7) means that we observe and note what problems if any, the tree has as commercial timber. (see table-III-1.) A sample from for noting these is shown in appendix-4.

Item	Situation
curvado	curved
descorchado	peeled off
hueco	hollow
inclinado	inclined
podrido	decayed
roto	broken
seco	dead
semi seco	semi dead
sin copa	without crown
sin gajo	without branches
sin hoja	without leaves

Table-III-1. Items of irregular trees.

III-2 Division of labor

We divided the work of the field survey among ourselves into (1) pin-pointing, (2) Measurement of compass, and (3) Mensuration.

The "Pin-point" team made sure of the access-road to the sample point and pinpoints it on the aerial photo, and measures the magnetic azimuth angles with a compass and calculates the distance to the sample plot on the aerial photo.

Consequently, the pin-pointing work sometimes required two days for one sample plot, because the forest itself including the sample plot sometimes disappeared because of logging or pasture. In addition, the access-road was sometimes too narrow or too difficult for vehicles to pass, and sometimes had already disappeared through disuse. Conversely, we could do two sample plots per day in some case where the plots were close or where these had been no changes between the time of the aerial photography and the period of the field survey.

The "measurement of compass" team begins to work from the pin-point where the "pin-point" team already located and measured the direction of the sample plots. This team requires 7 to 10 persons. That is, a compass-man set the direction with the compass and suggests a pole-man who set up a pole on the direction and measures the distance, while 3 cutting labors cut shrubs on the main line of the sample plot and 2 cut on the width-line. This team could do one sample plot per day.

The "mensuration" team measures trees in the sample plot where the "measurement of compass" team has already been. This team includes a recording man, two measuring men, and two or three clearance men. This team could also do one sample plot per day.

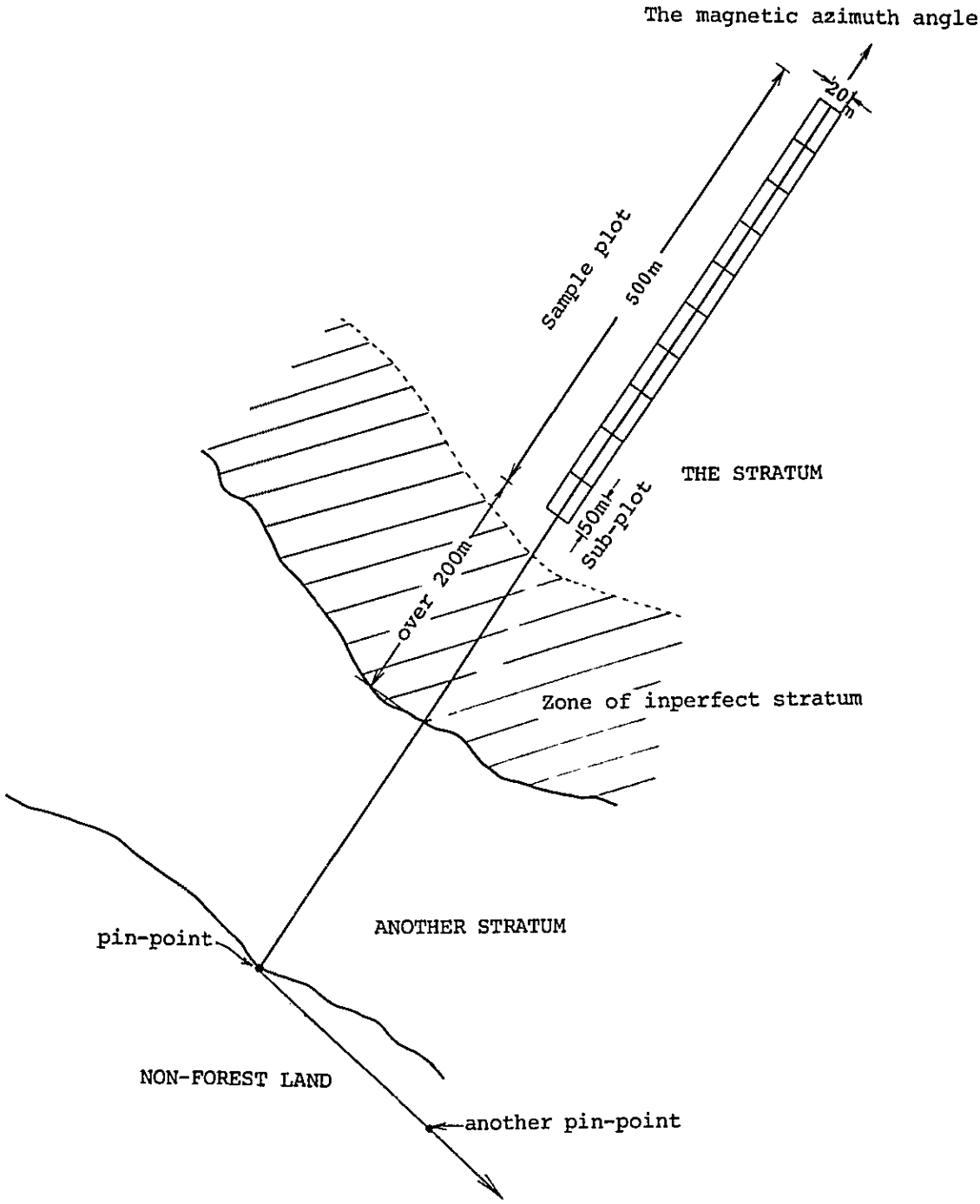


Figure-III-1. Sample plot and the plot site.

IV. RESULTS OF SAMPLE PLOTS

We have done surveys in the field for 32 sample plots, as in table-II-9, and the location corresponded with figure-II-3. The mensuration has been done for all of trees with a D.B.H. of over 10 cm in a sample plot (1 ha) according to the items decided in III-1-ii, beside, we could identify almost all the names of trees.

The data of the sample plots will be examined as to how they differ from or correspond to the criteria for photo-interpretation in table-II-3, and will be best used for a "re-photo-interpretation" which will be corrected if necessary.

In addition, we believe that the data will serve as sources of information not only to consider the ecology according to the results of the statistical method, but also to plan the next work in the total study area (1,500,000 ha) in 1982.

To discuss the commercial value, we adopted a classification of utility by species which the FAO decided in 1974. It is shown as follows;

Class A; has an actual value in both national and international markets.

Class B; has an actual value in both national and international markets, but the utility and the price are less than the class A.

Class C; probably has a value on the international market and has an increased value on the national market.

Class D; does not have commercial value at present, but probably will have in the future.

Class E; does not have commercial value and has little chance of having any.

IV-1 Location of sample plots

The location of the sample plots is shown in figure-IV-1 and the code number of the sample plots belong to the photo-strata as in the following table-IV-1.

Photo-stratum	Symbol	Number of sample plots	Code number of sample plot
Tall forest	A1	3	2,5,8
	A2	10	1,7,9,11,24,27,28,29,30,31
	A3	3	4,10,32
Mixed forest	M	3	12,13,17
Medium forest	M2	5	14,15,16,20,26
	M3	2	18,19
Low forest	B1	2	21,23
	B2	2	2,25
Exploited forest	E	2	6,22

Table-IV-1. Comparison of the photo-strata and the code number of the sample plots.

IV-2 Profile

We have observed the profile in the photo-strata, and could obtain satisfactory results when corresponding the profile of photo-strata with the photo-interpretation.

However, most of the photo-strata except the tall forest A3 and the low forest B1 were exploited more than we expected, and this might have an influence of intergrating the general profile and it may be difficult to analyze the data.

Tall forest A1

The upper trees are more than 15 m height and the density is less than 20 percent corresponding with the criteria for photo-interpretation. In other words, the forest had already been exploited and there were many shrubs left after the exploitation.

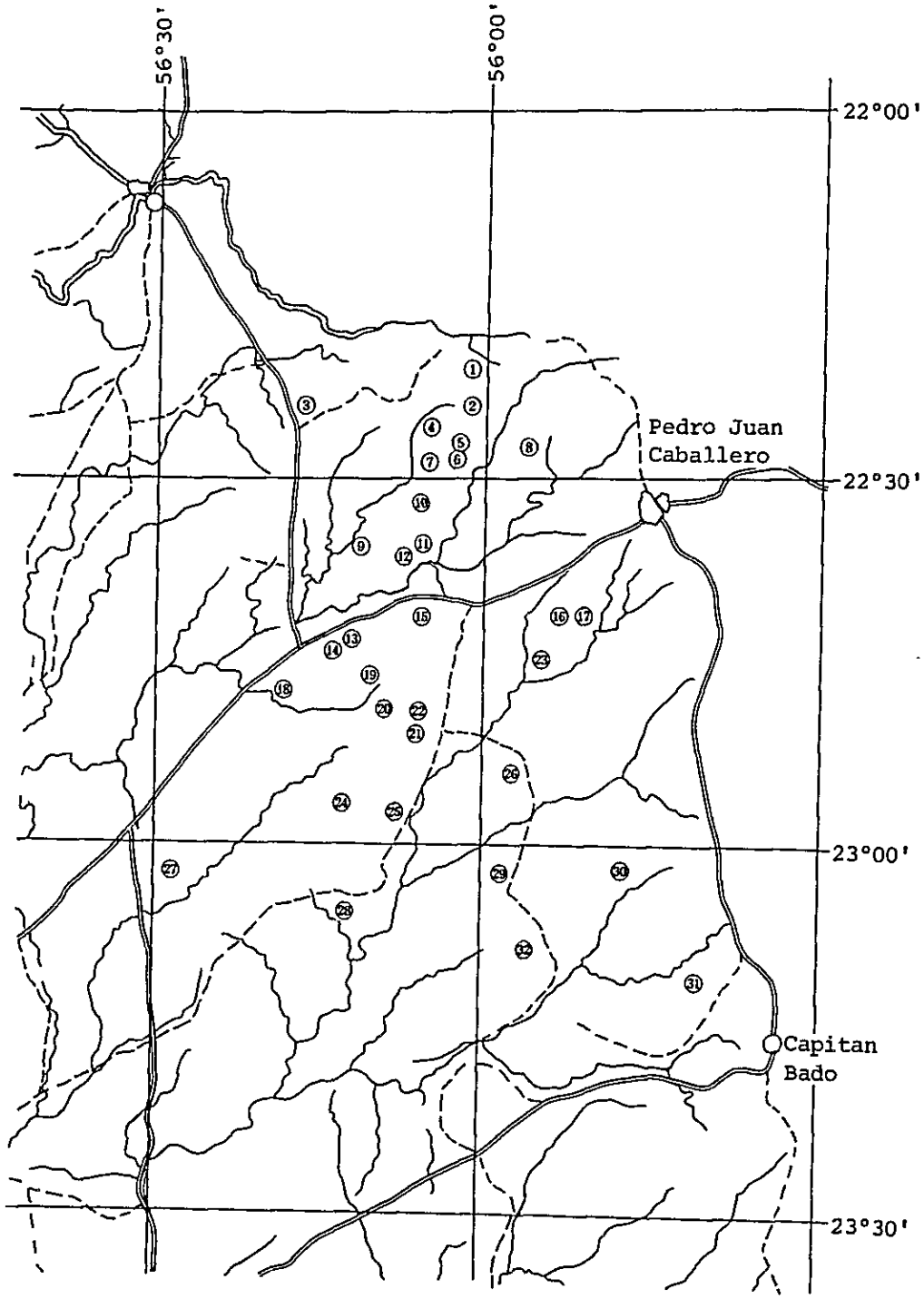


Figure-IV-1. Location of sample plots.

Tall forest A2

The upper trees are mostly 15 m to 20 m and the density is more than for A1. There is sometimes excessive exploitation, but the situation fluctuates depending on the local divisions.

Tall forest A3

This is mostly unexploited because of difficult access. The forest is mostly composed of big Peroba, but, in the case of exploitation, there are many other species, for example, Cancharana, Kupa y, and Ysy.

Mixed forest M and low forest B2

The mixed forests M are mainly located close to rivers, and the profile types are a mixture of upper and lower trees. Meanwhile, the low forest B2 is similar to the mixed forest, but the upper trees sometimes are of good quality.

Medium forest M2

This is similar to A2, but the crown is smaller, This is also mostly exploited.

Medium forest M3

This is more density of crown than for M2, because the crown itself is larger than for M2. However, the volume of trees can be expected to be the same value as for M2.

Low forest B1

This is completely comprised of low trees, and never exploited.

Exploited forest E

This has being exploited in the tall and medium forest, but is sometimes similar to A1 through post-exploitation. (see figure-IV-2.)

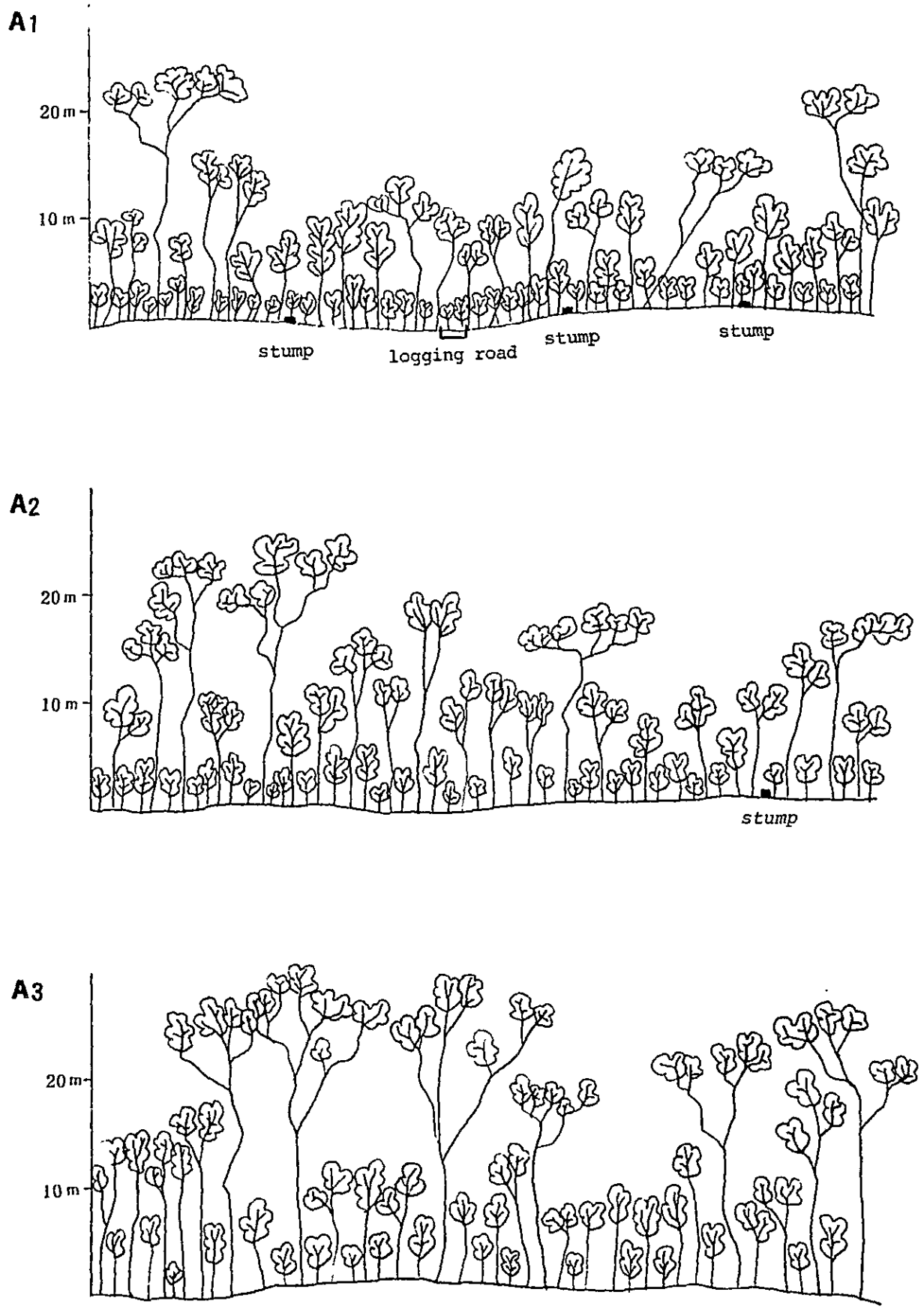
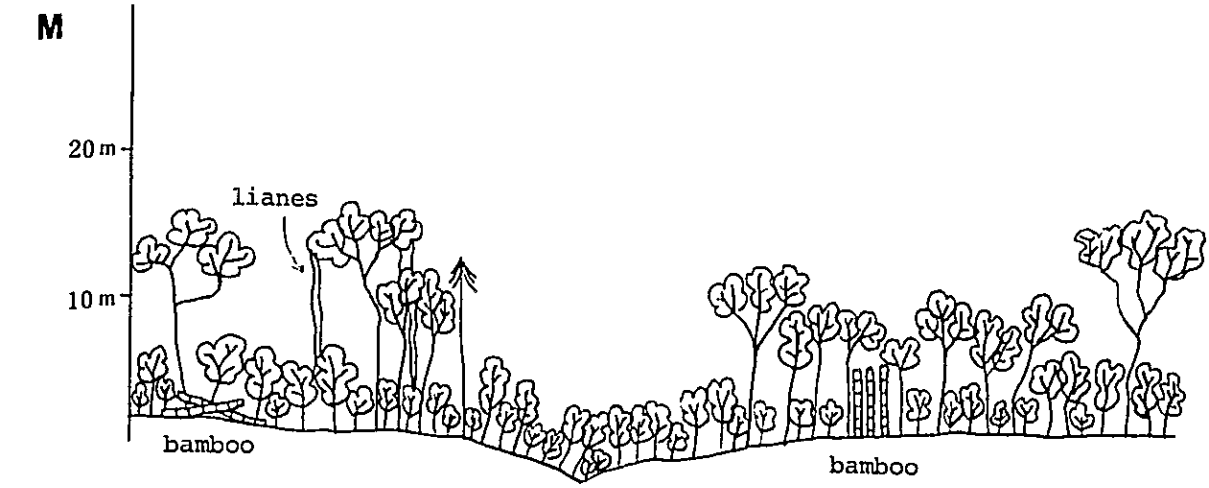
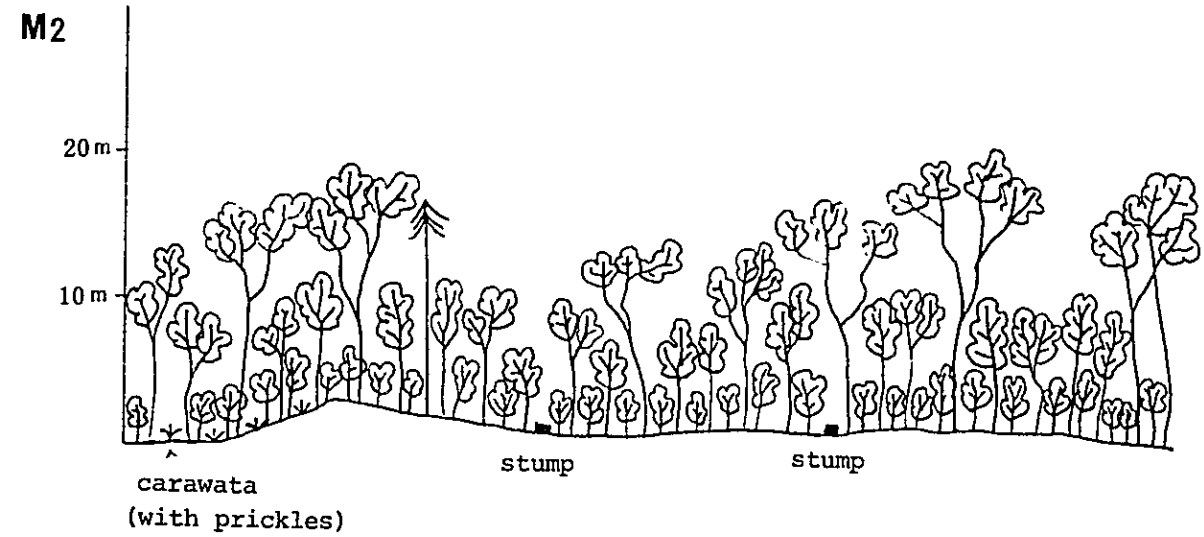
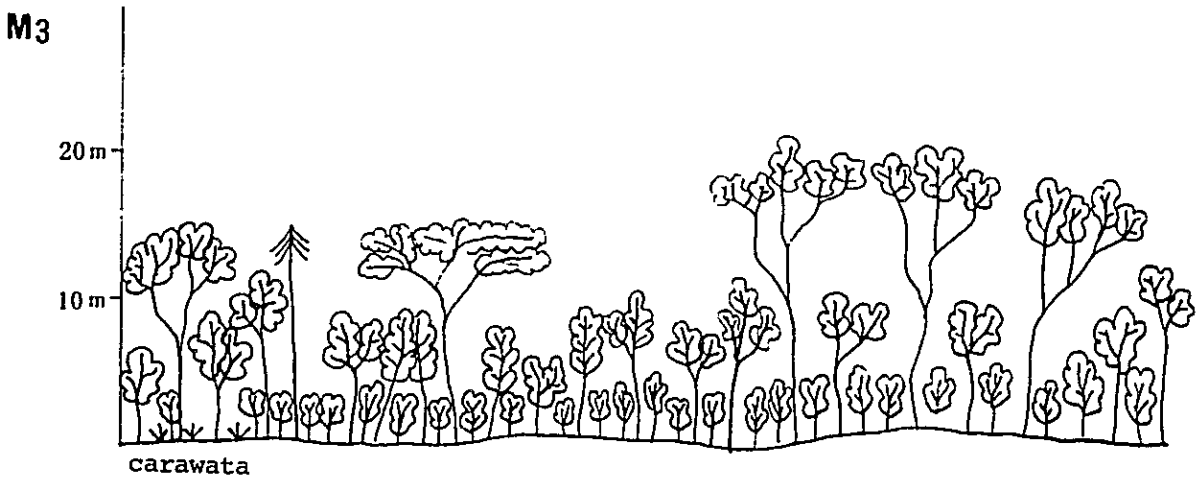
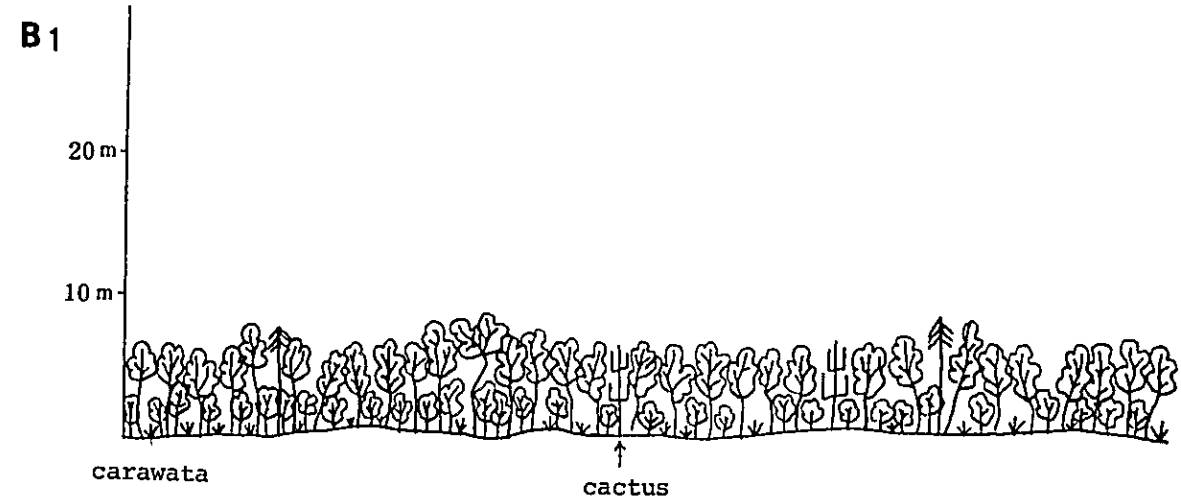


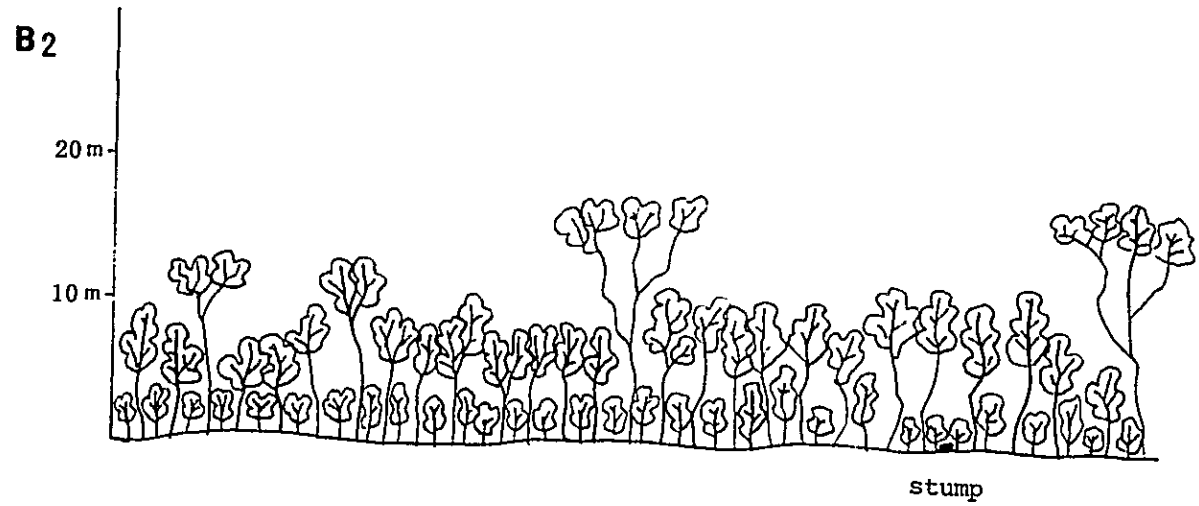
Figure-IV-2. Profile of photo-strata.

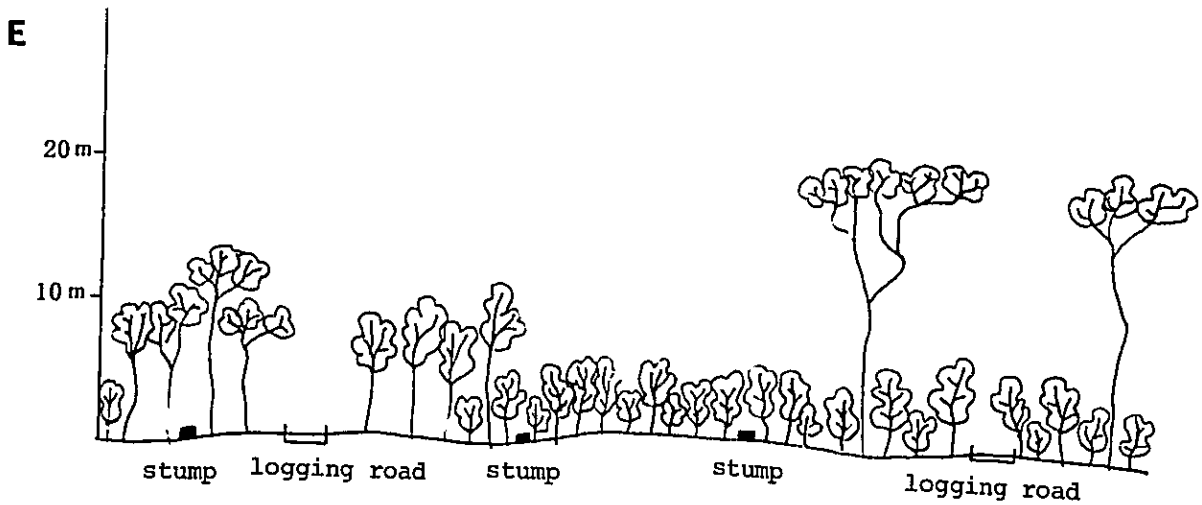

M
20 m
10 m
lianes
bamboo
bamboo


M2
20 m
10 m
carawata
(with prickles)
stump
stump


M3
20 m
10 m
carawata


B1
20 m
10 m
carawata
cactus


B2
20 m
10 m
stump


E
20 m
10 m
stump
logging road
stump
stump
logging road

IV-3 Number of trees

The number of trees with a D.B.H. over 10 cm in the 32 sample plots is 11,000, and the number of trees with a D.B.H. over 41 cm is 826 trees. In addition, the number of species in the study area is 114. Among them, 9 species are of Class A utility, and Classes B,C,D, and E have, respectively, 10,20, 35, and 40 species. (see appendix-5.)

i) Number of trees by species

The number of trees per hectare by species are shown in appendix-6. The most frequent species among all of the sample plots are shown in table-IV-2. In short, they are different species with diameters from over 10 cm to 41 cm, except Peroba. This may mean that species listed as D.B.H. over 10 cm can not grow to be big trees because of not being listed as D.B.H. over 41 cm. Another feature is that the Peroba is the most predominant species in the study area. Thus the Peroba occupies a higher ratio for both D.B.H. over 10 cm and 41 cm.

On the species mentioned, Peroba, Yvyrapiu and Marinero have many trees, both for D.B.H. over 10 cm and 41 cm. This means that these species can grow to be big trees. Meanwhile, the species of Yva poroity, Ñangapiry, Pakuri, Pindo, Laurel, Katigva, and Ysy can not grow bigger.

D.B.H. over 10 cm					
Local name	Family	Genus	Utility	No.of trees	%
1. Yvá poroitý	Myrtaceae	Myrciaria	D	1,102	10.0
2. Peroba	Apocynaceae	Aspidosperma	B	740	6.7
3. Ñangapirý	Myrtaceae	Eugenia	E	678	6.2
4. Yvyrá piú	Sapindaceae	Diatenopteryx	D	563	5.1
5. Pakurí	Guttiferae	Rhoedia	D	521	4.7
6. Pindó	Palmaceae	Arecastrom	E	501	4.6
7. Laurel	Lauraceae	Nectandra	C	486	4.4
8. Katiguá	Meliaceae	Trichilia	E	315	2.9
9. Ysý	Nyctaginaceae	Reichembachia	D	266	2.4
10. Marinero	Meliaceae	Guarea	D	258	2.3
Total				5,430	49.3

D.B.H. over 41 cm					
Local name	Family	Genus	Utility	No.of trees	%
1. Peroba	Apocynaceae	Aspidosperma	B	167	20.2
2. Yvyrá pytá	Leguminosae	Peltophorum	B	50	6.1
3. Guajayví	Boraginaceae	Patagonula	C	46	5.6
4. Kupa ý	Leguminosae	Copaifera	C	45	5.4
5. Samu hú	Bombacaceae	Chorisia	E	39	4.7
6. Yvyrá piú	Sapindaceae	Diatenopteryx	D	38	4.6
7. Kurupaý rá	Leguminosae	Piptadenia regida	B	33	4.0
8. Kurupay	Leguminosae	Piptadenia	A	32	3.9
9. Marinero	Meliaceae	Guarea	D	26	3.1
10. Cancharana	Meliaceae	Cabralea	B	21	2.5
Total				497	60.1

Table-IV-2. List of main species having many trees with a D.B.H. over 10cm and 41 cm.

ii) Number of trees by photo-strata

The number of trees according to sample plots, photo-strata, diameter class, and the class of utility are shown in appendix-7.

The number of trees for both D.B.H. over 10 cm and 41 cm by the photo-strata is shown in table-IV-3 and figure-IV-3. In table-IV-3, the low forests B1 and B2 have the most number of trees per hectare, and the next is the tall forest A3. However, for D.B.H. over 41 cm, the highest number is in the tall forest A3, and then, M2, A2, M3, A1, E, B2, M, and B1, in that order. This generally corresponds with the criteria for photo-interpretation (table-II-3) except for M3 and B2, because we interpreted the aerial photos according to the crown density of upper trees.

Photo-strata	A1	A2	A3	M	M2	M3	B1	B2	E	Total
D.B.H. 10 – 40cm	268	278	351	312	346	310	427	375	321	318
D.B.H. over 41cm	27	29	39	10	34	27	2	21	22	26
D.B.H. over 10cm	295	307	390	322	380	337	429	396	343	344
Ratio of D.B.H. over 41cm	9.2	10.6	10.0	3.1	8.9	8.0	0.5	5.3	6.4	7.6%

Table-IV-3. Number of trees per hectare by phot-strata.

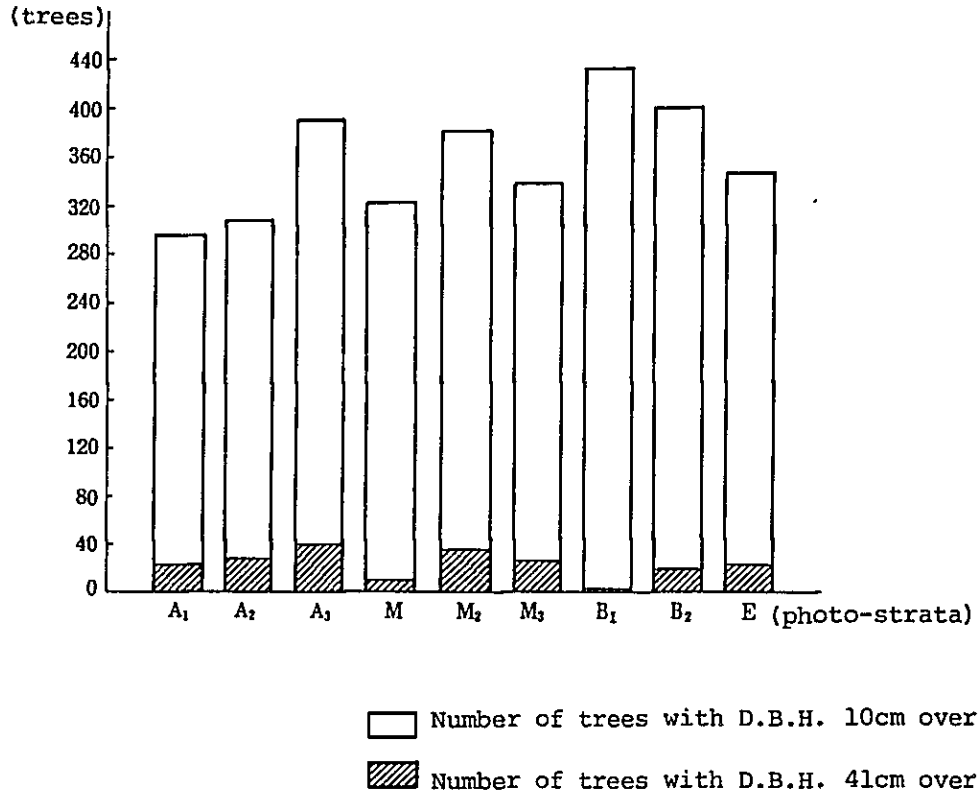


Figure-IV-3. Number of trees per hectare, by photo-strata.

By species

Table-IV-4 shows the main species of D.B.H.over 10 cm and 41 cm by photo-strata. One feature of the study area is that Peroba is distributed over all of the photo-strata except the low forests B1 and B2. Especially, for D.B.H. over 41 cm, it exists in a high percentage everywhere except for the low forest B1.

In the tall forests A2 and A3, Peroba occupies more than 10 percent of the total number of trees, but the tall forest A1 has only 5.3 percent Peroba. In addition, for D.B.H. over 41 cm, Peroba occupies more than 25 percent of the tall forests A2 and A3, but for A1 it's only 5 percent. Therefore, Peroba in the tall forest A1 might have been extracted before.

As for other species, there are many kinds of species among the tall forests A1, A2 and A3 mentioned below in detail in table-IV-5, but the main species of them are situated in the higher classes of utility. And in the mixed forest M, there are comparatively more in the middle classes of utility, but for D.B.H. over 41 cm, the high and low classes of utility are a mixture (for example, Yvra pyta, Samu hu). In the medium forests M2 and M3, there are more in the lower classes of utility than for the tall forests A1, A2 and A3 (for example, Pindo), but for D.B.H. over 41 cm, there are higher classes of utility (for example, Guatumbu). In the low forests B1 and B2, their composition is clearly a different forest, because B1 is mainly occupied by Ñangapiry (39 percent), and B2 by Yva poroity (14.3 percent) etc.

A 1

D.B.H over 10 cm					D.B.H. over 41 cm				
	Species	Utility	No. of trees	%		Species	Utility	No. of trees	%
1	Yvyrá piú	D	26 3	8.9	1	Urunde y pará	C	3.3	12.7
2	Katiguá	E	16 7	5 7	2	Palo blanco	D	3.0	11.5
3	Peroba	B	15.7	5.3	3	Guajayví	C	1.7	6 5
4	Yvá poroitý	D	14 0	4.7	4	Yvyrá piú	D	1.7	6 5
5	Laurel	C	12.3	4.2	5	Ombú	E	1.7	6.5
6	Yvyrá pytá	B	12 0	4 1	6	Yvyrá pytá	B	1.3	5.0
7	Sangre de dragón	E	10 7	3 6	7	Peroba	B	1.3	5 0
8	Aguaí	D	9.7	3.3	8	Guatambú	A	1.0	3.8
9	Ombú	E	8.7	2.9	9	Laurel	C	1.0	3 8
10	Urunde y pará	C	8.3	2.8	10	Manduvirá	C	1.0	3.8
Total			134 4	45 5	Total			17.0	65.1

A 2

D.B.H over 10 cm					D.B.H. over 41 cm				
	Species	Utility	No. of trees	%		Species	Utility	No. of trees	%
1	Peroba	B	34.0	11.1	1	Peroba	B	7.7	26 6
2	Pakurí	D	26 5	8 6	2	Samu hú	D	3.3	11.4
3	Yvyrá piú	D	25 1	8.2	3	Yvyrá pytá	B	2.1	7.2
4	Yvá poroitý	D	20.6	6 7	4	Kurupay	A	2.0	6 9
5	Katiguá	E	13.3	4 3	5	Guajayví	C	1.5	5 2
6	Laurel	C	11.9	3.9	6	Kurupaý rá	B	1.3	4.5
7	Ñangapiry	E	10.4	3.4	7	Kupa ý	C	1.3	4.5
8	Aguaí	D	9.0	2.9	8	Yvyrá piú	D	1.2	4.1
9	Mbavý	D	8.5	2 8	9	Ombú	E	0.6	2.1
10	Ysý	D	8 5	2.8	10	Taperyva Guasú	A	0.5	1.7
Total			167 8	54.7	Total			21.5	74.2

A 3

D.B.H over 10 cm					D.B.H. over 41 cm				
	Species	Utility	No. of trees	%		Species	Utility	No. of trees	%
1	Peroba	B	44 6	11.4	1	Peroba	B	10.3	25.8
2	Marinero	D	25 6	6 6	2	Cancharana	B	4.3	10.8
3	Laurel	C	24.0	6.2	3	Chipá rupá	C	2.3	5.8
4	Pakurí	D	23.0	5 9	4	Marinero	D	2.0	5.0
5	Yvyrá piú	D	17.7	4.5	5	Tatajyvá	B	1.7	4.3
6	Cancharana	B	17.3	4 4	6	Guajayví	C	1.7	4.3
7	Katiguá	E	16 3	4.2	7	Yvyrá piú	D	1.7	4.3
8	Ysý	D	15 7	4.0	8	Kurupaý rá	B	1.3	3.3
9	Yvá poroitý	D	14.3	3.7	9	Kupa ý	C	1.3	3.3
10	Mbavý	D	13 0	3.3	10	Cedro	A	0.7	1.8
Total			211.5	54.2	Total			27.3	68.7

Table-IV-4. List of main species for D.B.H. over 10cm and 41cm by photo-strata.

M

D.B.H over 10 cm				
	Species	Utility	No. of trees	%
1	Kupa ý	C	37.0	11.5
2	Laurel	C	32 3	10 0
3	Pindó	E	25.3	7 9
4	Yvá poroitý	D	21 7	6 7
5	Ombú	E	13.0	4 0
6	Marinero	D	12 0	3 7
7	Ysapy ý pytá	D	10 7	3 3
8	Peroba	B	9.0	2 8
9	Yvyrá ovi	C	8 7	2 7
10	Amores secos	D	7 4	2 3
Total			177 1	54 9

D.B.H. over 41 cm				
	Species	Utility	No. of trees	%
1	Kupa ý	C	3.0	31.0
2	Peroba	B	1.3	13.4
3	Yvyrá pytá	B	1.0	10 3
4	Samu hú	E	1.0	10.3
5	Tata juvá	C	0.7	7.2
6	Kurupay	A	0 3	3.1
7	Peterevý	A	0.3	3 1
8	Laurel	C	0 3	3.1
9	Manduvirá	C	0.3	3 1
10	Amores secos	D	0.3	3 1
Total			8 5	87.7

M 2

D.B.H over 10 cm				
	Species	Utility	No. of trees	%
1	Yvá poroitý	D	54 4	14 3
2	Pakurí	D	24.8	6 5
3	Peroba	B	24.6	6 5
4	Yvyrá piú	D	21.2	5 6
5	Pindó	E	20.8	5 5
6	Ñangapirý	E	18 6	4 9
7	Ysý	D	12 4	3.3
8	Mborevi ka á	E	12 2	3.2
9	Ombú	E	8.4	2 2
10	Pynó guasú	E	8.2	2 2
Total			205.6	54.2

D.B.H. over 41 cm				
	Species	Utility	No. of trees	%
1	Peroba	B	6 6	19.1
2	Guajayví	C	2.8	8.1
3	Yvyrá piú	D	2.2	6 4
4	Kurupaý rá	B	2.0	5.8
5	Yvyrá pytá	B	2 0	5.8
6	Marinero	D	1.8	5 2
7	Kupa ý	C	1.6	4 6
8	Guatambú	A	1.4	4.0
9	Chipá rupá	C	1.0	2.9
10	Kurupay	A	0.8	2 3
Total			22.2	64.2

M 3

D.B.H over 10 cm				
	Species	Utility	No. of trees	%
1	Pindó	E	43.0	12 8
2	Ysý	D	21.0	6 2
3	Marinero	D	19.0	5 6
4	Pakurí	D	19.0	5.6
5	Mbavý	D	18.5	5 5
6	Aguaí	D	13.5	4 0
7	Yvyrá piú	D	12 5	3 7
8	Yvá poroitý	D	12 0	3 6
9	Laurel	C	11.5	3 4
10	Peroba	B	11 0	3.3
Total			181 0	53.7

D.B.H. over 41 cm				
	Species	Utility	No. of trees	%
1	Peroba	B	4.5	17.6
2	Yvyrá pytá	D	2.5	9.8
3	Ombú	E	2.0	7.8
4	Kurupaý rá	B	1.5	5.9
5	Laurel	C	1.5	5.9
6	Palo blanco	D	1.5	5.9
7	Yvyrá katú	D	1.5	5 9
8	Guatambú	A	1.0	3.9
9	Kurupay	A	1.0	3.9
10	Cancharana	B	1.0	3.9
Total			18 0	70.5

B 1

D.B.H over 10 cm				
	Species	Utility	No. of trees	%
1	Ñangapirý	E	167.5	39 0
2	Pindó	D	84.5	19.7
3	Tataré	E	32.0	7.5
4	Yvyrá ovi	C	29.0	6 8
5	Laurel	C	27.5	6 4
6	Laurel canela	C	15.5	3.6
7	Yvá poroitý	D	10.0	2 3
8	Ka á	E	10.0	2.3
9	Kurupay	A	5.5	1.3
10	Cancharana	B	5.5	1.3
Total			387.0	90.2

D.B.H. over 41 cm				
	Species	Utility	No. of trees	%
1	Tataré	E	1.5	75.0
2	Kupa ý	C	0.5	25.0
3				
4				
5				
6				
7				
8				
9				
10				
Total			2.0	100.0

B 2

D.B.H over 10 cm				
	Species	Utility	No. of trees	%
1	Yvá poroitý	D	89.5	22 6
2	Mboreví ka á	E	36 5	9.2
3	Palo vino	D	26 0	6 6
4	Urunde y pará	C	25.0	6.3
5	Ñangapirý	E	23.0	5 8
6	Morosyvó	C	16 0	4.0
7	Incienso	A	15.0	3.8
8	Tataré	E	12.5	3 2
9	Para todo	E	12.5	3.2
10	Laurel	C	12 0	3 0
Total			268.0	67.7

D.B.H. over 41 cm				
	Species	Utility	No. of trees	%
1	Kupa ý	C	3 5	18.4
2	Lapacho	A	2.0	10.5
3	Peroba	B	2 0	10.5
4	Laurel	C	2.0	10.5
5	Palo vino	D	1.5	7.9
6	Kurupaý rá	B	1.0	5.3
7	Ysý	D	1.0	5.3
8	Ingá	E	1.0	5.3
9	Para todo	E	1.0	5.3
10	Cedro	A	0.5	2.6
Total			15.5	81.6

E

D.B.H over 10 cm				
	Species	Utility	No. of trees	%
1	Yvá poroitý	D	125.5	36 6
2	Yvyrá piú	D	20.0	5.8
3	Peroba	B	17.0	5.0
4	Yvyrá pepé	C	14.0	4.1
5	Ñangapirý	E	12.5	3.6
6	Mbavý	D	11.5	3 4
7	Guajayví	C	10.5	3.1
8	Laurel	C	10.0	2.9
9	Aguaí	D	8.0	2.3
10	Katiguá	E	6 5	1.9
Total			235.5	68.7

D.B.H. over 41 cm				
	Species	Utility	No. of trees	%
1	Guajayví	C	3.5	16.3
2	Peroba	B	2.5	11.6
3	Kurupay	A	1.5	7.0
4	Yvyrá pytá	B	1.5	7.0
5	Kupa ý	C	1.5	7.0
6	Yvyrá pepé	C	1.5	7.0
7	Yvá poroitý	D	1.5	7.0
8	Guatambú	A	1.0	4.7
9	Urunde y pará	C	1.0	4.7
10	Marinero	D	1.0	4.7
Total			16.5	77.0

Class of utility / Photo-stratum	A		B		C		D		E		Total		No.of samples
	No.of species	%	No. of species	%	No. of species	%	No. of species	%	No. of species	%	No. of species	%	
A1	4.0	44.4	5.3	53.0	8.7	43.5	14.7	42.0	13.7	34.3	46.3	40.6	3
A2	4.5	50.0	3.8	38.0	8.0	40.0	14.7	42.0	12.4	31.0	43.3	38.1	10
A3	5.3	58.8	5.3	53.0	9.0	45.0	17.7	50.6	13.7	34.3	50.0	43.9	3
M	3.7	41.1	3.3	33.0	6.7	33.5	10.7	30.6	10.7	26.8	35.0	30.7	3
M2	5.2	57.8	4.0	40.0	7.4	37.0	14.8	42.3	11.8	29.5	43.2	37.9	5
M3	5.0	55.6	4.0	40.0	7.0	35.0	14.5	41.4	12.5	31.3	43.0	37.7	2
B1	3.5	38.9	1.5	15.0	5.0	25.0	4.5	12.9	7.5	18.8	22.0	19.3	2
B2	5.5	61.1	3.0	30.0	8.0	40.0	9.0	25.7	12.0	30.0	37.5	32.9	2
E	5.0	55.6	4.0	40.0	7.5	37.5	14.0	40.0	11.0	27.5	41.5	36.4	2
Total	9	100	10	100	20	100	35	100	40	100	114	100	32

Table-IV-5. Number of species per hectare by photo-strata and by classes of utility.

Table-IV-5 shows number of species per hectare by photo-strata and the classes of utility. The most number of species by the photo-strata is 50.0 species per hectare in the tall forest A3. Their order is, A3 (50.0 sp./ha), A1 (46.3), A2 (43.4), M2 (43.2), M3 (43.0), E (41.5), B2 (37.5), M (35.0), and B1 (22.0). This means that the taller forest the more numerous the species. Especially, the low forest B1 is very limited in species.

By diameter class

The distribution of trees by diameter class is shown in figure-IV-4. Figure-IV-4 explains that the tall and medium forests have trees of bigger diameter classes.

By class of utility

Table-IV-6 and figure-IV-5 show that the higher classes of utility (A + B) have higher percentages in the bigger diameter classes over all of the photo-strata except for B1. This may mean that the species of higher classes of utility (A + B) can grow bigger than the lower classes.

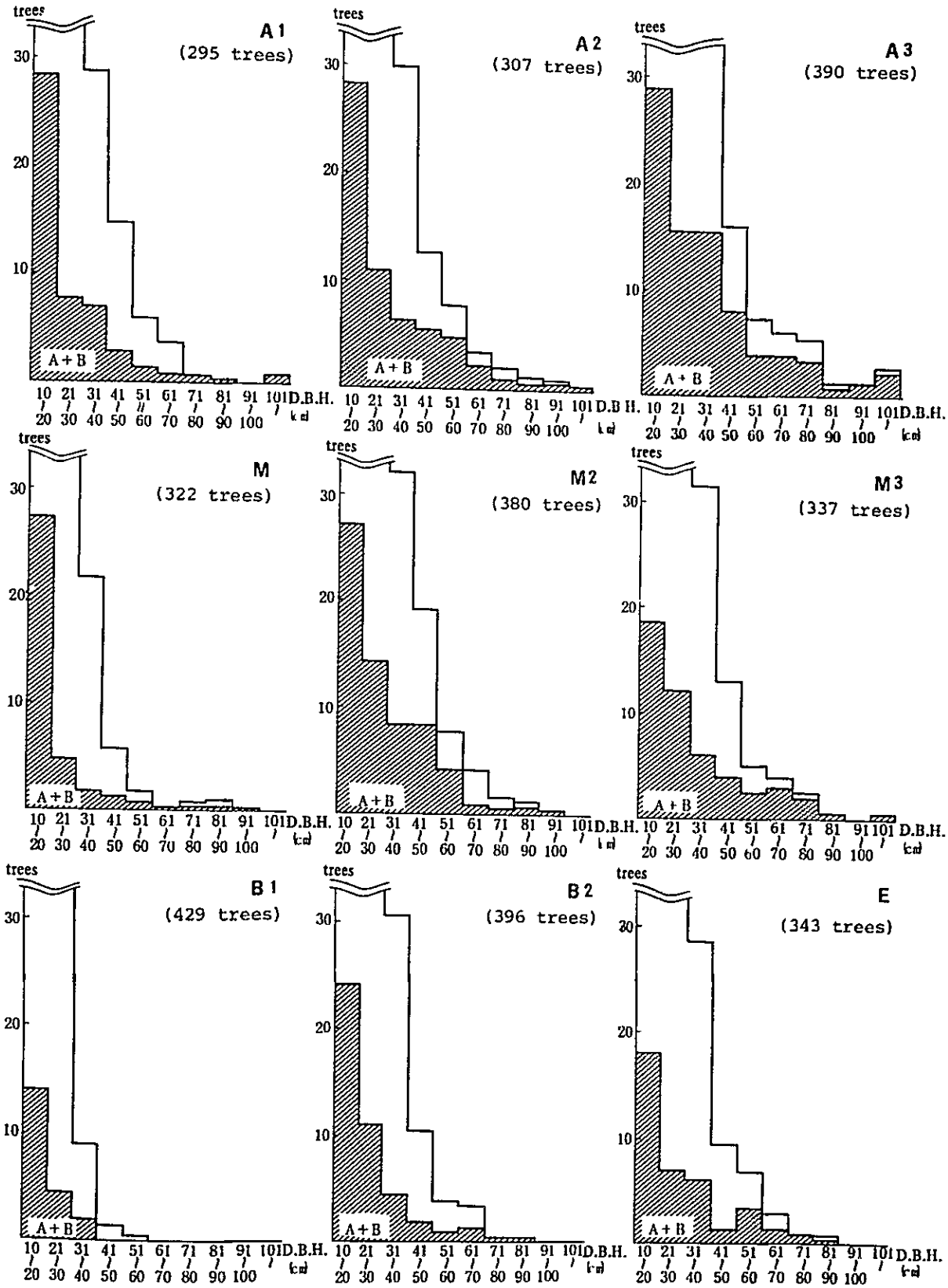


Figure-IV-4. Number of trees per hectare, by diameter class.

A 1

Utility (cm)	10～30	31～40	41～
A+B	(36) 15%	(7) 24%	(6 3) 24%
C	(35.3) 15%	(4.3) 15%	(8 3) 32%
D+E	(166 6) 69%	(17) 59%	(9) 35%
Defective	(1) 0 4%	(0.3) 1%	(2.3) 9%
Total	240. 7	28 7	26 0

A 2

Utility (cm)	10～30	31～40	41～
A+B	(39 4) 16%	(6 3) 21%	(1.5) 52%
C	(23.8) 13%	(5.6) 19%	(5) 17%
D+E	(125.2) 69%	(17.2) 57%	(8.5) 29%
Defective	(3.4) 2%	(0.9) 3%	(0.5) 2%
Total	247. 9	30. 0	29. 0

A 3

Utility (cm)	10～30	31～40	41～
A+B	(44) 14%	(15.3) 35%	(23) 58%
C	(41.7) 14%	(10.3) 24%	(7.7) 19%
D+E	(216.3) 71%	(17.3) 40%	(8 7) 21%
Defective	(4.3) 1%	(0.3) 1%	(0 7) 2%
Total	306 3	43. 3	40. 0

M

Utility (cm)	10～30	31～40	41～
A+B	(28.7) 10%	(1.3) 6%	(2.7) 28%
C	(83) 29%	(12) 55%	(4 3) 45%
D+E	(167.3) 58%	(6 7) 31%	(2) 21%
Defective	(11.3) 4%	(1.7) 8%	(0.7) 7%
Total	290. 3	21. 7	9. 7

M 2'

Utility (cm)	10～30	31～40	41～
A+B	(40.6) 13%	(8 4) 26%	(15) 43%
C	(27.8) 9%	(5.4) 17%	(7.2) 21%
D+E	(232) 74%	(17) 53%	(10.2) 29%
Defective	(13) 4%	(1) 3%	(2 2) 6%
Total	313. 4	32. 2	34. 6

M 3

Utility (cm)	10～30	31～40	41～
A+B	(30 5) 11%	(6) 19%	(12 5) 49%
C	(19) 7%	(2) 6%	(1.5) 6%
D+E	(228) 81%	(23.5) 75%	(10) 39%
Defective	(2.5) 1%	(0) 0%	(1.5) 6%
Total	280 0	31. 5	25. 5

B 1

Utility (cm)	10～30	31～40	41～
A+B	(18) 4%	(2) 22%	(0) 0%
C	(74) 18%	(4) 44%	(0.5) 25%
D+E	(319.5) 76%	(3) 33%	(1) 50%
Defective	(6.5) 2%	(0) 0%	(0.5) 25%
Total	418 0	9 0	2 0

B 2

Utility (cm)	10～30	31～40	41～
A+B	(35) 10%	(4.5) 15%	(5.5) 29%
C	(59.5) 17%	(7) 23%	(5.5) 29%
D+E	(24) 72%	(19) 62%	(7) 37%
Defective	(3) 1%	(0) 0%	(1) 5%
Total	346 5	30. 5	19. 0

E

Utility (cm)	10～30	31～40	41～
A+B	(25) 9%	(6) 21%	(8) 37%
C	(40) 14%	(9) 32%	(7) 33%
D+E	(225.5) 77%	(12) 42%	(4) 19%
Defective	(2.5) 1%	(1.5) 5%	(2.5) 12%
Total	293 0	28 5	21. 5

*Parentheses "( )" mean number of trees per hectare.

Table-IV-6. Percentages of number of trees per diameter class by photo-strata and by class of utility.

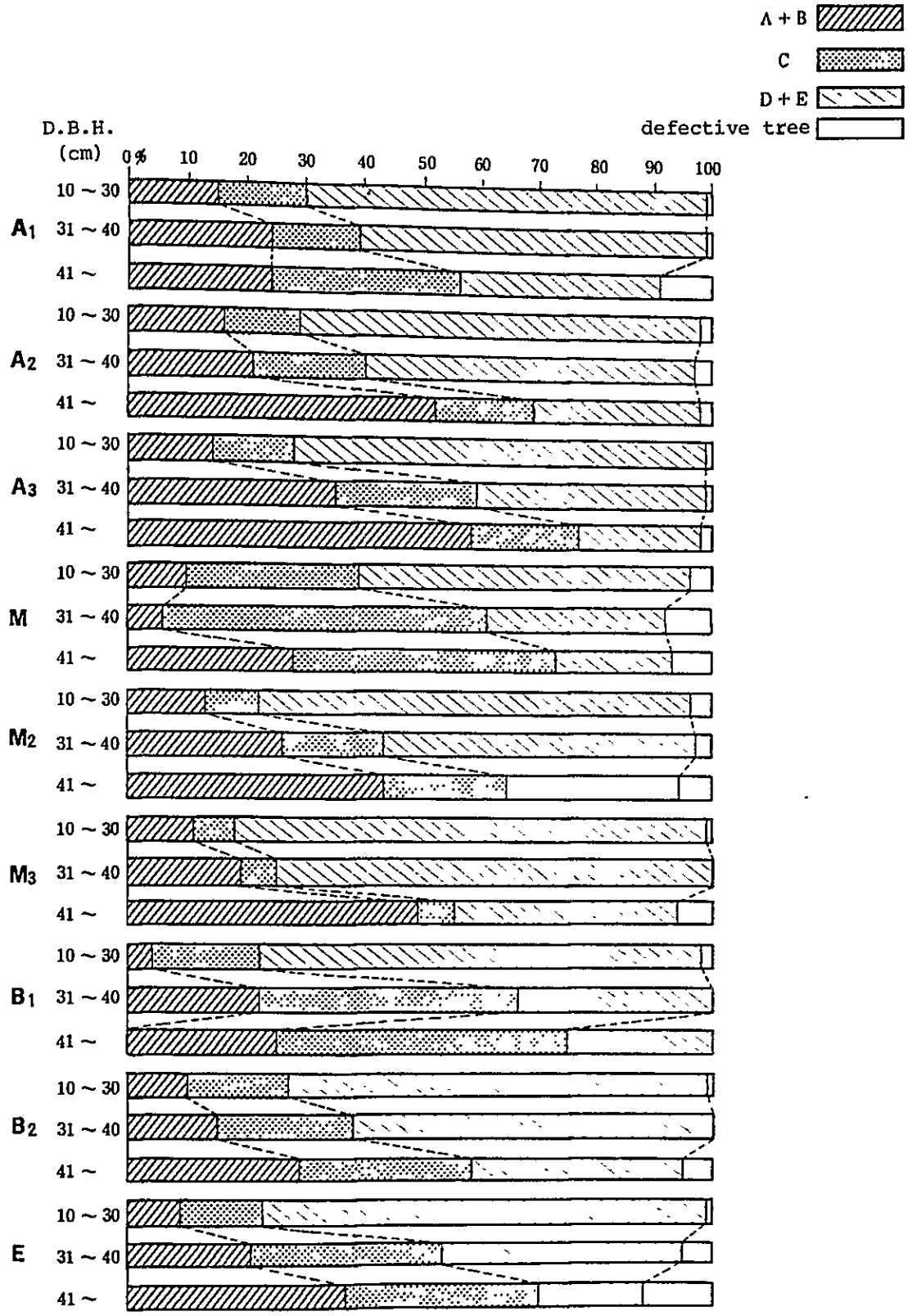


Figure-IV-5. Percentages of number of trees per diameter class by photo-strata and by class of utility.

IV-4 Volume

All the volume was calculated without bark. This method and the coefficient by species are according to the FAO report which established four formulas by species. In addition, since it is a major feature of the study area, Peroba was calculated with another formula designed specially for Peroba. (see appendix-8)

Meanwhile, the calculation of volume adopts the "Smalion", the same method as in the FAO report. The formula is as follows;

Commercial height more than 5 m

$$V = \frac{5(g_0 + g_5) + (g_5 + gn) \cdot (h - 5)}{2}$$

where,

h: commercial height

g_n: basal area at the commercial height

g_5: basal area at 5m of the commercial length

g_0: basal area at D.B.H.

Commercial height less than 5 m

$$V = \frac{(g_0 + gn) \cdot h}{2}$$

(see appendix-3)

i) Volume by species

Peroba has the most volume of all the species, in particular, the volume for D.B.H. over 41 cm occupies 37.4 percent of the total volume. (see table-IV-7).

In table-IV-7, there are seven species classified for both D.B.H. over 10 cm and over 41 cm. However, the species of Yva poroity, Laurel, and Pindo are only listed for D.B.H. over 10 cm. This means that it is difficult for these species to grow bigger. On the other hand, the species of Kurupay ra, Urunde y para, and Marinera are likely to grow bigger, because only these species are listed for D.B.H. over 41 cm.

D.B.H. over 10 cm.						
Local name		Family	Genus	Utility	Volume	%
1	Peroba	Apocynaceae	Aspidosperma	B	451.59	22.3
2	Yvyrá piú	Sapindaceae	Diatenopteryx	D	88.97	4.4
3	Yvá poroitý	Myrtaceae	Myrciaria	D	81.92	4.0
4	Yvyrá pytá	Leguminosae	Peltophorum	B	79.15	3.9
5	Kupa ý	Leguminosae	Copaifera	C	71.76	3.5
6	Laurel	Lauraceae	Nectandra	C	58.10	2.9
7	Kurupay	Leguminosae	Piptadenia	A	54.48	2.7
8	Guajayví	Boraginaceae	Patagonula	C	54.37	2.7
9	Samu hú	Bombacaceae	Chorisia	E	54.28	2.7
10	Pindó	Palmaceae	Arecastrom	E	52.40	2.6
Total					1,047.02	51.7

D.B.H. over 41 cm						
Local name		Family	Genus	Utility	Volume	%
1	Peroba	Apocynaceae	Aspidosperma	B	376.49	37.4
2	Yvyrá pytá	Leguminosae	Peltophorum	B	64.13	6.4
3	Kupa ý	Leguminosae	Copaifera	C	49.87	4.9
4	Samu hú	Bombacaceae	Chorisia	E	48.94	4.9
5	Kurupay	Leguminosae	Piptadenia	A	45.76	4.5
6	Guajayví	Boraginaceae	Patagonula	C	40.35	4.0
7	Kurapaý rá	Leguminosae	Piptadenia rigida	B	38.86	3.9
8	Yvyrá piú	Sapindaceae	Diatenopteryx	D	21.30	2.1
9	Urunde y pará	Anacardiaceae	Astonium	C	20.73	2.1
10	Marinero	Meliaceae	Guarea	D	19.92	2.0
Total					726.35	72.2

Table-IV-7. List of main species with much volume for D.B.H. over 10 cm and 41 cm.

ii) Volume by photo-strata

The amount of volume according to sample plot, photo-strata, diameter class, and the class of utility are shown in appendix-9.

The amount of volume per hectare for both D.B.H. over 10 cm and 41 cm by photo-strata is shown in table-IV-8 and figure-IV-6. The amount of volume for small diameters (10cm to 40cm) shows little variance ($\pm 30 m^3$)in all of the photo-strata. Meanwhile, the amount of volume among large diameter classes (over 41cm) corresponds with the density of the upper trees (over 15m) in the criteria for photo-interpretation. However, the medium forest M2 and the low forest B2 possess more volumes than for M3 and the mixed forest M, respectively, although we inversely expected. In any case, it will be necessary to do surveys in the field for more sample plots and to analyze the data in detail.

Photo-strata	A1	A2	A3	M	M2	M3	B1	B2	E	Total
D.B.H.10 to 40cm	25.75	30.86	48.09	27.09	35.91	32.65	21.50	33.84	32.07	32.23
D.B.H.over 41cm	24.20	39.27	78.04	11.67	33.70	29.26	0.55	20.51	25.32	32.94
D.B.H.over 10cm	49.95	70.13	126.13	38.76	69.61	61.91	22.05	54.35	57.39	65.17
Ratio of D.B.H. over 41cm	48.4	56.0	61.9	30.1	48.4	47.3	2.5	37.7	44.1	50.5%

Table-IV-8. Amount of volume (m^3)per hectare by photo-strata.

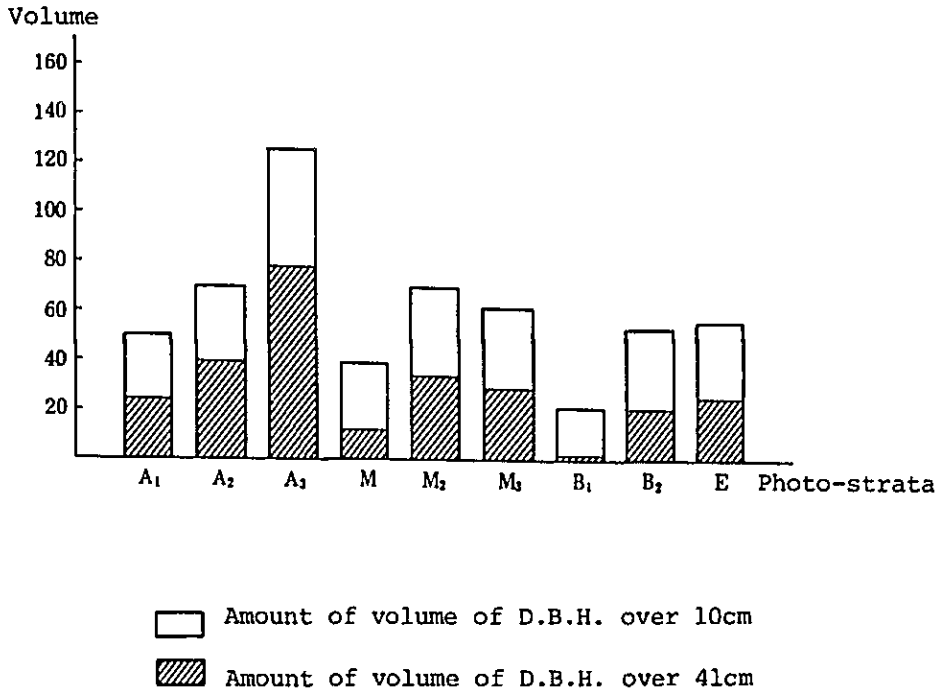


Figure-IV-6. Amount of volume per hectare, by photo-strata.

By species

In table-IV-9, Peroba shows the highest ranking except in the mixed forest M and the low forest B1. This is a feature of the study area. In addition, the list of species with D.B.H. over 10 cm is not so different from that for D.B.H. over 41 cm. And as for the class of utility, the tall forests A1, A2, and A3 possess the species in a higher class of utility than the medium forests M2 and M3. In addition, the low forest B1 is in a lower class of utility than the mixed forest M.

By diameter class

The distribution of volume by diameter class is shown in figure-IV-7. In figure-IV-7, the higher the percentage of high classes of utility (A+B) the more larger diameter classes there are. In addition, as it should be noted that the medium forests M2 and M3 do not have big trees with D.B.H. over 100 cm despite the fact that the tall forest A2 has them. Although the tall forest A2 and the medium forests M2 and M3 are calculated as having nearly the same volume. This can be also explained in table-IV-10, which shows the volume per tree for D.B.H. 10 cm to 40 cm and over 41 cm. The volume per tree for D.B.H. over 41 cm in the medium forests M2 and M3 is less than for the tall forest A2. The tall forest A3 has the biggest trees, as 2 m^3 per tree is a D.B.H. over 41 cm.

Moreover as shown in figure-IV-7, the amount of volume from D.B.H. 31 cm to 40 cm is high in all of the photo-strata, except the low forest B1, This is a very important for forest management and industry, because timber with a D.B.H. over 41 cm is being logged at present. But, if they are conserved for a short time, trees from D.B.H. 31 cm to 40 cm will move into the over 41 cm range in the near future.

D.B.H. \ photo-stratum	A1	A2	A3	M	M2	M3	B1	B2	E
D.B.H.10cm to 40cm	0.10	0.11	0.14	0.09	0.10	0.11	0.05	0.09	0.10
D.B.H. over 41cm	0.90	1.35	2.00	1.17	0.99	1.08	0.28	0.98	1.15

Table-IV-10. Volume (m^3) per tree by photo-strata .

A 1

D.B.H. over 10 cm				
	Species	Utility	Vo./ha	%
1	Peroba	B	4 67	9 7
2	Palo blanco	D	4.16	8.7
3	Urunde y pará	C	3 37	7.0
4	Yvyrá pytá	B	3 32	6 9
5	Yvyrá piú	D	3 05	6 4
6	Timbó	B	2 25	4.7
7	Guajayví	C	1.97	4.1
8	Guatambú	A	1.94	4 0
9	Laurel	C	1.90	4 0
10	Ombú	E	1.57	3.3
Total			28 20	58 8

D.B.H. over 41 cm				
	Species	Utility	Vo./ha	%
1	Peroba	B	3 24	14 4
2	Palo blanco	D	2.57	11.4
3	Yvyrá pytá	B	2 49	11.1
4	Urunde y pará	C	2 32	10.3
5	Timbó	B	2 25	10 0
6	Guajayví	C	1.57	7.0
7	Ombú	E	1.30	5 8
8	Laurel	C	0.70	3.1
9	Lapacho	A	0.69	3 1
10	Guatambú	A	0.67	3 0
Total			17.80	79.2

A 2

D.B.H. over 10 cm				
	Species	Utility	Vo./ha	%
1	Peroba	B	20.23	29.5
2	Samu hú	E	3.99	5 8
3	Yvyrá piú	D	3.48	5 1
4	Kurupay	A	2.91	4 2
5	Yvyrá pytá	B	2 76	4.0
6	Pakurí	D	2.50	3 6
7	Kupa ý	C	2.04	3.0
8	Guajayví	C	1.83	2.7
9	Yvá poroity	D	1.70	2 5
10	Laurel	C	1 53	2 2
Total			42.97	62 6

D.B.H. over 41 cm				
	Species	Utility	Vo./ha.	%
1	Peroba	B	16 53	43.0
2	Sam hú	E	3 48	9.0
3	Kurupay	A	2 60	6 8
4	Yvyrá pytá	B	2 45	6 4
5	Kupa ý	C	1.81	4.7
6	Guajayví	C	1.32	3.4
7	Tata juvá	C	0.90	2.3
8	Lapacho	A	0.86	2.2
9	Yvyrá piú	D	0.74	1.9
10	Marinero	D	0.63	1.6
Total			31.32	81.3

A 3

D.B.H. over 10 cm				
	Species	Utility	Vo /ha.	%
1	Peroba	B	47.05	37.9
2	Cancharana	B	6 31	5.1
3	Marinero	D	4.61	3 7
4	Yvyrá piú	D	3 32	2.7
5	Laurel	C	3.26	2 6
6	Mbavý	D	3.17	2.6
7	Pakurí	D	3.02	2 4
8	Chipá rupá	C	2.83	2 3
9	Kupa ý	C	2 73	2 2
10	Yvyrá pytá	B	2 60	2 1
Total			78.90	63.6

D.B.H. over 41 cm				
	Species	Utility	Vo./ha	%
1	Peroba	B	41.41	54.1
2	Cancharana	B	4.26	5.6
3	Yvyrá pytá	B	2.54	3 3
4	Marinero	D	2.40	3 1
5	Kurupaý rá	B	2.37	3.1
6	Kupa ý	C	2.16	2.8
7	Kurupay	A	1.97	2.6
8	Tatajyvá	B	1.36	1.8
9	Chipá rupá	C	1.32	1.7
10	Taperyva guasú	A	0.98	1.3
Total			60.77	79.4

Table-IV-9. List of species with much volume by photo-strata.

M

D.B.H. over 10 cm				
	Species	Utility	Vo./ha.	%
1	Kupa ý	C	6 86	18 5
2	Laurel	C	3 15	8.5
3	Pindó	E	2.80	7.6
4	Samu hú	E	2.38	6 4
5	Peroba	B	2 21	6 0
6	Yvyrá pytá	B	1.49	4 0
7	Manduvirá	C	1.30	3.5
8	Tata juvá	C	1.21	3.3
9	Yvyrá jú	D	1.17	3.2
10	Peterevý	A	1 13	3 0
Total			23 70	64.0

D.B.H. over 41 cm				
	Species	Utility	Vo./ha.	%
1	Kupa ý	C	2.41	23.4
2	Samu hú	E	2 38	23.1
3	Peroba	B	1.84	17.9
4	Yvyrá pytá	B	1.26	12.2
5	Manduvirá	C	0.68	6 6
6	Tata juvá	C	0.66	6 4
7	Kurupay	A	0.34	3 3
8	Laurel	C	0 20	1.9
9	Peterevý	A	0.16	1.6
10	Jacaratiá	E	0.06	1.0
Total			9.99	97.4

M 2

D.B.H. over 10 cm				
	Species	Utility	Vo./ha.	%
1	Peroba	B	9 90	14.8
2	Yvá poroitý	D	4.36	6 5
3	Yvyrá piú	D	3.96	5.9
4	Kurupaý rá	B	3.32	5.0
5	Guajayví	C	2 87	4.3
6	Yvyrá pytá	B	2.53	3.8
7	Kupa ý	C	2.25	3.4
8	Pindó	E	2.20	3.3
9	Ombú	E	2 04	3.1
10	Guatambú	A	1.81	2 7
Total			35.24	52 8

D.B.H. over 41 cm				
	Species	Utility	Vo./ha.	%
1	Peroba	B	7.82	24.9
2	Kurupaý rá	B	2.72	8.6
3	Guajayví	C	2.26	7.2
4	Kupa ý	C	1.91	6 1
5	Yvyrá pytá	B	1.65	5.2
6	Ombú	E	1.41	4.5
7	Yvyra piú	D	1.03	3.3
8	Samu hú	E	1.00	3.2
9	Kurupay	A	0.94	3.0
10	Chipá rupá	C	0.93	3.0
Total			21.67	69.0

M 3

D.B.H. over 10 cm				
	Species	Utility	Vo /ha.	%
1	Peroba	B	8 20	13.6
2	Yvyrá pytá	B	4.76	7.9
3	Yvyrá katú	D	4 75	7.9
4	Ysý	D	3.22	5.3
5	Pindó	E	3 18	5.3
6	Mbavý	D	3 10	5.1
7	Kurupaý rá	B	2.61	4.3
8	Pakurí	D	2 45	4.1
9	Yvyrá piú	D	2 35	3.9
10	Palo blanco	D	2.25	3.7
Total			36 87	61.1

D.B.H. over 41 cm				
	Species	Utility	Vo./ha.	%
1	Peroba	B	6 90	24.9
2	Yvyrá pytá	B	4.25	15.3
3	Kurupay rá	B	2.15	7.7
4	Palo blanco	D	1.82	6 6
. 5	Yvyrá katú	D	1.76	6 3
6	Kurupay	A	1.52	5.5
7	Ombú	E	1.41	5.1
8	Samu hú	E	1.00	3.6
9	Laurel	C	0.98	3.5
10	Ñangapirý	E	0.94	3.4
Total			22.73	81.9

B 1

D.B.H. over 10 cm				
	Species	Utility	Vo./ha	%
1	Pindó	E	7.10	32 7
2	Ñangapiry	E	3 99	18.4
3	Tataré	E	2 31	10.6
4	Laurel	C	1.46	6 7
5	Laurel canela	C	1.35	6.2
6	Yvyrá ovi	C	0.94	4.3
7	Kurupay	A	0.66	3 0
8	Yvá poroity	D	0.45	2 1
9	Kupa y	C	0.43	2.0
10	Cancharana	B	0.41	1.9
Total			19.10	87.9

D.B.H. over 41 cm				
	Species	Utility	Vo /ha	%
1	Tataré	E	0.24	57.1
2	Kupa y	C	0.18	42 9
3				
4				
5				
6				
7				
8				
9				
10				
Total			0.42	100.0

B 2

D.B.H. over 10 cm				
	Species	Utility	Vo./ha.	%
1	Peroba	B	7 17	13 6
2	Yvá poroity	D	6 96	13.2
3	Palo vino	D	5 06	9.6
4	Kupa y	C	3.37	6 4
5	Lapacho	A	3.24	6 1
6	Morosyvó	C	2.93	5 6
7	Para todo	E	2.16	4.1
8	Laurel	C	2.00	3 8
9	Urunde y pará	C	1.96	3.7
10	Incienso	A	1.46	2.8
Total			36 31	68.9

D.B.H. over 41 cm				
	Species	Utility	Vo./ha.	%
1	Peroba	B	6 63	34.8
2	Lapacho	A	2.68	14.1
3	Kupa y	C	2 56	13 4
4	Aratiku	E	0.75	3.9
5	Kurupay rá	B	0.70	3.7
6	Palo vino	D	0.70	3.7
7	Ingá	E	0.68	3.6
8	Ysy	D	0 57	3 0
9	Ysapy y pytá	D	0.55	2.9
10	Tata juvá	C	0.51	2.7
Total			16 33	85.8

E

D.B.H. over 10 cm				
	Species	Utility	Vo /ha	%
1	Yvá poroity	D	9.67	18.2
2	Yvyrá piu	D	4.37	8.2
3	Guajayvi	C	3 78	7.1
4	Peroba	B	3.65	6 9
5	Kurupay	A	2.90	5 5
6	Yvyrá pytá	B	2 89	5 4
7	Urunde y pará	C	2.69	5.1
8	Yvyrá pepé	C	2.39	4 5
9	Guatambú	A	2 17	4 1
10	Kurupay rá	B	1.98	3.7
Total			36 49	68.7

D.B.H. over 41 cm				
	Species	Utility	Vo./ha.	%
1	Peroba	B	2 80	13 0
2	Kurupay	A	2.58	12.0
3	Guajayvi	C	2 31	10 7
4	Yvyrá pytá	B	1.99	9.2
5	Kurupay rá	B	1 87	8.7
6	Urunde y pará	C	1.76	8 2
7	Kupa y	C	1.52	7.0
8	Yvyrá piu	D	1.30	6 0
9	Lapacho	A	1.27	5.9
10	Guatambú	A	0.87	4.0
Total			18.27	84 7

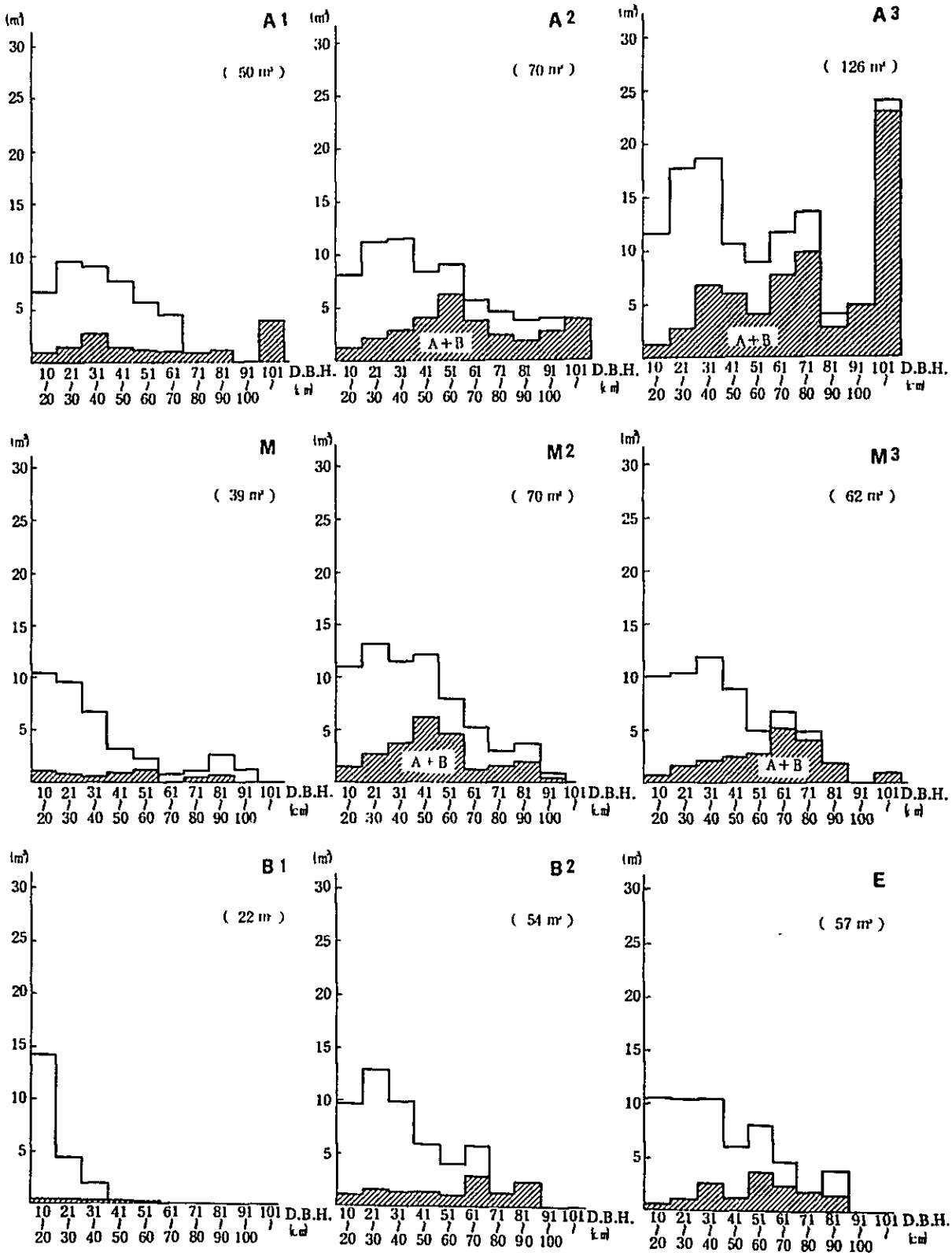


Figure-IV-7. Amount of volume per hectare, by diameter class .

A 1

(cm)	10 ~ 30	31 ~ 40	41 ~
A + B	(2.41m³) 14.6%	(2.76m³) 29.8%	(10.03m³) 41.4%
C	(3.11m³) 18.9%	(1.06m³) 11.4%	(6.57m³) 27.1%
D + E	(10.73m³) 65.1%	(5.41m³) 58.4%	(5.92m³) 24.5%
Defective	(0.22m³) 1.3%	(0.03m³) 0.3%	(1.69m³) 7.0%
Total m³/ha	16 49	9 26	24 2

A 2

(cm)	10 ~ 30	31 ~ 40	41 ~
A + B	(3.45m³) 17.9%	(2.96m³) 25.6%	(25.06m³) 63.8%
C	(3.11m³) 16.1%	(2.20m³) 19.1%	(5.61m³) 14.3%
D + E	(12.30m³) 63.7%	(6.07m³) 52.6%	(7.82m³) 19.9%
Defective	(0.45m³) 2.3%	(0.30m³) 2.6%	(0.80m³) 2.0%
Total m³/ha	19. 32	11. 54	39 28

A 3

(cm)	10 ~ 30	31 ~ 40	41 ~
A + B	(3.83m³) 13.1%	(6.89m³) 36.7%	(58.20m³) 74.6%
C	(4.34m³) 14.8%	(4.22m³) 22.5%	(8.31m³) 10.6%
D + E	(20.74m³) 70.8%	(7.52m³) 40.0%	(10.08m³) 12.9%
Defective	(0.38m³) 1.3%	(0.15m³) 0.8%	(1.44m³) 1.8%
Total m³/ha	29. 3	18. 79	78 04

M

(cm)	10 ~ 30	31 ~ 40	41 ~
A + B	(2.17m³) 10.6%	(0.55m³) 8.2%	(3.60m³) 30.8%
C	(7.25m³) 35.6%	(3.44m³) 51.3%	(3.94m³) 33.8%
D + E	(10.85m³) 53.2%	(2.50m³) 37.3%	(2.73m³) 23.4%
Defective	(0.13m³) 0.6%	(0.20m³) 3.0%	(1.39m³) 11.7%
Total m³/ha	20. 39	6 7	11. 67

M 2

(cm)	10 ~ 30	31 ~ 40	41 ~
A + B	(4.30m³) 17.6%	(3.87m³) 33.7%	(16.55m³) 49.1%
C	(2.89m³) 11.8%	(1.97m³) 17.1%	(7.57m³) 22.5%
D + E	(16.82m³) 68.9%	(5.43m³) 47.2%	(7.33m³) 21.8%
Defective	(0.40m³) 17.2%	(0.24m³) 2.1%	(2.24m³) 6.6%
Total m³/ha	24. 4	11. 5	33 7

M 3

(cm)	10 ~ 30	31 ~ 40	41 ~
A + B	(2.72m³) 13.2%	(2.22m³) 18.5%	(17.84m³) 61.0%
C	(1.62m³) 7.9%	(0.64m³) 5.3%	(0.97m³) 3.3%
D + E	(16.13m³) 78.3%	(9.16m³) 76.1%	(8.93m³) 30.5%
Defective	(0.15m³) 0.7%	—	(1.51m³) 5.2%
Total m³/ha	20. 61	12. 03	29 26

B 1

(cm)	10 ~ 30	31 ~ 40	41 ~
A + B	(1.35m³) 7.1%	(0.67m³) 28.4%	—
C	(3.56m³) 18.6%	(1.05m³) 44.5%	(0.18m³) 32.7%
D + E	(14.04m³) 73.4%	(0.63m³) 26.7%	(0.24m³) 43.6%
Defective	(0.19m³) 1.0%	—	(0.14m³) 25.5%
Total m³/ha	19. 14	2 36	0 55

B 2

(cm)	10 ~ 30	31 ~ 40	41 ~
A + B	(3.08m³) 13.1%	(1.52m³) 14.6%	(10.33m³) 50.4%
C	(5.38m³) 22.9%	(2.49m³) 24.0%	(4.16m³) 20.3%
D + E	(14.84m³) 63.3%	(6.38m³) 61.5%	(4.56m³) 22.2%
Defective	(0.15m³) 0.6%	—	(1.45m³) 7.1%
Total m³/ha	23 46	10. 38	20. 51

E

(cm)	10 ~ 30	31 ~ 40	41 ~
A + B	(2.07m³) 9.7%	(2.86m³) 26.7%	(11.69m³) 46.2%
C	(3.67m³) 17.2%	(3.48m³) 32.5%	(6.97m³) 27.5%
D + E	(15.53m³) 72.7%	(3.94m³) 36.8%	(2.93m³) 11.6%
Defective	(0.10m³) 0.5%	(0.43m³) 4.0%	(3.75m³) 14.8%
Total m³/ha	21. 36	10. 71	25. 32

Table-IV-11. Percentages of volume per hectare of diameter class by photo-strata and by class of utility.

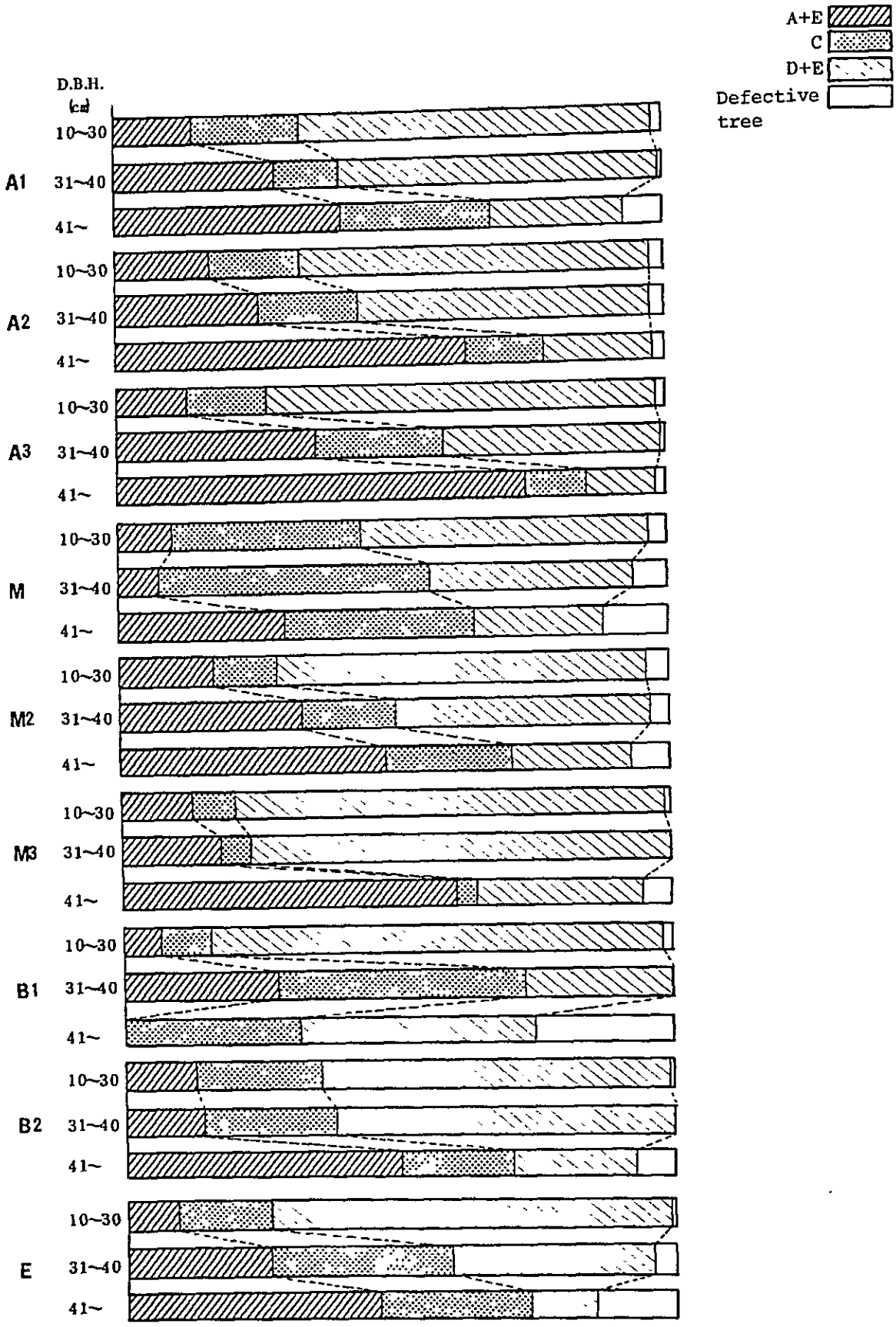


Figure-IV-8. Percentages of volume per hectare of diameter class by photo-strata and by class of utility.

By class of utility

A tendency more remarkable than the number of trees, is that, as shown in table-IV-11 and figure-IV-8, the higher classes of utility (A+B) have higher percentages in the larger diameter class over all of the photo-strata except B1.

IV-5 Height and diameter

Total height by photo-strata

The mean of the heights for D.B.H. over 10 cm in the 32 sample plots is 10.8 m, and that for D.B.H. over 41 cm among these is 18.2 m. (see appendix-10.)

Figure-IV-9 shows the mean tree heights of D.B.H. over 10 cm and 41 cm by photo-strata. The tall forests A1, A2, and A3 are comparatively higher than the medium forests M2 and M3, although these forests are the same density but have different crown of sizes in the criteria for photo-interpretation. (see table-II-3.) The low forest B2 has a higher mean than we expected, especially for D.B.H. over 41 cm. This may be because the low forest B2 is close to the exploited forest E, but only the forest land base of B2 as an unit is smaller than that of E.

Total height by diameter class

Figure-IV-10 shows the mean tree height by diameter class. The mean height of trees less than D.B.H. 40 cm is less than 15 m. This confirms that the total height of so-called "upper trees" in the criteria for photo-interpretation (table-II-3) corresponds to the more than 15 m for D.B.H. over 41 cm.

Total height and commercial height of trees

The tree volume is calculated by D.B.H. and commercial height of trees. However, the relation of the commercial height of trees to the total height may vary by species more than by the class of utility. Figure-IV-11 shows examples of main species and classes of utility in relation to total and commercial height. Unfortunately, these data are insufficient to

examine the tendency by species. But it may be said that those in a higher class of utility except Cedro (Peroba, Kurupay, and Yvyrá pytá) have a commercial height of more than 12 m. In addition, for commercial heights less than 5 m, the ratio of commercial height to total height in lower classes of utility is lower than in higher classes of utility.

In any case, this analysis ought to be examined more next year.

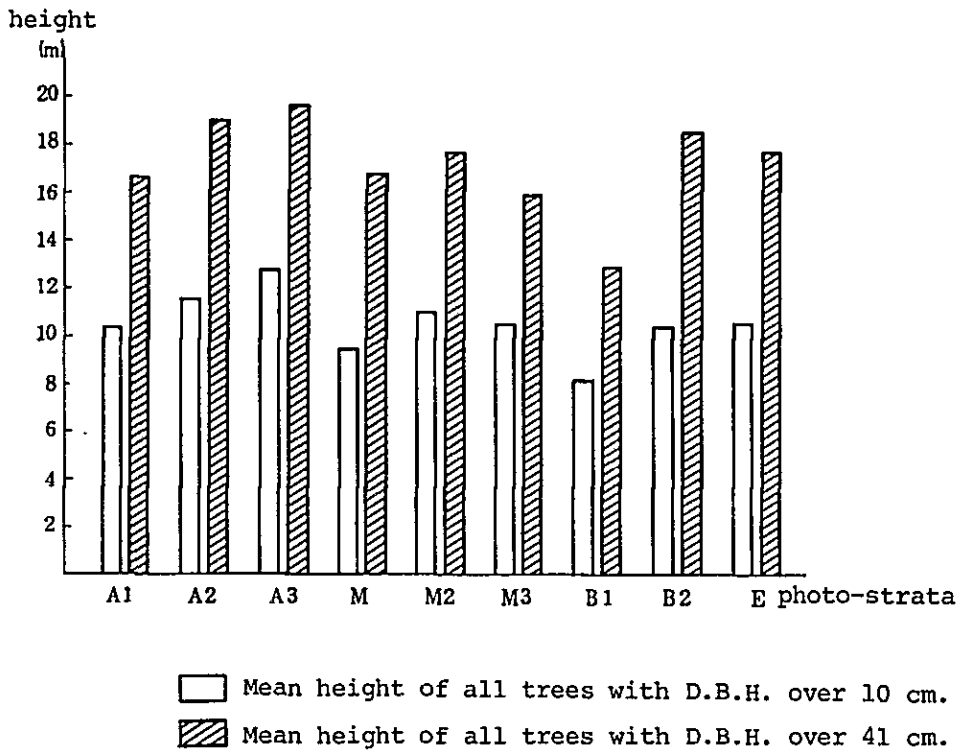


Figure-IV-9. Mean tree heights by photo-strata.

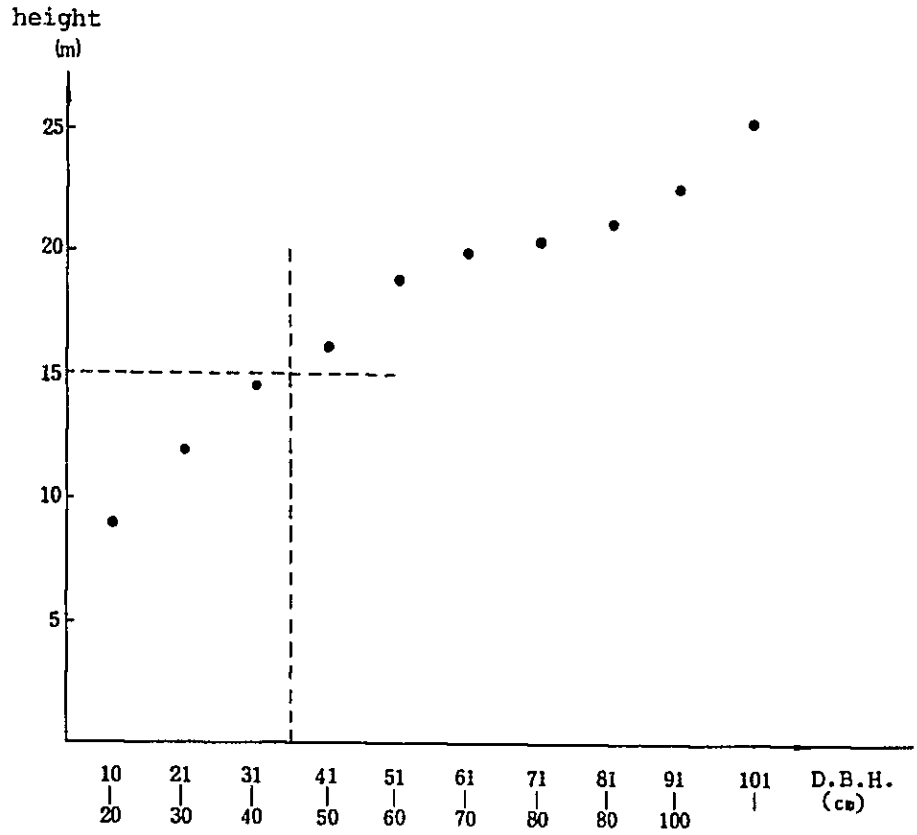


Figure-IV-10. Mean tree heights by diameter class.

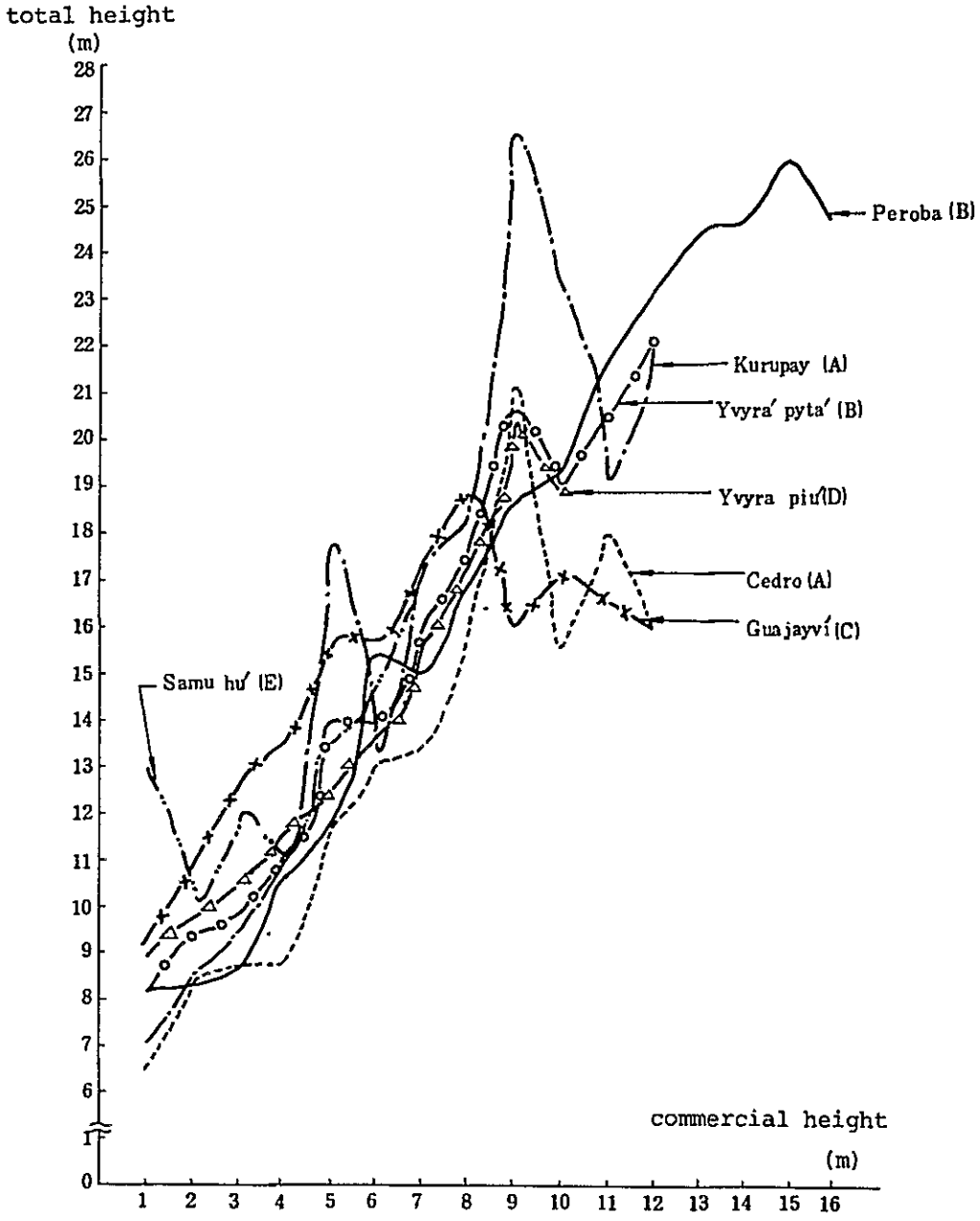


Figure-IV-11. Total height and commercial height.

V. STOCK

The volume in the total study area (1,500,000 ha) will be calculated by the mean of the photo-strata next year. In the meantime, the government of Paraguay now requires information on the location and extent of forest stock as excessive extraction and logging is being done at present. Since forest management and forest policy for forest industry require the distribution of stock and this information is urgently needed. Therefore, the study area (only 780,000 ha) was temporarily calculated as preliminary estimation of stock.

The stock will be shown in the 56 block divisions mentioned above as the unit for the sampling method, and by 17 local divisions mentioned below.

Also, a more precise distribution of stock and total stock will be calculated next year.

V-1 Local divisions

The block divisions mentioned above are useful in distribution of stock not only to the total study area, but also for comparison of other inventories of forest resources or land use in the future.

However, considering the importance and urgency of the study area, local and political divisions are necessary for controlling the logging, making management of forest more accessible and developing the forest industry. The local divisions are shown in figure-V-1 and each division is limited as follows;

Local division 1 ; is limited by the north border between Paraguay and Brazil, and the road leading to the town of Laguna Ciervo. (Department of Amambay)

Local division 2 ; is limited by the national roads, Routes 3 and 5, the border, and Arroyo Tacuara (river). (Dep. Amambay)

Local division 3 ; is limited by Route 5, the border, and Arroyo Tacuara. Pedro Juan Caballero city is included. (Dep. Amambay)

Local division 4 ; is the national park and forest in Cerro Corá. (Dep. Amambay)

Local division 5 ; is limited by Route 5, the local border between the departments of Concepción and Amambay, and the road leading to Cerro Corá. (Dep. Amambay)

Local division 6 ; is limited by Route 5, the road from Cerro Corá, and Rio Ypane (river). (Dep. Amambay)

Local division 7 ; is limited by Rio Ypane, Ao Ypane-mi (river), and the border. (Dep. Amambay)

Local division 8 ; is limited by the banks of Rio Ypane and Ao Ypane-mi. (Dep. Amambay)

Local division 9 ; is limited by Ao Ypane-mi, Ao Guazu (river), and the border. (Dep. Amambay)

Local division 10; is limited by Rio Ypane and Ao Blanco (river) (Dep. Amambay)

Local division 11; is limited by Ao Blanco and Ao Guazu. (Dep. Amambay)

Local division 12; is limited by Ao Guazu, the border, and Route 11 leading to Capitan Bado city. (Dep. Amambay)

Local division 13; is limited by Ao Guazu, Route 11 and the local border between the departments of San Pedro and Amambay. (Dep. Amambay)

Local division 14; is limited by the Routes 3 and 5. Ao Cagata (river), and the local border between the departments of Concepción and Amambay. (Dep. Concepción)

Local division 15; is limited by Ao Cagata, Ao Guaireño (river), the local border between the departments of Concepción and Amambay, and Route 3. (Dep. Concepción)

Local division 16; is limited by Ao Guaireño, Rio Ypane, and Route 3. (Dep. Concepción)

Local division 17; is not decided yet.

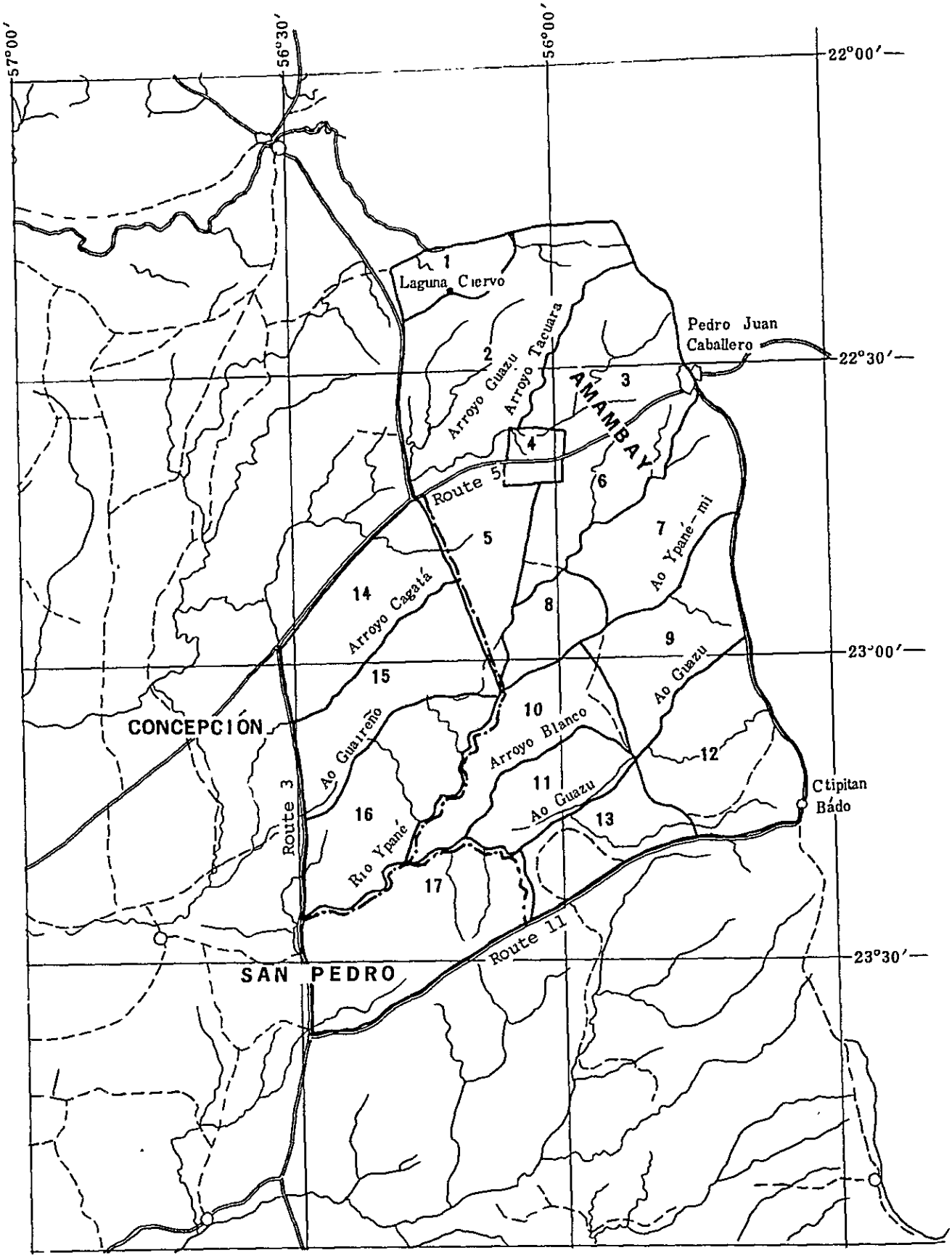


Figure-V-1. Local divisions of the study area.

V-2 Re-photo-interpretation

We photo-interpreted the photo-strata including the sample plots with the results analyzed from the sample plots, and confirmed that the images of height and crown density of upper trees in the criteria for photo-interpretation did correspond to the results of the sample plots.

Then, we re-photo-interpreted for correcting the photo-strata with photo's images including the sample plots. The results of the re-photo-interpretation are not so different from the first photo-interpretation mentioned before.

V-3 Mensuration of photo-stratum areas

The mensuration of the photo-stratum areas done by a machine (called COMOS) which is very precise since it has tremendous x, y coordinates, and measures the coordinates of the boundary lines of the photo-strata. Then, the data of the coodinates were calculated by a computer-analysis (Double Meridian Distance method) for the areas of each photo-stratum and land use. (see table-V-1.)

Photo-stratum and land use	Symbol	Hectare	Ratio to the study area	Ratio to the forest land
Tall forest	A1	29,799	3.8	7.0
	A2	124,772	16.0	29.5
	A3	14,380	1.8	3.4
Mixed forest	M	67,701	8.7	16.0
Medium forest	M2	104,992	13.5	24.8
	M3	18,510	2.4	4.4
Low forest	B1	12,204	1.6	2.9
	B2	32,208	4.1	7.6
Exploited forest	E	18,924	2.4	4.5
Total forest	—	423,486	54.4	100.0
Agriculture	Ag	59,849	7.7	16.8
Swamp	H	7,352	0.9	2.1
Pasture	G	217,632	27.9	61.2
Felling	C	68,946	8.9	19.4
Urban	P	1,735	0.2	0.5
Non forest	—	355,514	45.6	100.0
Total	—	779,004	100.0	—

Table-V-1. Area of photo-strata and land use in the study area.

V-4 Estimation of stock

The estimation of stock is calculated with the mean volume per hectare and the area of the photo-strata. The mean volume per hectare omits defective trees (mentioned in III-1-ii) as irregular trees), and small trees less than D.B.H. 40 cm. The means by photo-strata are in the following table-V-2.

Photo-strata	A1	A2	A3	M	M2	M3	B1	B2	E
Volume per hectare	22.51	38.47	76.60	10.30	31.47	27.76	0.42	19.06	21.57

Table-V-2. Volume per hectare of photo-strata for estimating the stock.

The volume of estimation for the stock by the photo-strata, by the block divisions, and by the local divisions are shown in appendix-11.

The total volume is estimated as 12,113,275 m^3, and Peroba accounts for about 4,980,500 m^3 (41%) in the study area.

Photo-strata	Symbol	Volume(m^3)	Ratio (%)
Tall forest	A1	670,774	5.5
	A2	4,800,214	39.6
	A3	1,101,419	9.1
Mixed forest	M	697,283	5.8
Medium forest	M2	3,302,858	27.3
	M3	513,623	4.2
Low forest	B1	5,033	-
	B2	613,827	5.1
Exploited forest	E	408,244	3.4
Total	—	12,113,275	100.0

Table-V-3. Stock by photo-strata.

V-5 Feature of local division

i) Profile

Table-V-4 shows the ratio of the photo-strata in the forest land by local division. Thus, the local divisions are explained as follows;

* Local division 1 is mainly a low forest.
* Local divisions 2 and 3 are mainly tall forest with an especially higher ratio of A3.
* Local division 4 is mainly a mixed forest and is preserved as a recreational forest and wild habitat as a national park and forest.
* Local divisions 5,6,7, and 14 are mainly medium forests in the southern area of Route 5.
* Local divisions 8,9, and 11 are mixtures of tall and medium forests, but there is a higher ratio of A3.
* Local divisions 10, 15, and 16 are mainly tall forests.

Further, divisions with a ratio of forest land less than 50 percent, include local division 3 including Pedro Juan Caballero city, and local divisions 6 and 7 which are in the environs of the city, and in addition, local division 12 which includes Capitan Bado city, and divisions 11 and 13 also in the environs of the city.

On the other hand, divisions with a ratio of forest land higher than 60 percent, local divisions 2,5,8, and 10 are the central areas of study. In addition, local divisions 2,5 and 10 also possess more than one million cubic meters. (see table-V-6, table-V-7 and figure-V-3.)

photo-stratum / local division	A1	A2	A3	M	M2	M3	B1	B2	E	Total
1	4.25	21.82		5.20	17.85		10.48	40.41		100
2	13.50	38.83	9.11	10.55	11.60	6.23	1.46	5.42	3.30	"
3	12.79	37.84	7.04	19.15	9.00	0.90	2.09	8.30	2.91	"
4	0.24			48.50	8.56	11.45	4.04	27.21		"
5	1.16	7.10	0.21	14.60	44.23	13.60	3.08	6.57	9.45	"
6	0.16		0.29	23.54	58.33	0.13	7.55	6.77	3.23	"
7	0.02	1.62		23.43	50.22	0.40	6.65	8.27	9.38	"
8	1.63	25.06	5.09	16.02	29.06		8.72	5.06	9.36	"
9	7.23	35.07	2.81	18.55	20.35		3.65	7.20	5.12	"
10	11.29	47.36	1.37	13.43	11.63	5.25	0.40	5.72	3.54	"
11		29.62	5.31	16.31	25.54	2.14	0.86	6.99	13.23	"
12	12.87	46.41		18.38	13.09		0.72	6.56	1.98	"
13		11.04		36.28	48.62			4.06		"
14	2.98	23.42	2.05	15.94	38.58	10.44	1.61	4.44	0.54	"
15	8.85	43.72	2.51	13.33	16.10	1.40	2.70	7.78	3.63	"
16	4.33	32.06	2.47	16.39	24.75	6.59	0.84	11.56	1.02	"
17		11.11		5.77	83.12					"
Total	7.04	29.46	3.40	15.99	24.79	4.37	2.88	7.61	4.47	"

Table-V-4. Ratio (%) of photo-strata in the forest land by local division.

Block division	1	2	3	4	5	6	7	8	9	10
Ratio of forest land	52.27	79.38	37.13	12.04	64.70	66.00	70.71	55.13	21.76	2.30
Block division	11	12	13	14	15	16	17	18	19	20
Ratio of forest land	51.29	65.33	88.39	53.88	8.78	3.40	36.26	72.58	55.15	63.70
Block division	21	22	23	24	25	26	27	28	29	30
Ratio of forest land	45.95	17.40	-	23.67	58.94	88.78	57.56	50.62	40.22	40.25
Block division	31	32	33	34	35	36	37	38	39	40
Ratio of forest land	40.66	54.37	55.97	72.09	54.06	74.77	59.91	33.99	8.79	58.60
Block division	41	42	43	44	45	46	47	48	49	50
Ratio of forest land	37.24	54.21	81.91	79.52	65.00	47.92	0.97	-	53.04	60.26
Block division	51	52	53	54	55	56	Total			
Ratio of forest land	73.75	45.76	47.06	37.87	58.11	14.01	54.36			

Table-V-5. Ratio of forest land by block division.

Local division	1	2	3	4	5	6	7	8	9	10
Ratio of forest land	53.58	64.59	36.73	52.49	68.17	47.18	36.44	66.55	56.11	80.60
Local division	11	12	13	14	15	16	17	Total		
Ratio of forest land	47.89	43.49	40.51	53.72	55.56	56.29	73.24	54.36		

Table-V-6. Ratio of forest land by local division.

No. local div.	A1	A2	A3	M	M2	M3	B1	B2	E	Total
1	9,207	80,753		5,150	54,014		416	74,079		223,619
2	232,910	1,145,384	534,701	83,281	279,789	132,554	464	79,186	54,536	2,542,805
3	86,213	436,040	161,537	59,077	84,780	7,492	258	47,360	18,790	901,547
4	158			14,357	7,739	9,129	48	14,904		46,335
5	11,232	116,993	6,970	64,455	596,353	161,773	543	53,668	87,349	1,099,336
6	878		5,438	58,830	445,385	860	756	31,313	16,913	560,373
7	113	13,196		51,003	333,834	2,331	579	33,295	42,757	477,108
8	6,911	182,088	73,684	31,156	172,611		679	18,201	38,119	523,449
9	47,586	394,337	62,960	55,843	187,145		441	40,118	32,295	820,725
10	93,011	666,832	38,527	50,622	133,886	53,304	61	39,870	27,937	1,104,050
11		171,623	61,275	25,306	120,988	8,935	54	20,068	42,972	451,221
12	70,163	432,386		45,843	99,722		72	30,264	10,333	688,783
13		20,506		18,045	73,864			3,735		116,150
14	18,706	251,452	43,888	45,812	338,679	80,804	185	23,594	3,258	806,378
15	70,996	599,353	68,398	48,912	180,444	13,847	397	52,848	27,872	1,063,067
16	22,690	287,270	44,041	39,313	181,388	42,594	80	51,324	5,113	673,813
17		2,001		278	12,237					14,516
Total	670,774	4,800,214	1,101,419	697,283	3,302,858	513,623	5,033	613,827	408,244	12,113,275

Table-V-7. Stock (m^3) by local division.

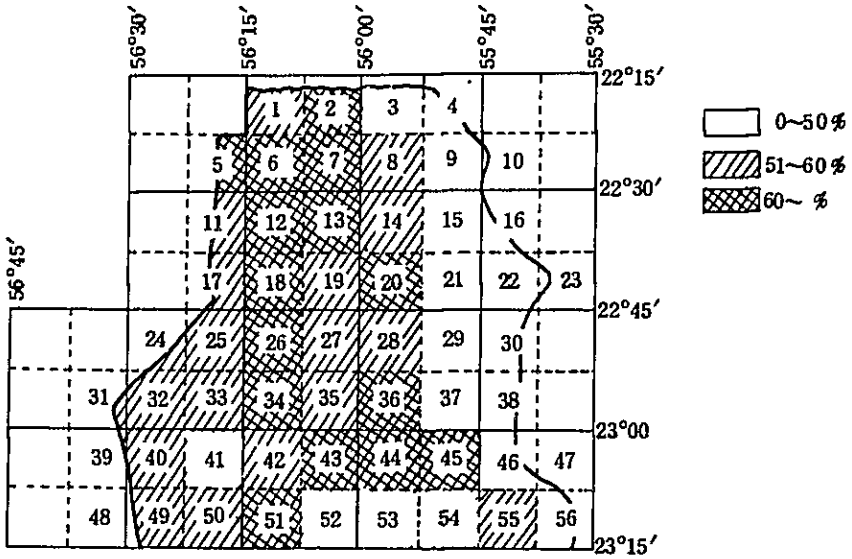


Figure-V-2. Ratio of forest land by block division.

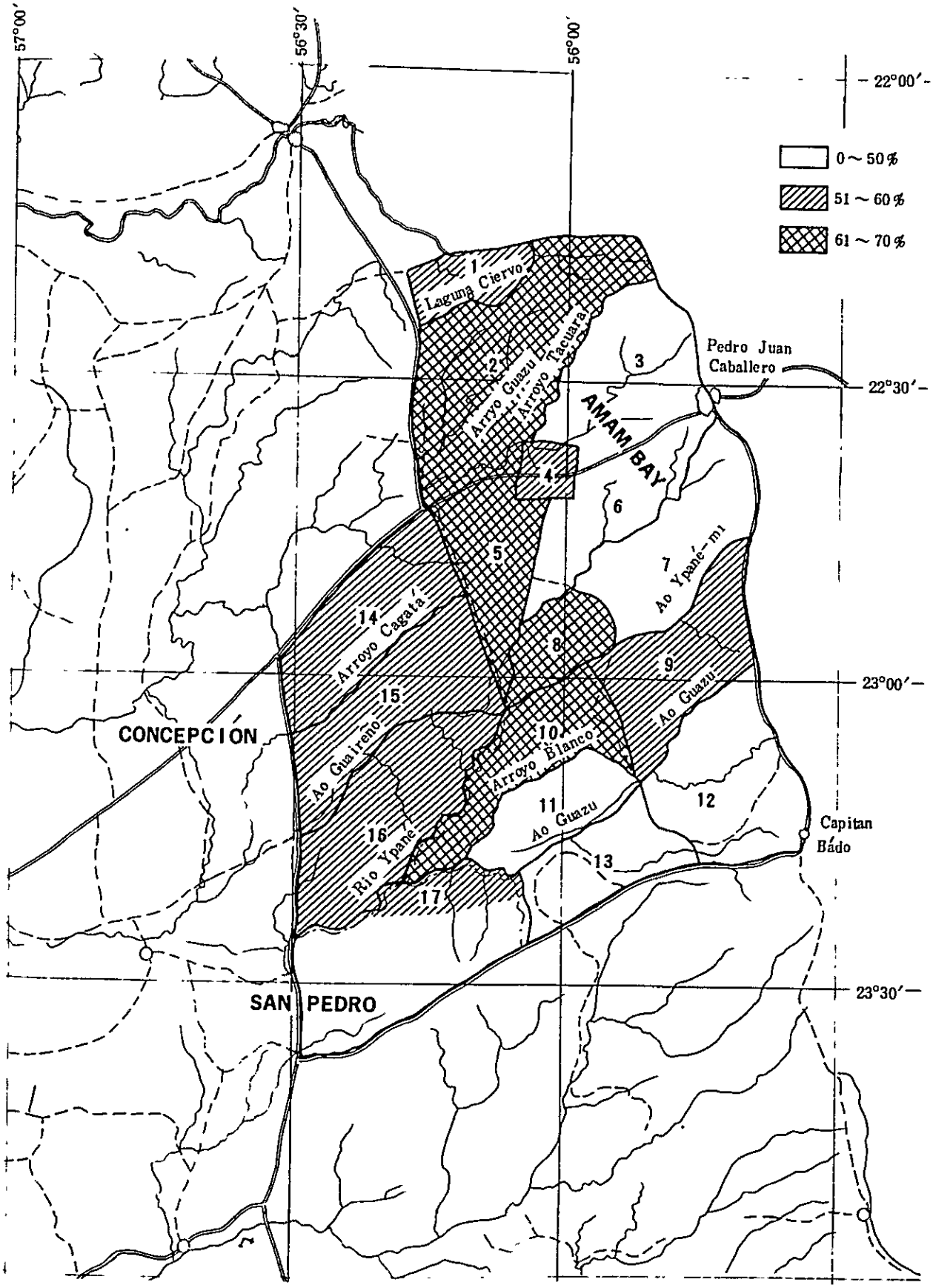


Figure-V-3. Ratio of forest land by local division.

ii) Ownership

National forest

There is a national park and forest (5,300 ha) in Cerro Corá about 40 km west of Pedro Juan Caballero city. There are camp sites, Independent Plaza and a forest office which generally looks after the conservation of the forest and wild habitat.

Indian reservations

The government of Paraguay provides Indian reservations for preserving the Indian way of life. There are 26 Indian reservations in the department of Amambay, and among them, the largest area is 12,000 hectares, and the smallest 300 hectares. The ownership of the reservations is registered as belonging to the Association of Paraguay Indians (Asociacion, Indigena del Paraguay). Therefore, they must pay a land tax, but now there are negotiations for a new law to exempt them.

The reservations include quite a bit of forest, but there are also cultivated fields, pastures, and so on. The chief of the reservation governs the other Indians' lives and can decide logging timbers. However, there is a law which prohibits extraction, logging, or sale of timber except for the timber the Indians use themselves.

Private forests

Most of the forests in the study area are privately owned. About ten years ago, Brazil demanded that Peroba be valued the same as in their markets, and the market value was rapidly increased. Therefore, huge forests in the study area were destroyed and changed into farms or pastures. But now, inflation in Brazil is high, and the market for timber is slack.

That is, the logging of Peroba is also decreasing, but by a little bit.

VI. PLANNING IN 1982

We have established the procedure and methodology for the forest resources inventory, and we will do the total forest resources inventory of 1,500,000 hectares next year using them. We believe that the procedure and methodology are accurate enough to estimate the total volume.

In addition, we will investigate other methodologies for the purpose of making full use of them in the future. This is because the study area has the remarkable feature of possessing much Peroba, being close to Brazil and finally being a big forest zone in Paraguay.

VI-1 Estimation of mean and standard deviation

The comparison of mean and standard deviation as results of the sample plots and as expected before the field survey is shown in table-VI-1.

Photo-stratum		A1	A2	A3	M	M2	M3	B1	B2	E
Mean per hectare (m^3)	Result of sample plots	23	38	77	10	31	28	0	19	22
	Expected value	30	70	90	15	30	30	2	5	30
Standard deviation (m^3)	Result of sample plots	5	15	50	8	9	13	0	13	17
	Expected value	25	35	30	10	20	30	2	5	30

Table-VI-1. Comparison of expected and resulted mean and standard deviation.

All of the values for the expected mean except B2 are higher than for the results of sample plots. This is because the mean values for the results are calculated without the bark, while, the expected mean includes the bark since it was calculated from the preliminary sample plots. In addition, they were exploited more than we expected, especially the tall forest A2, during the period between the time of the aerial photography and the field survey. Meanwhile, the low forest B2 had more volume than we expected.

This may be because the low forest B2 was close to the exploited forest E, but only the difference is its small unit area, or it might be a sampling error.

Consequently, we decided that the mean volume for the total inventory next year is mostly the middle values. However, the tall forest A2 is expected to be exploited more next year, and the tall forest A3 will be exploited only a little because of difficult access.

Most values for the standard deviation for the results of sample plots are less than for expected values except A3 and B2. This is because we classified many photo-strata, although we referred to the FAO report which has only four photo-strata. Then, we decided the standard deviation as a value close to the results of sample plots (see table-VI-2.).

Photo-stratum	A1	A2	A3	M	M2	M3	B1	B2	E
Expected mean (m^3)	25	45	85	15	30	35	1	20	20
Expected standard deviation (m^3)	15	25	45	10	15	20	1	15	20

Table-VI-2. Expected mean and standard deviation for the total study area (1,500,000 ha).

VI-2 Renumbering sample plots

We calculated the accuracy of the study according to the FAO, which adopted t = 1 (so-called, the confidence limit is at 68 percent as statistic term) and e = 0.1 (the permitted error is at 10 percent) for the forest resources inventory on southeastern region in Paraguay. Then, we are satisfied with the accuracy of the study. The reasons for high accuracy are: (1) more photo-strata were classified, and (2) the standard deviation of the photo-strata was mostly estimated as higher than in the results.

The "optimum allocation" is not influenced by area, but the accuracy depends on the mean and the standard deviation

with the weight (the ratio) of the photo-strata. Then, we expect that the ratio of the photo-strata in the total study area (1,500,000 ha) is not so different from this study area (780,000 ha).

However, photo-interpretation can classify only by crown, height, and density. Meanwhile, the tree volume depends on the D.B.H. and the commercial height. And, the relationship among them is expected to fluctuate with factors depending on species and local differences. Therefore, we must better confirm the mean and the standard deviation for each stratum and must calculate the new numbers for sample plots.

In addition, the study area has the remarkable feature of possessing much Peroba, being close to Brazil, and finally being a big forest zone in Paraguay.

Therefore, we require that the final goal of accuracy should be 90 percent of the confidential limit (t = 1.67), and 10 percent of the permitted error.

Then, the final number for sample plots in the total study area (1,500,000 ha) is calculated as follows;

	Sh	$\bar{Y}h$	Wh	Wh·Sh	Wh·$\bar{Y}h$
A1	15	25	0.070	1.050	1.750
A2	25	45	0.295	7.375	13.275
A3	45	85	0.034	1.530	2.890
M	10	15	0.160	1.600	2.400
M2	15	30	0.248	3.720	7.440
M3	20	35	0.044	0.880	1.540
B1	1	1	0.029	0.029	0.029
B2	15	20	0.076	1.140	1.520
E	20	20	0.045	0.900	0.900
Total				18.224	31.744

Table-VI-3. Calculation for renumbering sample plots.

$$n = \frac{1.67^2 \times 18{,}224^2}{0.1^2 \times 31{,}744^2} \fallingdotseq 92$$

VII. DISCUSSION

The field survey was done from September to November in 1981, and our experience included several important items in carrying out the field survey. Then, we must ascertain what forest resources will be inventoried and how it will be prepared to be most useful for Paraguay in terms of economy, natural resources, and political management.

We will discuss the points below.

VII-1 Forest situation

Since exports of raw materials were prohibited in 1972, the plant capacity of the sawing industry has rapidly increased, and logging also increased, especially because of a lack of timber in Brazil and Argentina.

Now, sawing mills are sometimes using logs with a smaller diameter, and this is expected to increase, because there are not so many big trees, and good trees in the forest.

Therefore, we must consider not only how good forest resources can be conserved, brought up, or cultivated, but also how the timber can be logged and what it can be used for.

i) Burning forests

There is no shifting cultivation, because they say that the soil is comparatively rich for cultivation in the study area.

However, there is much converting of forests to farms or pastures because of rich soil. The pattern of conversion is that first it is logged for commercial timber, and then they burn the forest. And then, the commercial trees remaind after burning are logged and floated before clearing the ground for pasture or farmland. Burning is done three or four times in general, and sometimes spreads to other forests near by.

There is a forest law in the books (in Vol.422, Ch.6,

Article of 42) stating; "A owner of more than 20 hectares of forest area must keep 25 percent of the forest land in disuse. If the owner can not maintain the 25 percent minimum, he must reforest 5 percent of the forest land". We observed small forest in disuse in old pastures and old farms, although we could not confirm which were decided as forest areas and the scale owned as a forest area. However, we could not recognize them in new pastures and new farms.

In 1975, the Central Bank of Paraguay reported that the species of Lapacho, Cedro, and Peroba occupied 76.5 percent of the total sawing timber. Therefore, we suppose that the other species are mostly burned up. In the study area, we noticed only Peroba and Lapacho as logging timber.

ii) Land use

Exported goods are mostly accounted for by livestock, forest products, and agricultural products in Paraguay.

In 1973, the Ministry of Agriculture and Animal Husbandry of Paraguay and the FAO reported the land use at present and in 2000 as in the following table-VII-1.

Land use	Area (hectares)		Percentage	
	1973	2000	1973	2000
Agriculture	958,000	4,000,000	2.36	9.83
Livestock	14,850,000	25,000,000	36.51	61.42
Forestry	23,924,000	8,900,000	58.81	21.87
Others	944,000	2,800,000	2.32	6.88
Total	40,676,000	40,700,000	100.00	100.00

Table-VII-1. Prediction of land use in 2000.

In table-VII-1, forest land occupied 59 percent in Paraguay 1973, but it will occupy only 22 percent (about a 1,500,000 ha decrease) in 2000. The rate of forest decrease is 2.3 percent every year.

Meanwhile, we analyzed part of the study area as in the following figure-VII-1 and figure-VII-2. (see REPORT ON THE LANDSAT ANALYSIS, THE FOREST RESOURCES INVENTORY IN THE NORTHEASTERN REGION, THE REPUBLIC OF PARAGUAY 1981)

In figure-VII-1, forest land was at 94 percent 1968, but it decreased to 69 percent in 1980. The rate of forest decrease is 2.1 percent every year. However, figure-VII-2 shows that the rate of forest decrease during 1975 to 1980 was 4.6 percent every year. This suggests the probability that forest land will be less than expected forest land in 2000 from table-VII-1.

Recently, unusual weather has been occurring in the world, and in Paraguay too, droughts, cold weather, and frost damage frequently occur. They say, it is because of deforestation. Forests have many qualities for humans, for example, forest products, controlling watersheds, protection of erosion, and recreation. Therefore, forests should be acknowledged for their entire qualities, and should be treated with careful and useful planning.

VII-2 Field survey in 1982

i) Season

The field work in 1981 was so trying because of hot weather and many insects. Fortunately, we did not encounter many rainy days because of unusual weather. In general, the weather of Paraguay is cooler and less rainy from June to September. Therefore, the field work would be easy during June to September because of cool weather and few insects. In addition, the schedule of the field work would be more exact because of less precipitation. This is a key point in the schedule, because we usually move from one sample plot to another over a long distance by vehicles. But if it is rainy, the vehicles can not get through on dirty roads which have turned to mud. The roads are not paved

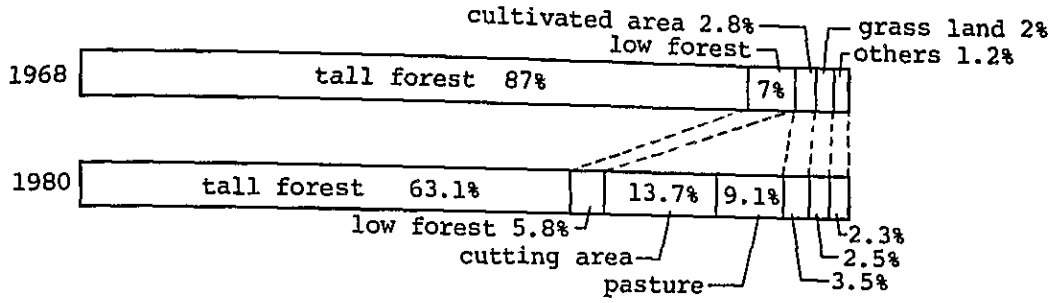


Figure-VII-1. Comparison of land use between 1980 and 1968.

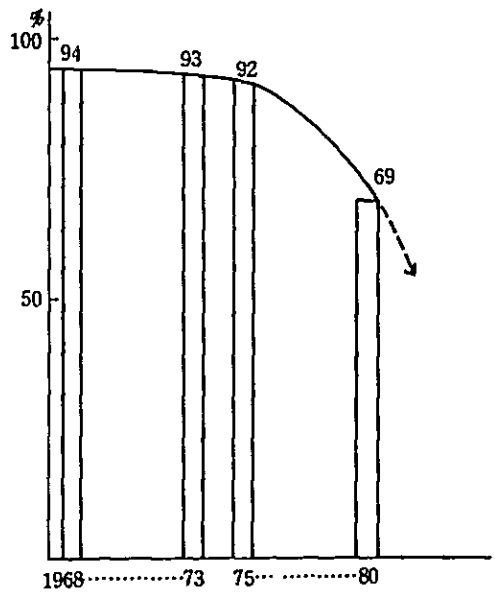


Figure-VII-2. Pattern of changing forest land.

and are clay soil. In addition, we frequently cross rivers with no bridges. But we can not cross them on rainy days.

Therefore, we should do the field survey from June to September.

ii) Safety

The study area is close to the border between Paraguay and Brazil. In general the public peace and order in, urban areas close to border is not maintained. The study area is also such an area. We sometimes heard that there are drug dealers, burglars, and thieves. Therefore, we must discuss the safety treatment with the government of Paraguay and will need exact and timely information for a changed situation for staying in the study area, although we can not avoid several restrictions in the field.