THE FOREST RESOURCES MANAGEMENT STUDY IN THE REPUBLIC OF COLOMBIA

PROGRESS REPORT II

DECEMBER, 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)

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1. INTRODUCTION

1.1 Background of the Study

This Progress Report II compiles all the findings and survey results upto and including the forest resources management plan basic surveys which were completed in fiscal 1990 (3rd year of the Forest Resources Management Study in the Republic of Colombia).

The Study in question has been implemented in accordance with the S/W agreed upon between INDERENA and JICA on July 13th, 1988. While the study period was originally planned for 3 years, this has now been extended by one year due to various reasons.

The ultimate purpose of the Study is the preparation of forest resources management guidelines as well as a model forest management plan for forest areas in Caldas Province. Remote sensing data analysis, aerial photography and mapping and surveys related to the forest resources management plan were planned to achieve this purpose.

The remote sensing data was analysed to determine the current conditions of forest distribution and land use in the 1.6 million ha of the Central Forest Reserve. The relevant field survey was conducted in fiscal 1988 (1st year) and the Remote Sensing Data Analysis Results Report was prepared in Japan in fiscal 1989 (2nd year) and submitted to the Government of Colombia.

The aerial photography and mapping of the 200,000 ha of the Intensive Area were conducted to prepare forest base maps for the forest resources management plan and the maps were completed in fiscal 1990 (3rd year).

With regard to the forest resources management plan, the preliminary study was conducted in the 1st year and the findings of this preliminary study were compiled in Progress Report I in Japan in the 2nd year which was duly submitted to the Government of Colombia. Basic surveys were subsequently conducted two times in Colombia and the findings of these surveys have now been compiled in this Progress Report II.

The scheduled activities of the 4th year are the preparation of forest resources management guidelines as well as the model forest resources management plan following

the completion of a plan preparation survey and field verification of the plan contents. The contents of the draft final report incorporating the guidelines and the model plan will be explained to the Colombian side and the opinions expressed by the Colombian side and the opinions expressed by the Colombian side on the draft final report will be referred to in the preparation of the final report in Japan.

1.2 Purpose of the Study

The purpose of the Study is to analyse Landsat data on the Central Forest Reserve in the Andes Region of Colombia, to prepare base maps using newly taken aerial photographs and to formulate forest resources management guidelines and a model forest resources management plan to be used for forest areas in Caldas Province in order to establish the most appropriate system for implementing forest resources management in the Republic of Colombia.

1.3 Subject Area of the Study

The subject area of the Study consists of the following 3 types of areas which are all related to the Central Forest Reserve in the Andes Region in Colombia.

(1) Study Area

1.6 million ha of the Central Forest Reserve stretching long and narrow in the north-south direction where the general survey on the forest and land use conditions was conducted using Landsat data (see Fig. 1-1).

(2) Intensive Area

An area of some 200,000 ha within the Study Area and subject to aerial photography, preparation of topographical maps and preparation of forest resources management guidelines (see Fig. 1-2).

(3) Model Areas

A total of 20,000 ha in 3 separate areas within the Intensive Area are chosen as the Model Areas where forest inventory, soil and socio economic surveys are conducted. Those areas are marked out as the subject areas for the model forest management plan to test the working of the forest resources management guidelines. These 3 areas are the national forest zone at the ridge of the Central

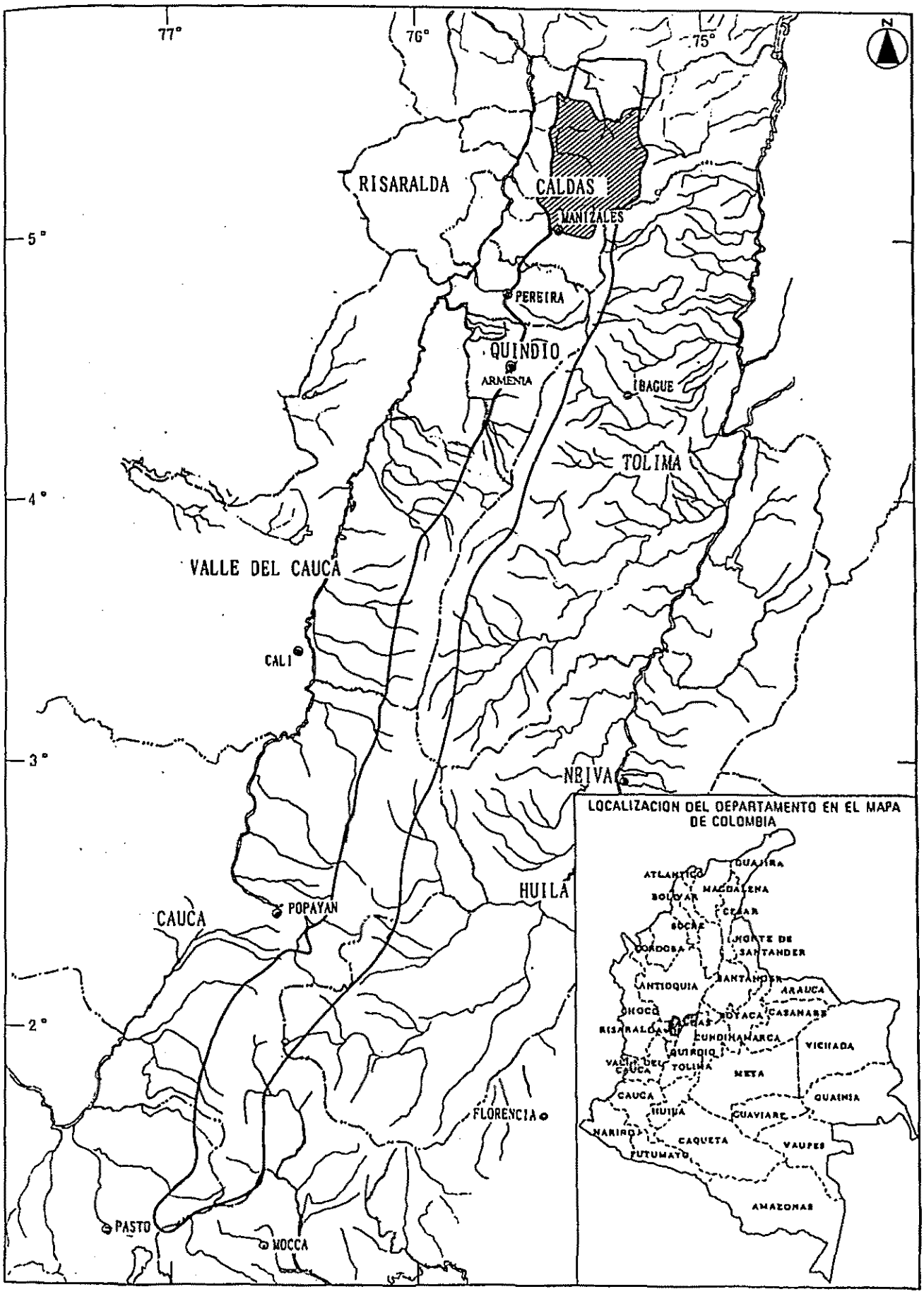


Fig. 1 - 1 Subject Area of the Study

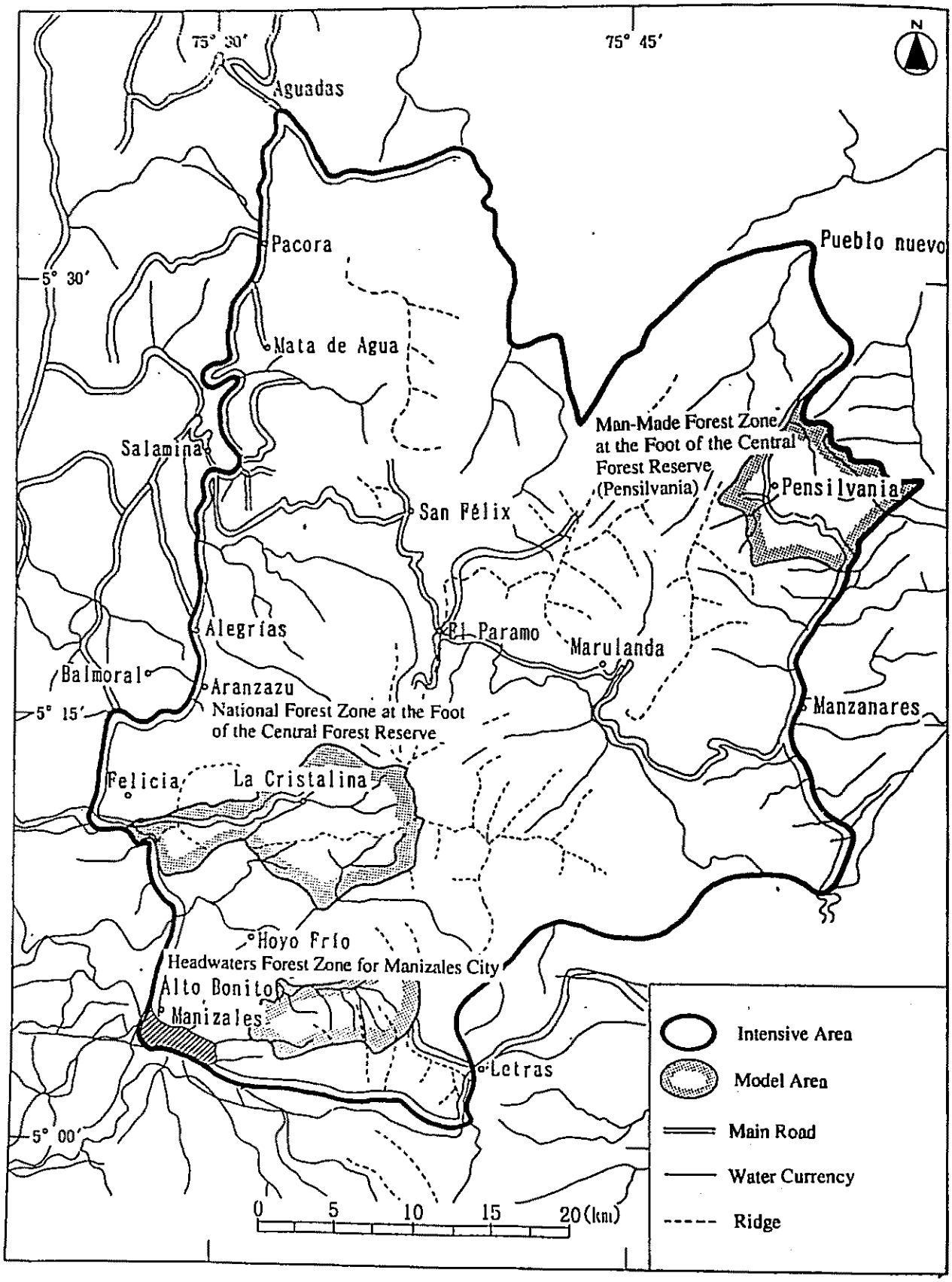


Fig. 1 - 2 Intensive Area

Forest Reserve (Río Tapias Model Area), the headwaters forest zone for Manizales City (Manizales Model Area) and the man-made forest zone at the foot of the Central Forest Reserve (Pensilvania Model Area).

1.4 Outline of the Study

The surveys and work conducted in each year are outlined below.

(1) Fiscal 1988 (January, 1988 - March, 1989)

① Aerial Photography

While it was originally planned to complete all the aerial photography of the Intensive Area by the end of March, 1989, some areas were not photographed due to bad weather.

② Preparation of Forest Base Maps

A control point survey was conducted to identify the points for mapping.

③ Remote Sensing Data Analysis

A field investigation in connection with the remote sensing data analysis was carried out.

④ Forest Resources Management Plan Survey

A preliminary survey for the forest resources management plan was conducted.

(2) Fiscal 1989 (April, 1989 - March, 1990)

① Aerial Photography

The aerial photography was continued until February, 1990 when the photography of 1,730 km^2 (86.5% of the originally planned 2,000 km^2) was completed. It was then decided that the photography of the remaining 270 km^2 (either not photographed or photographed but covered by clouds) would be abandoned.

② Preparation of Forest Base Maps

a. An aerial triangulation survey was conducted for the Intensive Area to prepare the forest base maps using new aerial photographs (half of the subject area had been photographed by this time) and the existing photographs taken by the IGAC between 1974 and 1978.

b. Detailed mapping as part of the mapping process for the forest base maps was conducted and the preliminary basic maps were completed.

③ Remote Sensing Data Analysis

The Landsat data were analysed and the Remote Sensing Analysis Report was prepared.

④ Forest Resources Management Plan Survey

a. The findings of the preliminary survey were compiled in Progress Report I.
b. Basic surveys for the formulation of the forest resources management plan were conducted, mainly on the Pensilvania Model Area for which the aerial photography had already been completed.

(3) Fiscal 1990 (April, 1990 - March, 1991)

① Preparation of Forest Base Maps

The areas plotted on the preliminary basic maps completed in fiscal 1989 using the existing photographs were further detailed with data contained in the new photographs. These preliminary basic maps were further edited and drafted to prepare the forest base maps. With regard to the unphotographed areas, plotting was based on the existing photographs. The plotting of those areas covered by clouds in both the existing and new photographs was based on the survey maps (scale: 1: 25,000) prepared by the IGAC.

② Forest Resources Management Plan Survey

a. Basic field surveys for the formulation of the forest resources management plan were mainly conducted for the remaining model areas, i.e. Río Tapias Model Area and Manizales Model Area.
b. Based on the analysis results of the survey findings in fiscal 1989 and fiscal 1990, the first drafts of the forest resources management guidelines and the forest resources management plan, forest type maps, draft soil maps, draft land use plan maps and Progress Report II were prepared.

(4) Fiscal 1991 (April, 1991 - March, 1992) (Schedule)

a. A survey for the preparation of the forest resources management plan will be conducted.
b. Based on the findings of the above survey, the second drafts of the forest resources management guidelines and forest resources management plan will be prepared.

c. A field verification survey will be conducted based on these second drafts.
d. The forest resources management guidelines for the Intensive Area and the model forest resources management plan for the Model Areas will be formulated based on the findings of the above verification survey.
e. Soil maps, land use plan maps, model forest resources management plan implementation maps and forest inventory books for the Model Areas will be prepared.
f. The draft final report will be explained to the Colombian side.
g. The final report will be prepared based on the results of the explanation of the draft final report.

Fig. 1 - 3 shows the flow of the surveys and other work described above.

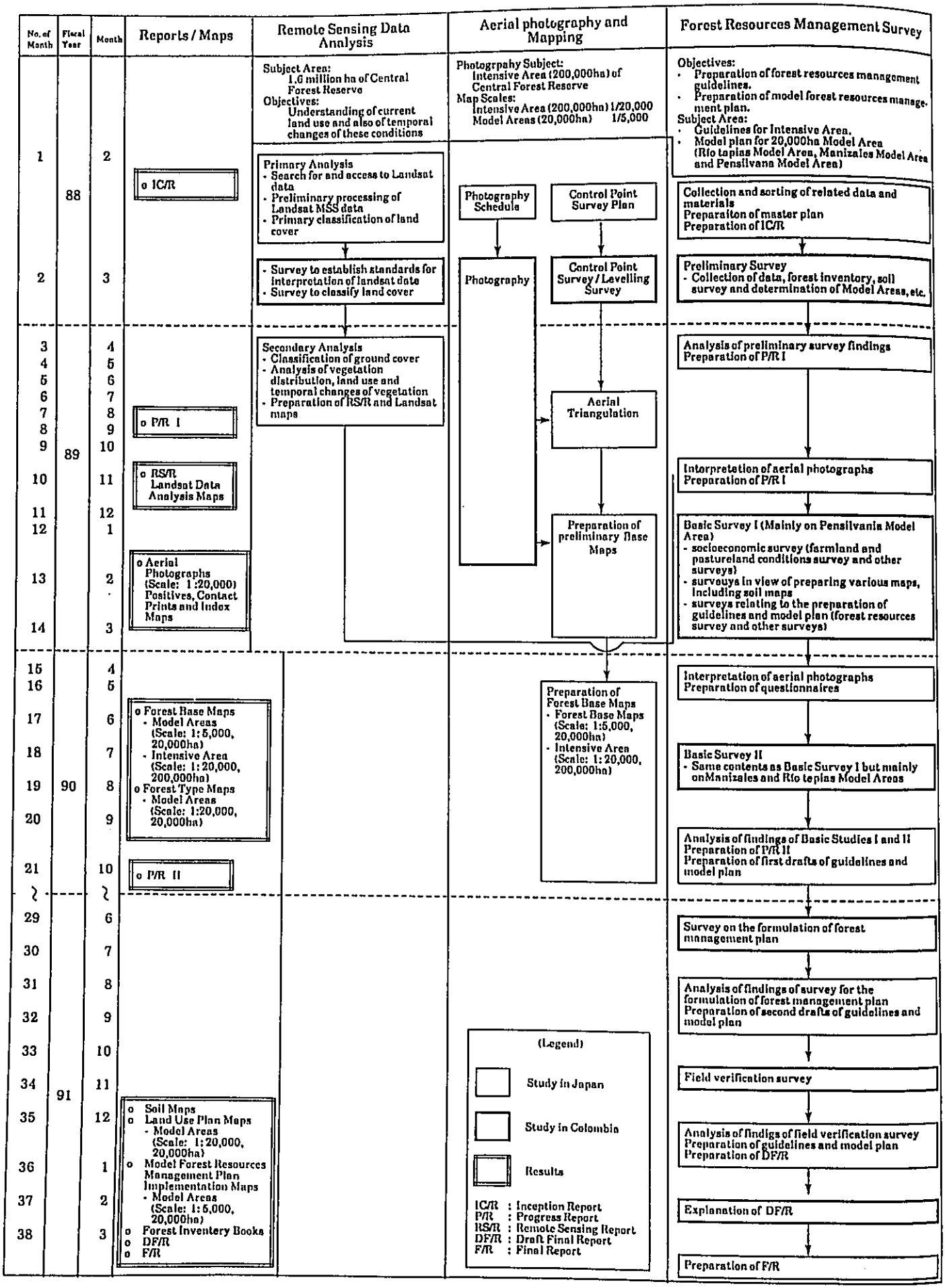


Fig. 1-3 Flow Chart of Surveys and Other Work

2. INDIVIDUAL SURVEY RESULTS

2.1 Socioeconomic Conditions Surveys

2.1.1 General Socioeconomic Survey

An interview survey was conducted in 9 cities (Manizales, Manzanares, Pensilvania, Marulanda, Aguadas, Pacora, Salamina, Aranzazu and Neira) and at the CRAMSA, etc. in Caldas Province in the Intensive Area to obtain knowledge on the general socioeconomic conditions of the Intensive Area. The survey items included the existence of a local development plan and the current conditions of industries, economy, society and infrastructure, etc. and the survey results are described below.

(1) Local Development Plan

Half of the cities surveyed have their own development plan although they have not yet been implemented. In particular, Pensilvania has an urban development plan which was jointly prepared by the community and the municipal government and the SENA and the plan covers diverse fields, including erosion control, drinking water supply, road construction and management, education, countermeasures for unemployment, adjustment of consumer prices, housing improvement, improved electricity supply and park construction and some parts of the plan have already been implemented. At Salamina, the preparation of a land conservation plan is in progress by the CRAMSA. In general, the water and electricity supply conditions in the Intensive Area are good while the road conditions are poor despite gradual improvement over the years. All the municipal governments hope to prepare and implement a comprehensive development plan which stresses on the consolidation of such infrastructure as housing and roads but the lack of sufficient funds has delayed the implementation of concrete steps towards plan formulation.

(2) Socioeconomy

Private land ownership is common. In Neira, as farmers tend to sell their land due to hardship, there appears to be a trend towards the concentration of land ownership. Most inhabitants of the Intensive Area earn their living solely from farming and/or stock raising and their income level is somewhere in the region of Colombia's middle to low income levels. The minimum monthly wage at present is 43,000 pesos per person (March, 1990), an increase of 32.6% on the 32,560 pesos per person one year ago (March, 1989). Given the estimated annual price increase of food of 37.1% based on a 17.1% increase over a 6 month period between

between February and August, 1990 observed at a supermarket in Pensilvania, life is generally getting harder. The demographic data show a population outflow of young people from rural areas to such large cities as Bogota and Manizales for better employment or educational opportunities. As a result, the population of most of the cities surveyed is showing a slightly declining trend. The unemployment rate is generally 10 - 15%, except during the coffee bean harvest season in Pensilvania.

(3) Industries

The main industries in the Intensive Area are agriculture and stock raising with more than 80% of the population being engaged in these industries. The leading farm products are coffee and sugar cane. As little idle land is available, the slash-and-burn method of agriculture is employed on only a minor scale. Cattle raising on vast ranches is extensively conducted with 1ha of land being allocated per head. There is no strong desire to change the work as agriculture and cattle raising are long established local industries. In Aranzazu, however, a new trend is observed where the grassland is being transformed to orchards due to the rapid price increase of land and the appropriateness of the land for such a new venture.

In the field of forestry, only small privately owned timber mills exist in most areas and forestry activity in the Intensive Area is generally poor except in Manizales and Pensilvania. Afforestation assistance is only provided on a small scale by the CRAMSA and volunteer organizations. The afforestation record is poor and the degree of dependence of the Intensive Area on forestry is low. In Pensilvania, however, 3 timber companies are in operation and the number of full-time workers is constantly some 150. Pensilvania considers the promotion of forestry to be one of its basic policy objectives and plans a large-scale afforestation project. More than one afforestation company in Manizales are on the road to successful forest management based on a short rotation period.

2.1.2 Local Inhabitants and Forest Survey

An interview survey was conducted on 32 households mostly located in the Model Areas which use the forests for their livelihood in order to obtain knowledge on the attitude of local inhabitants to the forests. The survey items included the actual form of use of trees, slash-and-burn method of agriculture (migrating agriculture), deforestation and awareness of forest functions.

The subject households included 6 households with permanent residence as administrative staff members in the headwaters forest zone and one household engaged in forestry work. All the other households are engaged in either agriculture or stock raising with no relation to forestry. The survey findings are as follows.

(1) Forest Products

The 6 households of the administrative staff members in the headwater forest zone in Manizales and the one household engaged in forestry work in the Pensilvania Model Area produce charcoal, wood piles and sawn timber to sell in the market while all the other interviewed households only produce firewood, charcoal, wood piles and shade trees for their own use. The proportions of households engaged in the production of forest products and the main species used are given in Table 2-1-1 and Table 2-1-2 respectively.

Table 2 - 1 - 1 Proportion of Households Engaged in Production of Forest Products

(Unit: %)

Model Area	Firewood	Charcoal	Wood Piles	Shade Trees	Sawn Timber
Río Tapias	88.9	11.0	77.8	55.6	0
Manizales	80.0	0	30.0	0	0
Pensilvania	76.9	7.7	15.4	30.8	7.7

Note: The production of charcoal, wood piles and sawn timber by the administrative staff in the Manizales headwater forest zone is not included in the Table.

Table 2 - 1 - 2 Tree Species in Use for Forest Products

Product	Model Area		
	Río Tapias	Manizales	Pensilvania
Firewood	Guamo, Arboloco, Cafe, Aliso, Chilco	Alizo, Guayabo, Gavilan	Guamo, P. Patula, Cafe, Carate
Charcoal	Guamo	Aliso	Encenillo, Azuceno, Guayabo
Wood Piles	Guadua, Arboloco, Gavilan	Eucalipto, Gavilan, Encenillo, Aliso	Cafe, Carbonero, Guadua
Shade Trees	Guamo	-	Guamo, Carbonero
Sawn Timber	-	Aliso	Azuceno, Laurel

Note: All names are local names.

In the Pensilvania Model Area, most of the households collect firewood and wood pile materials from coffee plantations while those in the Río Tapias Model Area often use bamboo for piles.

(2) General Findings of Forestry-Related Questions

① Decline of Soil Fertility

Many of the households in the Pensilvania Model Area said that the soil fertility was declining. This decline is presumably caused by intensive land use for agriculture. In contrast, those people with extensive land use, such as those engaged in stock raising, are less aware about the decline of soil fertility.

② Use of Fertilizers

Many of the farming households use fertilizers. The chemical fertilizers mostly in use include 15-15-15 and 17-6-18-2 as well as simple urea and potassium chloride. Organic fertilizers, including coffee pulpa, are also used.

③ Sufficiency of Farming Land Size

The sufficiency of the farming land size is felt less in the Pensilvania Model Area although the desirable land size is rather small due to the inclination of those households which replied that their land holding was inadequate towards the intensive cultivation of coffee.

④ Deforestation

Most of the households in all the Model Areas said that no deforestation has taken place. This reflects the fact that most of the forests have already been transformed into either farmland or pasture land. The areas surrounding those households which answered that gradual deforestation is taking place are subject to felling all year round and soil erosion has occurred in some areas.

⑤ Recent Natural Disaster (s)

In the Pensilvania Model Area, 30% of the households said that they had had natural disasters in recent years. In the other two model areas, the answer was unanimously no. The natural disasters conceived are floods and soil erosion due to excessive felling and hardly any countermeasures have been implemented.

⑥ Afforestation Experience

The administrative staff living in the Manizales headwater forest zone have some experience of afforestation work as part of their maintenance work for the

headwater forest zone. In the Pensilvania Model Area, small-scale afforestation work is conducted on the coffee plantations for land conservation purposes or to obtain shade, fruit or firewood.

⑦ Understanding of Forest Functions

All the households pointed out such functions as the preservation of the headwater zone and firewood supply. Shade for pasture land is not considered unplausible due to the high elevation of the Model Areas.

⑧ Necessity for Afforestation Work

All the households are fully aware of the necessity for afforestation work.

⑨ Forestry Development Requirements

All the households pointed out the necessity for education to prevent excessive felling, distribution of sampling for afforestation and the provisions of grants. They all hope that the central government will provide technical assistance in relation to the planting and felling of trees.

2.1.3 Market Distribution Survey

An interview survey was conducted at sawmills and furniture factories in the Intensive Area and at a paper mill in Cali outside the Intensive Area to obtain a proper understanding of the current conditions of forest product prices and the timber distribution mechanism. The survey findings are described below.

(1) Distribution Inside Intensive Area

There are no large sawmills or large furniture factories in the Intensive Area. All the furniture factories are small with only several employees. Pro Oriente and Maderas de Oriente have sawmills in the Pensilvania Model Area and 60% of the local demand for sawn timber is met by these two mills. Crude wood is largely thinned wood from the companies' own plantations with prices ranging from 7,000 pesos/m^3 for wood with an top end diameter of 8 - 10cm, 8,000 pesos/m^3 for 12cm and 10,000 pesos/m^3 for 13 - 15cm to 12,000 pesos/m^3 for 16 - 18cm (March, 1989). The subject species are Pinus patula (P. Patula) and Cupressus lusitanica (Ciprés) and the crude wood prices are the same for both species. The end product price, however, is slightly higher for Cipres than P. Patula because of the better quality. Crude wood with a diameter upto 12cm is used to produce piles

for ranches and coal mines. Other products include construction timber, bed timber, wall timber and box timber. Bed timber accounts for 80% of the total production volume and is mainly marketed in Barraquilla and Bogota. The demand for this type of timber is said to be still fairly strong.

Waste wood is used for firewood or charcoal production. The local timber standards and forest product prices are shown in Table 2 - 1 - 3 and Table 2 - 1 - 4 respectively. As a large-scale afforestation plan is in progress in Pensilvania, it is expected that the range of locally produced forest products will expand in the future.

All the cities in the Intensive Area have several small furniture factories which obtain materials from timber dealers for the manufacture of wardrobes, beds, tables and chairs, etc. for the general furniture market.

There are several small timber wholesalers in Manizales. These wholesalers generally obtain the sawn timber of natural trees from the Pacific coast and sell it to the local furniture factories. In addition to timber form wholesalers, the factories purchase such large diameter trees as Nogal from farmers who grow them on the coffee plantations to create shade. Manizales also has a bamboo product factory and a liquor barrel factory. Farmers purchase bamboo from neighbouring provinces while the latter obtain materials (such as Roble) from the Pacific coast. The distribution network is, therefore, rather complicated as small distribution channels exist for each type of product.

(2) Distribution Outside Intensive Area

Cartón de Colombia S. A. which is located in Cali outside the Intensive Area is one of the 3 largest paper mill in Colombia. It is said that the mill produces 66,000 tons of corrugated cardboard boxes, 40,000 tons of paper bag, 36,000 tons of thick paper boxes and 32,000 tons of printing and letter paper which are marketed all over the country. The consumption volumes of the main raw materials are 250,000 tons of hardwood (Eucalyptus) and 240,000 tons of softwood (mainly pine). The raw materials are supplied by the mill's own plantation concessions along the Pacific coast and general supplies in other provinces (Pasto, Cundinamarca, Medellin, Popayan and Caldas). The average crude wood price per ton is 9,000 pesos for hardwood and 11,000 pesos for softwood (July, 1990), inclusive of the transport, felling and logging and standing tree costs.

Table 2 - 1 - 3 Timber Standards (Pro-oriente)

Standard	size (cm) Thickness	width	Product Type	Standard	size (cm) Thickness	width	Product Type
*P - 1	10	10	Construction & Structural Timber	RT	2.5	10	Construction & Bed Timber
E - 1	7.5	7.5	"	RT - 2	2.5	10	" (with chamfered surface)
B - 1	5	13	"	V - 2	2.5	5	Structural Timber
*R - 1	5	10	"	V - 3	2.5	7	"
*R - 2	5	7.5	"	C - 2	2.5	2.5	
*L - 1	5	5	"	T - 1	3	20	
*M - 1	1	8	Wall Timber				
G - 1	1	6	"				
G - 2	1	3	"				
G - 3	1	4	"				

Note: * denotes the national standard.

Table 2 - 1 - 4 Timber Prices in Intensive Area (1988)

City	Timber Type	Size Thickness (inch)	Size Width (inch)	Size Length (m)	Price (Pesos)	Species
Manizales	Listón	2.5	2.5	3	240	Sajo
	Varillón	2.0	2.0	3	100	Sajo
	Vigueta	2.0	4.0	3	600	Sajo
	Tabla	1.0	10	3	650	Sajo
	Telera	2.0	10	3	1,200	Sajo
	(Precio pulgada)				130	Nogal
	(Precio pulgada)				130	Cedro
	(Precio pulgada)				130	Guayacán
	Telera	2.0	8.0	3	1,400	Chanul
	Sobrebasa	(per 4)			100	Guadua
	Sepa				130	Guadua
	Esterilla				140	Guadua
	Revoltura Fina	1.0	24cm	3	700	Sajo
Pensilvania	Tabla	1.0	8.0	3.2	6,000 (per dozen)	Laurel, Guacamayo
	Tabla	1.0	8.0	3.2	8,000 (per dozen)	Nogal, Cafetero, Comino

Source: Precios de Productos Forestales, Proyecto Administracion Bosques Naturales, INDERENA

2.1.4 Farmland and Pasture Land Survey

An interview survey was conducted on 48 households engaged in farming and/or stock raising mostly in the Model Areas to obtain an understanding of the current conditions of both farmland and pasture land. The questioned items included the types of land ownership, size of land owned, conditions of soil conservation and types/production volumes of both agricultural and stock raising products. Additional interviews were held with owners of pasture land in the Río Tapias Model Area to obtain a better understanding of stock raising in the area. The survey findings are summarized in Table 2-1-6 and are also described for each model area below.

(1) Río Tapias Model Area

The Río Tapias Model Area consists of 10,617 ha which is all privately owned except for some 1,100 ha owned by Cementos Caldas S.A.. La Cristalina District mostly consists of pasture land of large land owners living in either Neira or Manizales. Most of the local inhabitants are caretakers and their families of ranches. Beef and dairy cattle are generally raised on the pasture land with an approximate density of one head per ha. The existing cattle species include local species, Normand (serving for both beef and milking purposes), Holstein (for milking only) and their crossbreeds. The grass species used for cattle feed are generally Kikuyo on pasture land and Imperial in the meadows. The boundaries between pasture land and roads are often marked by fences although those boundaries between pasture land and natural forests are not clearly marked. Some natural trees have been left standing, mostly along small streams in the pasture land, to prevent landslides but they are not consciously attended. Farm products for the consumption of the local inhabitants are grown using the slash and burn method. When the soil fertility grows poor, the pasture land is converted to brushland (which is eventually used for slash and burn after several years.)

In areas along the roads in the vicinity of Neira, including the downstream of Río Tapias River, and in low elevation areas near Pan de Azucal, sugar cane and coffee beans are cultivated. Platano (cooking bananas) are often planted along with coffee trees. Most of the inhabitants of these areas are also plantation caretakers who do not possess their own land.

(2) Manizales Model Area

Of the 4,429 ha of the Manizales Model Area, some 3,000 ha located to the south of Río Blanco is owned by the Manizales Municipal Public Works Bureau. The houses

of 22 maintenance staff of the headwater forest zone and one office building are scattered in this municipal land. These staff members are mainly engaged in the maintenance of man-made forests and water channels. They receive municipal wages and are provided with a house as well as 3 dairy cattle, 1 horse and small pasture land. Their houses have kitchen gardens to grow vegetables, etc. for their own consumption. Most of the pasture land is also used to grow Alunus jorullensis (Aliso). The grassland belonging to each household in this Model Area is larger than that in the other Model Area as the figure includes forest grazing land.

Some 15 farming households located in some 1,000 ha of privately owned land to the north of Río Blanco are engaged in potato cultivation as well as cattle raising. Most of them are, in fact, the caretakers of ranches and farms in the area and the real land owners are mainly merchants living in Manizales. The land use cycle in the area consists of one year's cultivation of potatoes, followed by seeding for some 4 years' use as pasture land. The caretakers receive half of the potato production on top of their set wages and use several part-time workers during the busy farming season.

(3) Pensilvania Model Area

The elevation of the central part of the Model Area, which is bordered by provincial roads stretching to La Linda in the east and Manzanares in the south, is generally low and traditional coffee cultivations is conducted using the mountain slopes.

The average land area owned by a coffee growing family is 5 - 10 ha. While this is basically a family business, some extra workers are hired during the harvest seasons, i.e. March/April and November/December (see Table 2-1-5 Main Farm Products and Cultivation Cycles in Model Areas). Because of the adoption of the intensive cultivation of such cash crops as sugar cane and coffee, the annual cash income of each household in this central area is comparatively high despite the generally small farmland size. Pasture land is spread in the surrounding high elevation ares where the population density is approximately one head per ha as in the case of the other Model Areas. Having appointed caretakers, however, most of the ranch owners live in urban areas.

Forest grazing is currently conducted by saw mills in the plantation site of P. patula as follows.

Pro-oriente S.A.	:	250 ha, 153 heads
Maderas de Oriente S.A.	:	600 ha, 30 heads

The average length of settlement of the inhabitants in the Pensilvania Model Area is longer than that of the other 2 Model Areas because of the high proportion of independent farmers.

Table 2 - 1 - 5 Main Farm Products and Cultivation Cycles in Model Areas

Season / Month / Product	Dry Season / Dry Season / Dry Season 1 2 3 4 5 6 7 8 9 10 11 12	Growing Period	Producing Area
Coffee (café)	∿∿∿	all year	C P
Potatoes (Papa)	∿∿∿∿ △------△——∿	7 - 8 months	M
Sugar Cane (Caña)	∿∿∿∿∿∿∿∿∿∿∿∿∿∿∿∿∿∿∿∿	all year	C P
Maize (Maíz)	△----△——∿∿∿∿∿∿∿∿∿	6 - 7 months	C P

Note: △·····△ Seeding Season ∿∿∿ Harvesting Season
C : Río Tapias Model Area
M : Manizales Model Area
P : Pensilvania Model Area

2.1.5 Forest Product Supply and Demand Survey

Data on the forest product supply and demand was collected from the INDERENA and other forestry-related organizations and an interview survey was conducted at these organizations to determine the current supply and demand conditions of forest products. The survey findings are described below.

(1) Timber Supply and Demand Trend in Colombia

As little statistical data is available on the timber supply and demand and as the collected data is statistically not very reliable, the reference materials presented at the meeting for the Plan de Acción Forestal para Colombia (PAFC) held in May, 1990 were used to analyse the general supply and demand of timber in Colombia.

The annual Colombian demand for timber currently stands at some 4.3 million m^3, of which 81% is used for furniture and construction while the remaining 19% is used for paper. 96% of the demand is met by domestic production (53% of which comes from natural forest while 47% comes from man-made forests) and the remaining 4% is imported in the form of final products.

Table 2 - 1 - 6 (1) Summary of Survey Findings

1989/90

Survey Item			Model Area			Remarks
			Río Tapias	Manizales	Pensilvania	
No. of Subject Households			16	16	16	
Average Years of Settlement			9.7	4.3	20.3	
Employment type (No. of House-holds)	Independent Full-time Farming		5	0	7	Inclusive of ranch
	Independent Part-time Farming		2	0	6	
	Caretakers		7	4	1	
	Others		2	12	2	
No. of Families/ Household	Total		5.3	5.3	5.4	
	Sex	Male	2.6	2.7	3.2	
		Female	2.7	2.6	2.2	
Owned Land Size (ha)	Total		286	528	235	Inclusive of commissioned labour
	Farmland		109 (11 households)	110 (13)	67 (14)	
	Grass land	Meadow	1 (1)	–	2 (2)	man-made grassland includes forest grazing land
		Man-Made Grassland	132 (11)	403 (14)	111 (13)	
		Natural Grassland	–	–	2 (1)	
	Forest	Natural Forest	44 (2)	15 (1)	53 (9)	
		Man-Made Forest	–	–	–	
Cash Income/ Household (pesos)	Agriculture		851,125	1,296,700	207,550	876,504	2,103,125	2,576,250	1US$= 500pesos
	Others		445,575		668,954		473,125		
Housing Expenses	Monthly Living Cost/ Household (Pesos/ Month)	Total	54,484 (100.0%)		59,249(100.0 %)		56,933 (100.0%)		
		Food Grain	26,982 (49.5%)		33,603(56.7 %)		13,422 (23.6%)		Inclusive of, seasonings
		Food Meat	10,962 (20.1%)		8,556(14.4 %)		10,638 (18.7%)		
		Food Vege tables	4,513 (8.3%)		7,556(12.8 %)		1,775 (3.1%)		
		Lighting & Heating	2,801 (5.1%)		390(0.7 %)		2,782 (4.9%)		
		Clothes	6,510 (12.0%)		6,407(10.8 %)		9,625 (16.9%)		
		Education	2,066 (3.8%)		1,966(3.3 %)		1,875 (3.3%)		
		Others	650 (1.2%)		771(1.3 %)		16,816 (29.5%)		

Table 2 - 1 - 6 (2) Summary of Survey Findings

1989/90

Survey Item				Model Area: Río Tapias		Model Area: Manizales		Model Area: Pensilvania		Remarks
Housing Expenses	Firewood Consumption/ Household (m^3/mth)		Fire wood	0.6599		1.0750		0.8438		converted to solid volume
	Use & Acquisition Method of Fuel (Multiple Answers)	Fire wood	Total	13 (81.3%)		15 (93.8%)		12 (75.0%)		
			Self Collection	13 (81.3%)		15 (93.8%)		10 (62.5%)		
			Purchase	–		–		2 (12.5%)		
		Charcoal		2 (12.5%)		1 (6.3%)		1 (6.3%)		
		Gas		3 (18.8%)		4 (25.0%)		7 (43.8%)		
		Electricity		9 (56.3%)		5 (31.3%)		11 (68.8%)		
		Oil		1 (6.3%)		–		6 (37.5%)		
		Candle		–		–		2 (12.5%)		
Present Conditions of Stock Raising and Farming	Annual Cash Income/Household (pesos)		Stock Raising	117,219	851,125	57,550	207,550	186,688	2,103,125	
			Farming	733,906		150,000		1,906,437		
	Stock Raising Volumes (in Numbers)		Cattle	170 (8 household)		140 (14)		97 (12)		
			Pigs	7 (5)		17 (9)		6 (3)		
			Horses	10 (5)		12 (9)		11 (7)		
			Chickens	105 (12)		161 (16)		132 (13)		
			Sheep	25 (3)		10 (2)		–		
			Rabbits	–		–		21 (4)		
			Turkeys	2 (2)		–		–		
			Geese	2 (1)		2 (1)		–		
	Farming (Planting Area: ha)		Total	101		109		69		
			Coffee	74 (4)		–		54 (11)		
			Potatoes	–		109 (5)		–		
			Sugar Cane	23 (2)		–		9 (5)		
			Maize	2 (4)		–		4 (9)		
			Plátano bananas	- (3)		–		2 (6)		
			Beans	2 (4)		- (1)		–		
			Others	Tree tomatoes (2), Cassava (1), Spring Onions (1), Fruit (1), Yuca (1), Peruvian Turnips (1), Pumpkins (1), Passionflowers (1) Rasberries (1)		Cabbages (3), Tree tomatoes (3) Passionflowers (3), Spring Onions (2), Fruit (1)		Yuca (3), Pumpkins (1), Spring Onions (1), Fruit (1)		

The timber demand has been increasing at an annual rate of 3% and it is estimated that it will reach 6.1 million m^3 in the year 2000 and 9 million m^3 in 2010. However, no plan has yet been drafted to increase the timber supply to meet such demand increases.

Some 35% of the population rely on fuelwood as their household fuel, creating an annual demand as large as 9.8 - 12.7 million m^3, of which approximately 1 million m^3 is made into charcoal. Fuelwood is mainly provided from agroforestry areas, including coffee and cocoa plantations and coppice forests in abandoned former farmland, both of which are generally located not far from the populated areas. Fuelwood is hardly supplied from natural forests or man-made forests.

The data on the timber supply and demand situation is compiled in Table 2-1-7.

Table 2 - 1 - 7 Timber Demand in Colombia

(Unit: 1,000m^3)

Year / Consumption	Present	Demand Forecast				Est. Growth Rate (%)		
	1989	1990	1995	2000	2000/05	90/95	95/00	00/05
Timber	3,116.3	3,257.2	3,859.4	3,909.4	4,146.9	3.5	0.3	0.9
Laminated Wood	189.3	208.9	325.6	479.6	576.8	9.3	8.1	7.3
Veneer or Plywood	173.5	175.5	185.8	196.8	202.6	1.2	1.2	1.2
Pulpwood	777.2	934.7	1,047.7	1,556.0	1,822.7	2.3	8.2	8.3
Total	4,256.3	4,576.3	5,418.5	6,141.8	6,749.0	3.4	2.5	3.5

Note: Converted to log

(2) Timber Supply and Demand In and Around Intensive Area

Most of the timber supply sources in and around the Intensive Area are man-made forests. In the vicinity of Manizales, harvesting from the man-made forest created by such afforestation companies as Compañia Forestal de Colombia S.A. and Maderas y Celulosas S.A. has just begun. In Pensilvania, such companies as Pro-oriente S.A., Maderas de Oriente S.A. and Agropecualia Betania S.A. are engaged in afforestation work. Some of the trees planted by these companies are already 15 - 18 years old and the production of thinned wood has commenced. The typical trees painted are P. patula and Ciprés and all the above companies have their own small saw mills. Each afforestation company in Manizales produces some 500 tons of timber a month, 70% of which is sold to Caltón de Colombia S.A. in Cali as pulpwood. The remaining 30% is sold as construction timber and wood piles, etc. to local timber wholesalers or directly to the local inhabitants.

In Pensilvania, Pro-oriente S.A. has the largest saw mill which was opened in 1987 with a sawing capacity of approximately 600m3. As already described in 2-1-3, there is a sufficient demand for the products.

The timber supply network is very complicated as there are many channels to cater for small demands. No accurate statistics are available due to the lack of an appropriate marketing mechanism.

2.2 Natural and Environmental Conditions Surveys

2.2.1 Land Use Survey

The aerial photographs were interpreted to understand the current land use conditions in the Intensive Area and Model Areas. With regard to the Model Areas, a field investigation was conducted to survey those areas which were impossible or difficult to interprete and also to confirm the interpretation results. The survey findings are described below.

(1) Interpretation Criteria

The interpretation criteria adopted are shown in Table 2-2-1.

Table 2 - 2 - 1 Land Use Interpretation Criteria

Land Use Category	Symbol	Description
Forest	N, S etc.	natural, secondary, man-made and bamboo forests, etc. (as used for forest type interpretation criteria)
Farm Forest	Ba	forest where coffee and sugar cane are planted under the shade of other trees
Coffee Plantation	Cf	coffee plantation without covering trees
Farmland	C	farmland (other than coffee plantation) including sugarcane farmland
High Altitude Grassland	Pr	natural grassland with elevation of 3,000 m or above with scattered bush
Pasture and Grassland	P	improved grassland for stock raising and natural grassland
Denuded Area	T	denuded area with outcrop of rocks and cut-over area, collapsed site
Drainage System	Ag	water area such as river and lake
Settlement	H	settlement with houses and other buildings
Road	Cm	road for vehicle traffic
Others	O	others

(2) Current Land Use Conditions in Intensive Area

The interpretation results of the land use by cities are shown in Table 2-2-2. The most dominant land use category in the Intensive Area is pasture and grassland (including high altitude grassland) which accounts for 49.7% of the total land, followed by forest use with 39.2%. Together, these two categories account for 89% of the total land. The third largest category is farmland with 4.2%. The ratio of coffee plantations is given as 1.3%. However, in view of the fact that most farm forests are used to grow coffee, the combined ratio of these categories of 4.3% should be treated as a more realistic land use ratio for coffee plantations. Pensilvania enjoys the highest forest ratio of 59.4% which is followed by Manzanares with 49.6%. Roads are not included in the interpreted area as they are shown by mere lines.

As not all the judicial areas of the subject cities are included in the Intensive Area, the areas of land use categories given in Table 2-2-2 are slightly different from those given by the official figures published by the Caldas Provincial Government or other official organizations.

(3) Land Use in Model Areas

The present land use in each Model Area is shown in Table 2-2-3. As the table clearly shows, the state of land use varies from one Model Area to another. In the Río Tapias Model Area, the proportion of forests is 45.5%, the lowest of all the Model Areas, followed by 34.6% for pasture and grassland, 9.9% for high altitude grassland, 8.0% for farmland and 1.3% for farm forests, showing a very high percentage of grassland and farmland. In the case of the Manizales Model Area, the highest forest proportion of all the three areas of 61.7% is recorded, followed by 29.2% for high altitude grassland, 8.8% for pasture and grassland and 0.8% for farmland, indicating the area's good position to preserve the headwater forests. In the Pensilvania Model Area, forests account for 49.2%, followed by pasture and grassland with 30.9%, coffee plantations with 10.5%, farmland with 4.4% and farm forests with 3.3%. This area has no high altitude grassland. The fact that it has many coffee plantations indicates the generally low elevation of this Model Area.

Table 2 - 2 - 2 Current Land Use Intensive Area

	City Name		Forest	Farm Forest	Coffee Plantation	Farmland	High Alt-Grass land & Pasture	Denuded Area	Drainage System	Settlement	Other	Cloud Cover	Total
1	Manizales	Area	7,087	95	418	988	9,006	-	-	418	-	988	19,000
		%	37.3	0.5	2.2	5.2	47.4	-	-	2.2	-	5.2	100.0
2	Neira	Area	8,430	280	163	1,211	12,442	52	-	23	-	699	23,300
		%	36.2	1.2	0.7	5.2	53.4	0.2	-	0.1	-	3.0	100.0
3	Aranzazu	Area	2,670	1,510	129	877	7,353	-	-	26	-	335	12,900
		%	20.7	11.7	1.0	6.8	57.0	-	-	0.2	-	2.6	100.0
4	Salamina	Area	5,293	1,575	570	971	24,522	-	-	67	-	502	33,500
		%	15.8	4.7	1.7	2.9	73.2	-	-	0.2	-	1.5	100.0
5	Pacora	Area	3,841	64	75	321	6,206	-	-	-	-	193	10,700
		%	35.9	0.6	0.7	3.0	58.0	-	-	-	-	1.8	100.0
6	Aquadas	Area	5,541	-	-	719	7,445	-	-	-	-	395	14,100
		%	39.3	-	-	5.1	52.8	-	-	-	-	2.8	100.0
7	Marulanda	Area	18,324	606	364	2,060	17,897	-	81	-	-	1,050	40,400
		%	45.4	1.5	0.9	5.1	44.3	-	0.2	-	-	2.6	100.0
8	Manzanares	Area	5,406	316	229	458	4,316	-	55	55	65	-	10,900
		%	49.6	2.9	2.1	4.2	39.6	-	0.5	0.5	0.6	-	100.0
9	Pensilvania	Area	23,689	1,756	718	1,037	12,568	-	40	88	4	-	39,900
		%	59.4	4.4	1.8	2.6	31.5	-	0.1	0.2	-	-	100.0
	Total	Area	80,299	6,202	2,666	8,642	101,755	52	176	629	69	4,162	204,700
		%	39.2	3.1	1.3	4.2	49.7	-	0.1	0.3	-	2.0	100.0

Table 2 - 2 - 3 Current Land Use in Model Areas

(Unit: ha)

Land Use Category	Model Area						Total	
	Río Tapias		Manizales		Pensilvania			
	Area	%	Area	%	Area	%	Area	%
Forest	4,830	45.5	2,734	61.7	2,792	49.2	10,356	50.0
Farm Forest	142	1.3	-	-	184	3.3	326	1.6
Coffee Plantation	-	-	-	-	594	10.5	594	2.9
Farmland	845	8.0	37	0.8	249	4.4	1,131	5.5
High Altitude Grassland	1,054	9.9	1,292	29.2	-	-	2,346	11.3
Pasture and Grassland	3,677	34.6	366	8.3	1,748	30.9	5,791	28.0
Denuded Area	52	0.5	-	-	-	-	52	0.2
Drainage System	-	-	-	-	-	-	-	-
Settlement	17	0.2	-	-	88	1.6	105	0.5
Road	-	-	-	-	-	-	-	-
Other	-	-	-	-	4	0.1	4	-
Total	10,617	100.0	4,429	100.0	5,659	100.0	20,705	100.0

2.2.2 Forest Type and Vegetation Survey

The current conditions of the forest types and vegetation in the Model Area were examined by means of aerial photograph interpretation. A field survey was also conducted to survey those places where the above interpretation was found difficult or impossible. The interpretation results were also checked during this field investigation. The interpretation and survey findings are described below.

(1) Interpretation Criteria

The adopted interpretation criteria are shown in Table 2-2-4.

Table 2 - 2 - 4 Forest Type and Vegetation Interpretation Criteria

Forest Type			Stand Type		
Category	Symbol	Specie Classification	Category	Symbol	Description
Natural Forest	N	Natural Forest	Crown Diameter (C)	1	small (- 10m)
	S	Secondary Forest		2	medium (11 - 15m)
				3	large (160m -)
			Crown Density (D)	1	- 10%
				2	11 - 40%
				3	41 - 70%
				4	71% -
	B	Bamboo Forest	-	-	-
Man-Made Forest	P	P. patula	Tree Height (A)	1	- 5 m
	C	Ciprés		2	6 - 10 m
	A	Aliso		3	11 - 15 m
	E	Eucalipto		4	16 - 20 m
				5	21 - 25 m
				6	26 m -
			Crown Density (D)	1	- 10 %
				2	11 - 40 %
				3	41 - 70 %
				4	71 % -

(2) Current Forest Types and Vegetation in Model Areas

The interpretation and survey findings were compiled in terms of the respective areas of forest type and vegetation categories in each Model Area (Table 2-2-5) and in terms of the respective areas of stand types in each Model Area (Table 2-2-6). As all the forests, including natural forests, in the Model Areas appear to have been subject to some degree of human activity, the distinction between a natural forest and a

secondary forest in the present survey was based on any trace of uniform regeneration after clear cutting on the aerial photographs. As a result, those natural forests showing such a trace were classified as secondary forests.

With regard to forest types, the Río Tapias Model Area has an overwhelming proportion of natural forests of 91.5%, followed by secondary forests with 4.6% and Aliso forests with 3.4%. The proportion of natural forests declines to 72.9% in the Manizales Model Area where the remaining 27.1% consists of Aliso forests. In the Pensilvania Model Area, the respective percentages are 43.5% for natural forests, 41.7% for P. patula forests, 9.5% for Ciprés forests and 5.3% for secondary forests.

In the case of stand types, natural forests with medium crown diameter and high crown density are particularly dominant in the Río Tapias and Manizales Model Areas. This stand type, however, does not exist in the Pensilvania Model Area where natural forests with medium crown diameter and degree 3 crown density are dominant, indicating the progressing stage of felling in natural forests in this Model Area.

Of various man-made forests, P. patula forests and Ciprés forests only exist in the Pensilvania Model Area while most of the Aliso forests are located in the Manizales Model Area. In the Río Tapias Model Area, the existence of young Aliso forests indicates afforestation efforts in recent years.

Table 2 - 2 - 5 Areas by Forest Type and Vegetation Categories in Model Areas

(Unit: ha)

Forest Type and Vegetation Categories		Model Area						Total	
		Río Tapias		Manizales		Pensilvania			
		Area	%	Area	%	Area	%	Area	%
Natural Forest	Natural Forest	4,423	91.5	1,992	72.9	1,217	43.5	7,632	73.8
	Secondary Forest	221	4.6	-	-	148	5.3	369	3.5
	Bamboo Forest	18	0.4	-	-	-	-	18	0.2
Man-made Forest	P. patula	-	-	-	-	1,163	41.7	1,163	11.2
	Ciprés	-	-	-	-	264	9.5	264	2.5
	Aliso	164	3.4	742	27.1	-	-	906	8.7
	Eucalipto	4	0.1	-	-	-	-	4	0.1
Total		4,830	100.0	2,734	100.0	2,792	100.0	10,396	100.0

Table 2 - 2 - 6 Areas by Forest Type and Stand Type

(1) Model Areas Total

(Unit: ha)

Stand C/A	Type D	Natural Forest		Secondary Forest		Man-Made Forest							
						P.patula		Ciprés		Aliso		Eucalipto	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
1	1	-	-	31	0.3	-	-	-	-	116	1.1	-	-
1	2	43	0.4	46	0.4	-	-	-	-	-	-	-	-
1	3	242	2.3	171	1.7	-	-	-	-	-	-	-	-
1	4	718	6.9	121	1.2	-	-	-	-	-	-	-	-
2	2	377	3.6	-	-	-	-	-	-	-	-	-	-
2	3	1321	12.8	-	-	19	0.2	-	-	18	0.2	-	-
2	4	4742	45.8	-	-	52	0.2	-	-	19	0.2	-	-
3	2	4	-	-	-	8	0.1	89	0.9	-	-	-	-
3	3	21	0.2	-	-	48	0.5	33	0.3	26	0.3	-	-
3	4	164	1.6	-	-	467	4.5	39	0.4	40	0.4	-	-
4	3	-	-	-	-	35	0.3	33	0.3	70	0.7	-	-
4	4	-	-	-	-	534	5.2	70	0.7	137	1.3	-	-
5	2	-	-	-	-	-	-	-	-	13	0.1	-	-
5	3	-	-	-	-	-	-	-	-	88	0.8	-	-
5	4	-	-	-	-	-	-	-	-	379	3.7	-	-
6	2	-	-	-	-	-	-	-	-	-	-	1	-
6	3	-	-	-	-	-	-	-	-	-	-	3	-
Total		7632	73.6	369	3.6	1163	11.3	264	2.6	906	8.8	4	-

(2) Río Tapias Model Area

(Unit: ha)

Stand C/A	Type D	Natural Forest		Secondary Forest		Man-Made Forest							
						P.Patula		Ciprés		Aliso		Eucalipto	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
1	1	-	-	31	0.6	-	-	-	-	116	2.4	-	-
1	2	1		46	1.0	-	-	-	-	-	-	-	-
1	3	31	0.6	39	0.8	-	-	-	-	-	-	-	-
1	4	634	13.1	105	2.2	-	-	-	-	-	-	-	-
2	2	330	6.8	-	-	-	-	-	-	-	-	-	-
2	3	136	2.8	-	-	-	-	-	-	-	-	-	-
2	4	3141	65.0	-	-	-	-	-	-	-	-	-	-
3	2	4	0.1	-	-	-	-	-	-	-	-	-	-
3	3	21	0.4	-	-	-	-	-	-	-	-	-	-
3	4	125	26	-	-	-	-	-	-	-	-	-	-
5	4	-	-	-	-	-	-	-	-	48	1.0	-	-
6	2	-	-	-	-	-	-	-	-	-	-	1	-
6	3	-	-	-	-	-	-	-	-	-	-	3	-
Total		4423	91.4	221	4.6	-	-	-	-	164	3.4	4	-

(3) Manizales Model Area

(Unit: ha)

Stand C/A	Type D	Natural Forest		Secondary Forest		Man-Made Forest							
						P.Patula		Ciprés		Aliso		Eucalipto	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
1	2	36	1.3	-	-	-	-	-	-	-	-	-	-
1	3	167	6.1	-	-	-	-	-	-	-	-	-	-
1	4	60	2.2	-	-	-	-	-	-	-	-	-	-
2	3	89	3.3	-	-	-	-	-	-	18	0.6	-	-
2	4	1601	58.6	-	-	-	-	-	-	19	0.6	-	-
3	3	-	-	-	-	-	-	-	-	26	1.0	-	-
3	4	39	1.4	-	-	-	-	-	-	40	1.5	-	-
4	3	-	-	-	-	-	-	-	-	70	2.6	-	-
4	4	-	-	-	-	-	-	-	-	137	5.0	-	-
5	2	-	-	-	-	-	-	-	-	13	0.5	-	-
5	3	-	-	-	-	-	-	-	-	88	3.2	-	-
5	4	-	-	-	-	-	-	-	-	331	12.1	-	-
Total		1992	72.9	-	-	-	-	-	-	742	27.1	-	-

(4) Pensilvania Model Area

(Unit: ha)

Stand C/A	Type D	Natural Forest		Secondary Forest		Man-Made Forest							
						P.Patula		Ciprés		Aliso		Eucalipto	
		Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
1	2	6	0.2	-	-	-	-	-	-	-	-	-	-
1	3	44	1.6	132	4.7	-	-	-	-	-	-	-	-
1	4	24	0.8	16	0.6	-	-	-	-	-	-	-	-
2	2	47	1.7	-	-	-	-	-	-	-	-	-	-
2	3	1096	39.2	-	-	19	0.7	-	-	-	-	-	-
2	4	-	-	-	-	52	1.9	-	-	-	-	-	-
3	2	-	-	-	-	8	0.3	89	3.2	-	-	-	-
3	3	-	-	-	-	48	1.7	33	1.2	-	-		
3	4	-	-	-	-	467	16.7	39	1.4	-	-	-	-
4	3	-	-	-	-	35	1.3	33	1.2	-	-	-	-
4	4	-	-	-	-	534	19.1	70	2.5	-	-	-	-
Total		1217	43.5	148	5.3	1163	41.7	264	9.5	-	-	-	-

Note: C: Crown Diameter, A: Tree Height, D: Crown Density

2.2.3 Forest Resources Survey

A forest resources survey was conducted too determine the amounts of the available forest resources in the Model Areas. All the forest inventory plots, surveys on which were conducted over 3 periods, i.e. February - March, 1989, February - March, 1990 and July - August, 1990, were included in the present survey and analysis. The adopted survey method and the survey findings are described below.

(1) Survey Method

Using the following criteria, every tree measurement was conducted at those forest inventory plots selected in view of forest type and stand type based on the results of the aerial photograph interpretation.

a) Plot Size ..... 0.1 ha (the standard size which can be modified depending on the topographical and other conditions)

b) Plot Shape ..... a rectangular shape of 20m by 50m

c) Survey Items ..... tree species, diameter breast height (tree of dBh 10cm and over) commercial height, full tree height, quality

d) Natural Generation Survey ..... survey on species, number and height of young trees with a diameter breast height of upto 10cm which are excluded from the every tree measurement in 3 subplots ($20m^2$: 1m x 20m) located at the 2 ends and the central part of each inventory plot
(only for Natural Forests)

(2) Survey Sites (Inventory Plots) and Locations

A total of 80 plots were surveyed represent the 3 Model Areas as well as the different types of forests as shown in Table 2-2-7. The plot locations are given in Fig. 2-2-1.

Table 2 - 2 - 7 Number of Forest Inventory Plots

Forest Type		Model Area			Total
		Río Tapias	Manizales	Pensilvania	
Natural or Secondary Forest		14	10	8	32
Man-made Forest	P.patula	-	-	16	16
	Ciprés	-	-	12	12
	Aliso	9	11	-	20
Total		23	21	36	80

(3) Survey Results

① Identified Tree Species in Natural Forests

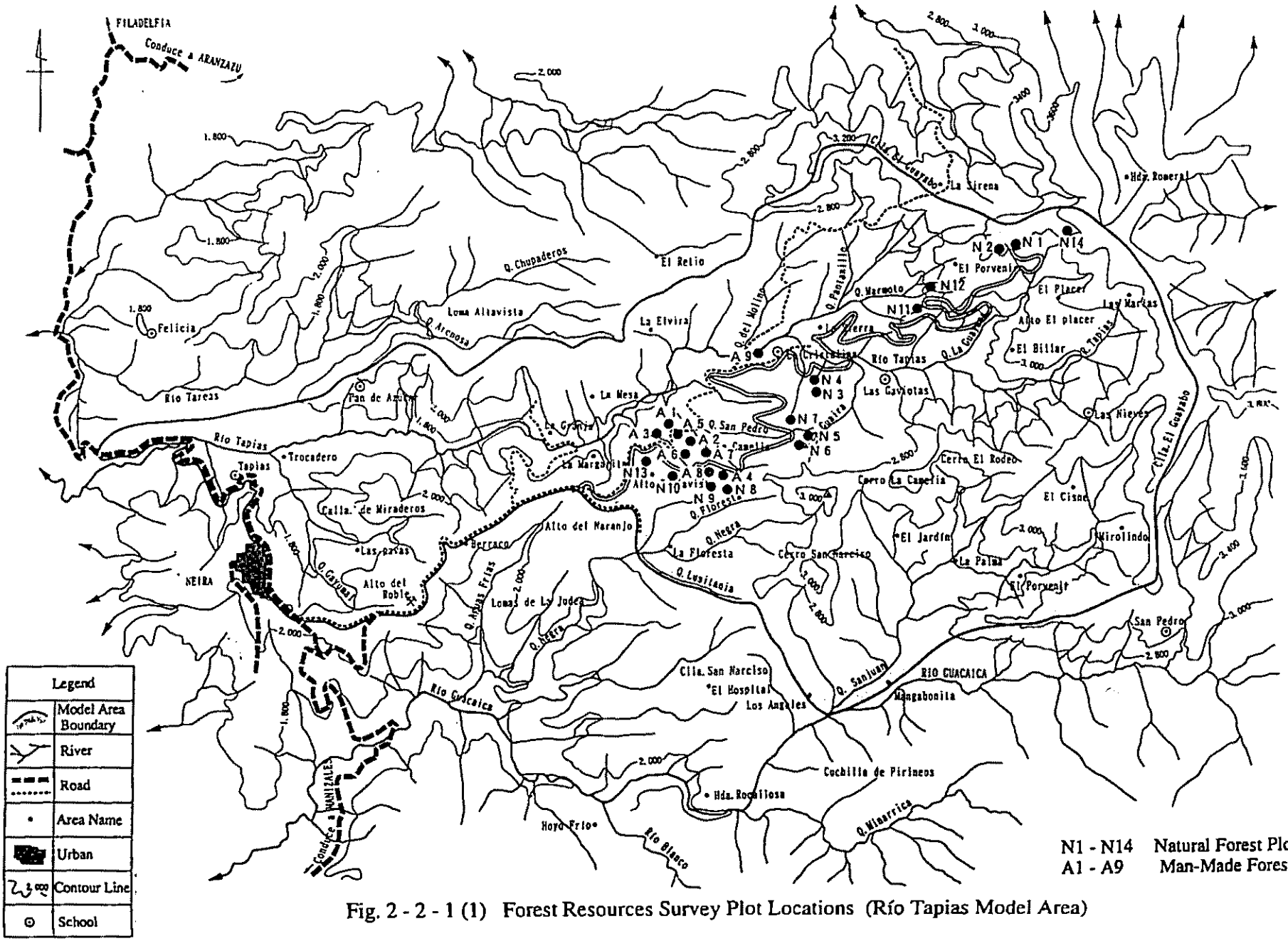
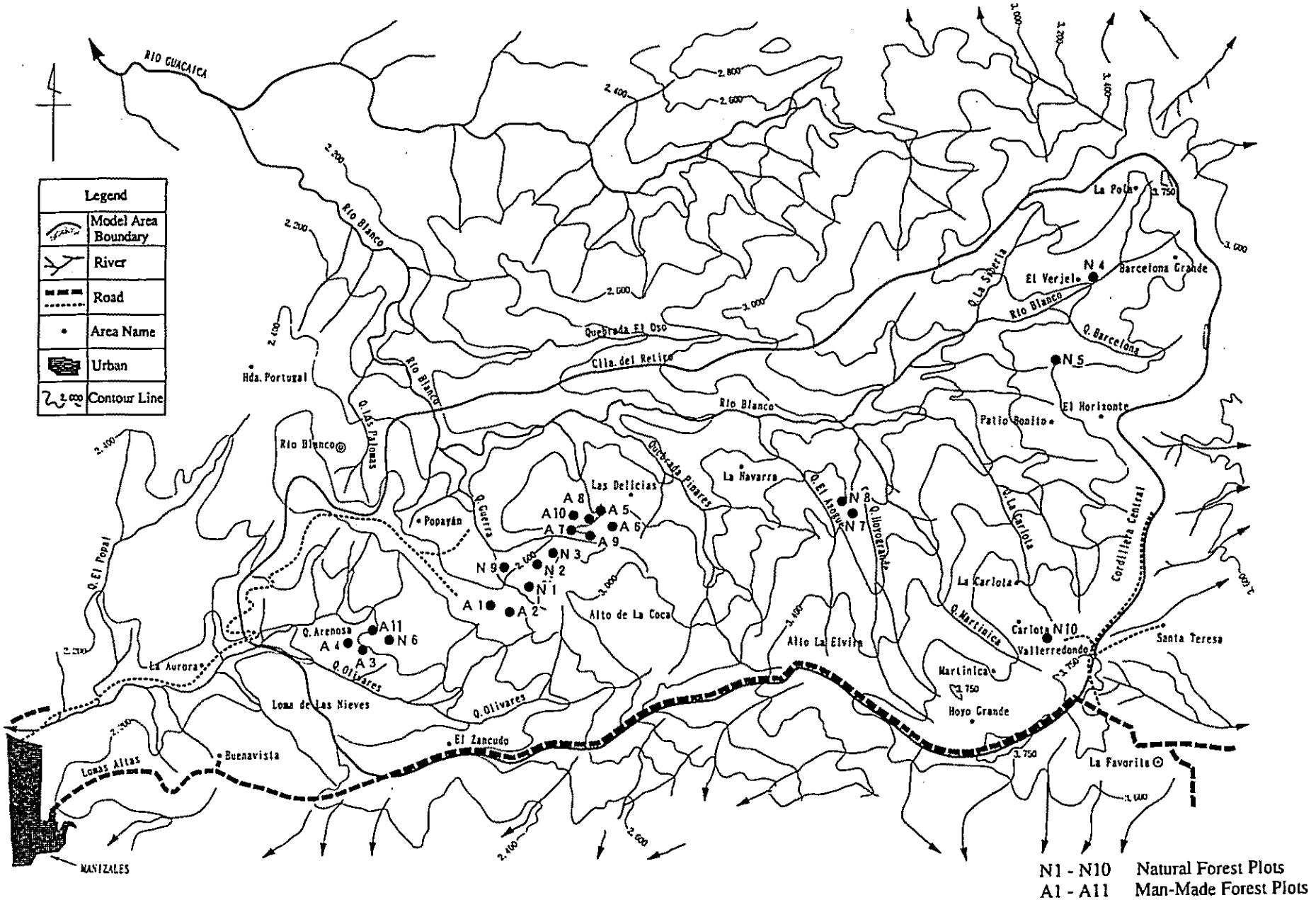


Fig. 2 - 2 - 1 (1) Forest Resources Survey Plot Locations (Río Tapias Model Area)



Fgi. 2 - 2 - 1 (2) Forest Resources Survey Plot Locations (Manizales Model Area)

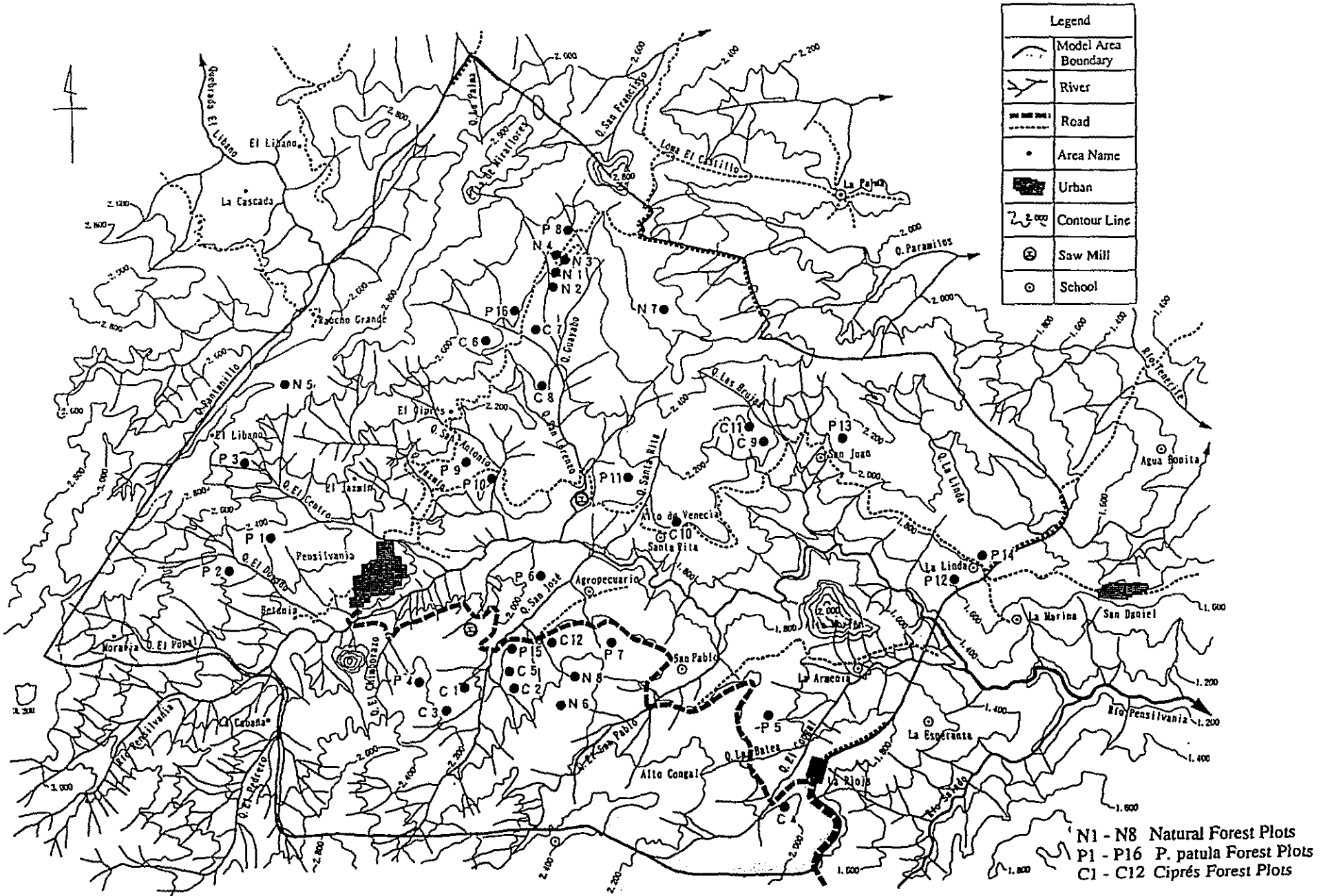


Fig. 2 - 2 - 1 (3) Forest Resources Survey Plot Locations (Pensilvania Model Area)

The assistance of CONIF (National Forest Protection Institute) technicians was enlisted to identify the tree species for the implementation of the survey in question. However, local research on species identification has made little progress. In addition to the relative scarcity of data, uncertain factors existed, including the fact that the same tree name could mean different species depending on areas. Consequently, the identification work was deliberately limited to family or genus except in the case of those trees identifiable based on reliable data. Table 2-2-9 gives a list of the species identified by the natural forest survey and the natural regeneration survey. With all the unidentified species being regarded as one species, a total of 147 species were identified.

② Calculation of Single Tree Volume in Inventory Plots

The tree volume was calculated using the equations shown in Table 2-2-8.

Table 2 - 2 - 8 Volume Equations Used

Species	Volume Equation	Source
Natural or Aliso Forest	0.0035 + 0.46 (D^2 x A)	Tablas de volumen para árboles en pie (INDERENA)
P. patula Forest	0.007799 + 0.474277 (D^2 x A)	Maderas de Oriente S.A.
Ciprés Forest	0.011704 + 0.394465 (D^2 x A)	Pro-oriente S.A.

Note: D: diameter breact height A: tree height

③ Inventory Plot Survey Findings

Data on the factors of 80 surveyed inventory plots is compiled by Model Area as well as by species in Table 2-2-10.

(4) Total Stand Volume

The total stand volume of each Model Area was estimated by firstly preparing an aerial photograph-based volume table to calculate the volume per ha of each forest or stand type using data obtained from each plot and then by multiplying this volume by the area of each stand type obtained by the forest type and vegetation survey.

① Preparation of Aerial Photograph-Based Volume Table

This process involved the estimation of the stand volume per ha using the aerial photograph interpretation elements. Based on the assumption that such elements as the crown diameter (C for natural forests), tree height (A for man-made forests) and crown density (D for both natural and man-made forests) would have a correlation

Table 2 - 2 - 9 List of Identified Tree Species (1)

Code No.	Botanical Name: Family	Genus	Local Name
10101	Actinidaceae	Saurania brachybotrys	Dulumoco
20101	Anacardiaceae	Hauria sp.	-
30101	Annonaceae	Anona sp.	Anon
30201	//	Guatheria sp.	Naranjo de monte, Cargadero
30301	//	Raimondia sp.	Anon de monte, Naranjo de monte
30401	//	Duguettia sp.	-
40101	Araceae	Xanthosoma sp.	Rascadera
50101	Arallaceae	Dendropanax spp.	Pata de danta
50201	//	Oreopanax sp.	Pata de danta
50202	//	Oreopanax spp.	-
50301	//	Schefflera sp.	Cinco dedos
60101	Betulaceae	Alnus jorullensis	Aliso
70101	Bombacaceae	Hatisia sp.	-
70201	//	Spiroteca sp.	Palo santo
80101	Boraginaceae	Cordia ferruginea	Verde negro
80102	//	Cordia spp	-
80201	//	Tournefortia spp.	Guasimo
90101	Brunelliaceae	Brunellia sp.	Rinon, Laurel, Comino, Candero
100101	Caprifoliaceae	Viburnum spp.	Cedrillo, Cedro rinon
110101	Caricaceae	Carica spp.	-
120101	Chloranthaceae	Hedyosmun bonplandianum	Silba silba, Silbo silbo
120102	//	Hedyosmun sp.	Granizo
120103	//	Hedyosmun spp.	-
130101	Clethraceae	Clethra bicolor	Chiriguaco, Cargagua
130102	//	Clethra spp.	-
140101	Compositae	Bacharis bogot	Chilco blanco
140102	//	Bacharis floribunda	Chilca
140103	//	Bacharis sp.	Chilco
140201	//	Montanoa sp.	Camargo
140301	//	Peresuia sp.	Tuno
140401	//	Polymnia sp.	Arboloco
150101	Cucurbitaceae	Sechium sp.	Bejoro
160101	Cunoniaceae	Weinmannia pinnata	Encenillo
160102	//	Weinmannia spp.	-
170101	Cyatheaceae	Cyathea arborea	Helecho arboreo
170102	//	Cyathea spp.	-
180101	Dilleniaceae	Sauraula ursina	Dulumoco
190101	Elaeocarpaceae	Valea stipularis	Campano,Raque
200101	Ericaceae	Cavendishia sp.	Uvito de monte
210101	Escalloniaceae	Escallonia mirtiflora	Chilco colorado
210102	//	Escallonia spp.	-
220101	Euphorbiaceae	Alcornia sp.	-
220201	//	Croton magdalenensis	Drago
220202	//	Croton sp.	Sangre drago
220301	//	Hyeronima sp.	Drago, Candelo
220401	//	Phyllanthus sp.	-
230101	Fagaceae	Quercus sp.	Roble
240101	Flacourtiaceae	Abatia parbiflora	Durasnillo, Velitas
250101	Gesneriaceae	Kohleria spicuta	Caracola
250201	//	Beleria sanguna	Gota sangre

Table 2 - 2 - 9 List of Identified Tree Species (2)

260101	Gramineae	Chusquea sp.	Chusque, Bambu
270101	Guttiferae	Chrysochlamis sp.	Gaque, Cabuyo, Chagualo
270201	//	Clusia sp.	Chagualo, Cucharo, Papabarbo
270301	//	Vismia sp.	Punta de lanza
280101	Hippocastanaceae	Billia colombiana	Manzano de monte, Cariselo
290101	Juglandaceae	Juglans neotropica	Cedro negro, Nogal
290201	//	Alfaroa sp.	Cedrillo
300101	Lauraceae	Aniba perutilis	Laurel comino
300102	//	Aniba sp.	Laurel
300201	//	Nectandora spp.	Laurel
300301	//	Ocotea sp.	Laurel
300401	//	Persea mutisii	Agua catillo
300402	//	Persea spp.	Agua catillo
310101	Lobeliaceae	Centropogon sp.	Cresta de gallo
320101	Loganiaceae	Buddleja bulluta	Gavilan, Gallinazo
330101	Loranthaceae	Gayaden drontagua	Cabuyo
340101	Lyperaceae	Rynchospora arisfata	Cortalera
340201	//	Bellucia sp.	Danto
350101	Melastomataceae	Blakea sp.	Niguito, Danto
350201	//	Clidemia sp.	Esmeralda
350301	//	Meriania nobilis	Danto
350401	//	Miconia smaragdina	Niguito
350402	//	Miconia theaezam	Niguito
350403	//	Miconia sp.	Mortino, Danto, Tuno
350404	//	Miconia spp.	-
350501	//	Tibouchina sp.	-
360101	Meliaceae	Cedrela adorata	Cedro blanco
360102	//	Cedrela spp.	-
360201	//	Guarea sp.	Cedro macho
370101	Mimosaseae	Inga sp.	Guamo
380101	Monimiaceae	Siparuna sp.	Clavo pasao
390101	Moraceae	Cecropia sp.	Yarumo
390201	//	Ficus sp.	Higueron, Caucho
390301	//	Morus insigne	Lechero
390302	//	Morus spp.	-
400101	Myrsinaceae	Geissanthus andinus	Quimula
400201	//	Myrsine guianensis	Espadero
400301	//	Rapanea ferruginea	Espadero
400302	//	Rapanea sp.	Espadero
410101	Myrtaceae	Mircia popayan	Arrayana
410102	//	Mircia sp.	Guayabito de monte
410103	//	Mircia spp.	Guayabo
420101	Nyctaginaceae	Neea sp.	Aguanoso
430101	Ochnaceae	Godoya sp.c	-
430201	//	Cespedesia sp.	Paco
440101	Palmae	Ceroxilum sp.	Palma de cera
440201	//	Chamaedorea brerifrons	Palmiche
440301	//	Geonoma colombiana	Palmiche
450101	Papaneraceae	Bocconia frutesens	Trompeto
460101	Piperaceae	Piper sp.	Cordoncillo

Table 2 - 2 - 9 List of Identified Tree Species (3)

460102	//	Piper aurltum	Plpllongo
470101	Polypodlaceae	Polypodium sp.	Helecho
470201	//	Blechum occideutule	Helecho
480101	Proteaceae	Panosls yalombo	Yolombo
480102	//	Panosls sp.	Yolombo
490101	Rhamnaceae	Rhamnus sp.	Naranjo de monte
500101	Rosaceae	Polilepsls sp.	-
500201	//	Hesperomeles sp.	Naranjo de monte
510101	Rubiaceae	Cinchona pubescens	Cascarillo
510102	//	Cinchona sp.	Quina
510201	//	Condaminae sp.	Azuceno blanco
510301	//	Hoffmannia sp.	-
510401	//	Ladenbergia macrocarpa	Azuceno, Perillo, Quina blanca
510501	//	Palicourea crocea	Nigulto
510502	//	Palicourea macrobotri	Niguito
510503	//	Palicourea spp.	-
510601	//	Pailasla	Verde negro
510701	//	-	Hueslto
520101	Rutaceae	Zanthoxyion martinicense	Doncel, Candelo
530101	Sapindaceae	Aliophylus sp.	Cabuyo
530201	//	Cupania sp.	Cacao de monte
530301	//	Serjania sp.	Espadero
540101	Sapotaceae	Pouteria locuma	Mediacaro, Platero
540201	//	Mastichodendron sp.	Lechudo
550101	Saurauiaceae	Saurauia braquibotrls	Oulumoco
550102	//	Sauraula sp.	Oulumoco
560101	Solanaceae	Acuistas sp.	Sin muerte
560201	//	Cestrum sp.	Chucho
560202	//	Cestrum spp.	Sin muerte
560301	//	Solanum sp.	Lulillo, Frutillo
560401	//	Huertaea sp.	Cerezo
570101	Staphyleaceae	Turpinia sp.	-
580101	Theaceae	Eurya nervosa	Arenillo
580201	//	Freziera sp.	Alizo colorado, Cerezo macho
580301	//	Lapiacea sp.	Magnollo
590101	Tiliaceae	Heliocarpus popayanensis	Balso blanco, Pestana de mula
590102	//	Heliocarpus spp.	-
600101	Ulmaceae	Losanella sp.	-
600201	//	Trema micrantha	Zurrumbo
610101	Urticaceae	Pilea rhoumbea	-
620101	Verbenaceae	Aeglphila novogranatensis	Tabaquillo, Saca hojo negro
620201	//	Cytarexilon sp.	-
620301	//	Lippia hirsuta	Saca hojo blanco
620302	//	Lippia sp.	Gallinazo, Gavilan
620303	//	Lippia spp.	-
630101	Winteraceae	Drymes glauca	Canelo deparand
999999	No identificado	-	-

Table 2 - 2 - 10 Inventory Plot Survey Results

(1) Río Tapias Model Area (Every Tree Measurement Results for Natural Forests)

Plot No.	Crown Dia. (C)	Crown Dens. (D)	No. of Trees/ha	Mean DBH (cm)	Commercial Height (m)	Mean Total/ Height	Commercial Volume (m^3/ha)	Elevt. (m)	Bearing	Mean Incl. (°)	Topography	Soil Type	Plot Area (ha)	Survey Date	Field note No.
1	1	2	240	14.9	4.8	7.0	19.80	3,260	NW	35°	Concave Slope	Tm	0.05	1990.7	RN 1
2	2	2	720	20.1	5.3	10.9	127.00	3,260	S 10° E	46°	Complex Slope	Bh	0.05	1990.7	RN 2
3	2	4	360	21.3	12.1	17.1	131.80	2,340	S	40°	Straight Slope	Bh	0.10	1990.7	RN 3
4	2	4	580	19.9	7.1	13.6	123.10	2,320	N 70° W	35°	Straight Slope	Bh	0.10	1990.7	RN 4
5	2	3	710	16.6	7.1	11.3	108.10	2,440	SE	40°	Straight Slope	Bh	0.10	1990.7	RN 5
6	3	4	1,120	18.6	5.9	11.0	211.40	2,460	N 40° E	45°	Convex Slope	Th	0.10	1990.7	RN 6
7	2	3	640	14.7	6.4	10.7	72.40	2,410	S 20° W	45°	Straight Slope	Bh	0.10	1990.7	RN 7
8	3	4	1,200	15.8	9.6	14.1	196.70	2,490	E	43°	Straight Slope	Bh	0.10	1990.7	RN 8
9	1	3	710	15.3	4.9	11.2	69.60	2,500	N 10° W	50°	Straight Slope	Bh	0.10	1990.7	RN 9
10	1	3	710	15.7	5.9	12.7	89.70	2,440	E	30°	Complex Slope	Bh	0.10	1990.7	RN 10
11	3	4	690	16.9	13.1	16.6	196.20	2,860	W	40°	Straight Slope	Bh	0.10	1990.7	RN 11
12	2	4	1,300	15.4	5.1	10.4	148.40	2,940	SW	49°	Straight Slope	Bh	0.10	1990.7	RN 12
13	2	4	770	17.7	7.0	14.8	179.60	2,370	NE	32°	Straight Slope	Bh	0.50	1989.2	Previous Year 4
14	2	4	700	18.6	7.1	14.2	153.00	2,770	E	36°	Complex Slope	Bh	0.10	1989.2	Previous Year 8
Av.	—	—	746	17.3	7.2	12.5	130.49	—	—	—	—	—	—	—	

(2) Río Tapias Model Area (Every Tree Measurement Results for Man-Made Aliso Forests)

Plot No.	Tree Height (A)	Crown Dens. (D)	Stand Age (yrs)	No. of Trees/ha	Mean DBH (cm)	Commercial Height (m)	Mean Total/ Height	Commercial Volume (m^3/ha)	Elevt. (m)	Bearing	Incl. (°)	Topography	Soil Type	Plot Area (ha)	Survey Date	Field note No.
1	5	4	25	250	30.4	21.8	24.4	247.40	2,230	SE	13°	Straight Slope	Bh	0.10	1990.7	RA 1
2	5	4	25	270	33.4	22.1	25.2	324.00	2,240	E	8°	Convex Slope	Bh	0.10	1990.7	RA 2
3	5	4	25	210	34.0	24.5	28.1	297.60	2,230	W	5°	Tableland	Bh	0.10	1990.7	RA 3
4	1	1	4	650	5.5	0.0	5.0	19.50	2,360	E	15°	Straight Slope	Bh	0.10	1990.7	RA 4
5	5	4	19	360	30.1	13.5	22.1	229.90	2,250	N 50° E	27°	Straight Slope	Bh	0.10	1990.7	RA 5
6	5	4	19	240	31.0	13.8	21.5	165.20	2,260	S 25° W	25°	Straight Slope	Bh	0.10	1990.7	RA 6
7	5	4	29	380	29.0	14.4	22.1	240.20	2,300	N 10° W	33°	Complex Slope	Bh	0.10	1990.7	RA 7
8	1	1	4	950	4.9	0.0	3.9	28.50	2,370	N 35° W	9°	Straight Slope	Bh	0.10	1990.7	RA 8
9	5	4	18	340	25.7	14.0	22.1	164.70	2,260	NE	23°	Complex Slope	Bh	0.10	1989.2	Previous Year 9
Av.	—	—	—	406	24.9	13.8	19.4	190.78	—	—	—	—	—	—	—	—

(3) Manizales Model Area (Every Tree Measurement Results for Natural Forests)

Plot No.	Crown Dia. (C)	Crown Dens. (D)	No. of Trees/ha	Mean DBH (cm)	Commercial Height (m)	Mean Total/ Height	Commercial Volume (m^3/ha)	Elevt. (m)	Bearing	Mean Incl. (°)	Topography	Soil Type	Plot Area (ha)	Survey Date	Field note No.
1	2	4	770	18.9	8.4	14.5	165.50	2,680	N 25° W	34°	Straight Slope	Bh	0.10	1990.7	MA 1
2	3	4	1,320	17.1	10.7	16.4	278.60	2,720	NW	35°	Straight Slope	Tm	0.10	1990.7	MA 2
3	2	4	1,080	18.5	4.8	11.7	142.90	2,740	N 65° W	33°	Complex Slope	Tm	0.10	1990.7	MA 3
4	1	3	420	10.7	0.0	6.0	12.60	3,400	NW	45°	Concave Slope	Th	0.05	1990.7	MA 4
5	1	3	780	10.4	0.0	4.6	23.40	3,580	N 40° E	39°	Straight Slope	Th	0.05	1990.7	MA 5
6	2	4	540	21.7	8.8	13.7	173.90	2,460	N 60° W	36°	Complex Slope	Bh	0.10	1990.7	MA 6
7	2	4	820	14.5	13.6	17.3	149.30	3,020	SE	30°	Straight Slope	Bh	0.10	1990.7	MA 7
8	3	4	1,390	18.0	5.9	12.6	217.20	3,030	S 5° E	35°	Complex Slope	Tm	0.10	1990.7	MA 8
9	2	4	834	18.0	8.3	15.6	148.34	2,700	S 40° W	32°	Straight Slope	Bh	0.50	1989.2	MA 9
10	2	4	1,350	17.2	3.4	13.8	158.10	3,550	NE	32°	Complex Slope	Bh	0.10	1989.2	MA 10
Av.	—	—	930	16.5	6.4	12.6	146.98	—	—	—	—	—	—	—	—

(4) Manizales Model Area (Every Tree Measurement Results for Man-Made Aliso Forests)

Plot No.	Tree Height (A)	Crown Dens. (D)	Stand Age (yrs)	No. of Trees/ha	Mean DBH (cm)	Commercial Height (m)	Mean Total/ Height	Commercial Volume (m^3/ha)	Elevt. (m)	Bearing	Incl. (°)	Topography	Soil Type	Plot Area (ha)	Survey Date	Field note No.
1	5	4	19	470	21.7	16.8	21.4	203.60	2,720	E	35°	Straight Slope	Th	0.10	1990.7	MA 1
2	4	4	18	600	25.8	11.1	19.1	253.30	2,720	SE	25°	Convex Slope	Th	0.10	1990.7	MA 2
3	5	4	19	380	23.5	18.9	23.9	212.00	2,460	W	15°	Concave Slope	Bh	0.10	1990.7	MA 3
4	4	3	16	510	17.8	10.7	17.6	109.20	2,440	S 50° W	33°	Concave Slope	Tm	0.10	1990.7	MA 4
5	5	4	25	330	24.5	20.8	23.8	207.30	2,780	E	10°	Straight Slope	Bh	0.10	1990.7	MA 5
6	5	3	25	240	25.4	20.4	22.7	156.70	2,820	NW	22°	Straight Slope	Bh	0.10	1990.7	MA 6
7	5	5	25	400	29.8	19.3	24.5	380.90	2,800	SE	30°	Straight Slope	Th	0.10	1990.7	MA 7
8	5	3	30	180	34.3	14.4	22.1	155.90	2,790	N 25 E	10°	Concave Slope	Bh	0.10	1990.7	MA 8
9	4	3	20	270	25.9	12.7	20.2	123.10	2,820	N 10 E	13°	Straight Slope	Th	0.10	1990.7	MA 9
10	4	3	25	210	31.0	13.3	20.6	154.20	2,800	N 40 W	15°	Complex Slope	Bh	0.10	1990.7	MA 10
11	5	4	17	390	22.9	17.0	27.1	193.60	2,400	S	30°	Complex Slope	Bh	0.10	1989.2	Previous Year 1
Av.		—	—	362	25.7	15.9	22.1	195.44	—	—	—	—	—	—	—	—

(5) Pensilvania Model Area (Every Tree Measurement Results for Natural Forests)

Plot No.	Crown Dia. (C)	Crown Dens. (D)	No. of Trees/ha	Mean DBH (cm)	Commercial Height (m)	Mean Total/ Height	Commercial Volume (m^3/ha)	Elevt. (m)	Bearing	Mean Incl. (°)	Topography	Soil Type	Plot Area (ha)	Survey Date	Field note No.
1	3	3	1,700	17.4	7.2	12.5	279.00	2,380	S 65 W	39°	Convex Slope	Tm	0.01	1990.7	PN 1
2	2	3	1,700	12.1	3.9	8.6	107.00	2,370	W	15°	Straight Slope	Tm	0.01	1990.7	PN 2
3	2	3	1,300	14.2	5.3	10.6	124.00	2,420	S 60 W	34°	Straight Slope	Gm	0.01	1990.7	PN 3
4	1	3	1,200	13.3	3.6	9.0	77.00	2,440	S 80 W	41°	Complex Slope	Gm	0.01	1990.7	PN 4
5	2	3	970	16.9	8.2	15.2	173.00	2,280	N 70 W	30°	Straight Slope	Tm	0.10	1990.2	Previous 1
6	2	3	590	19.1	5.2	13.4	88.60	2,680	S 30 W	44°	Straight Slope	Tm	0.10	1990.2	Survey 2
7	2	3	930	15.8	6.5	15.8	113.70	2,660	E	36°	Straight Slope	Tm	0.10	1990.2	〃 3
8	3	3	1,250	17.7	8.3	16.0	276.20	2,280	N 70 W	30°	Straight Slope	Tm	0.10	1990.2	〃 4
Av.	—	—	1,205	15.8	6.0	12.6	154.81	—	—	—	—	—	—	—	—

(6) Pensilvania Model Area (Every Tree Measurement Results for Man-Made P. patula Forests)

Plot No.	Tree Height (A)	Crown Dens. (D)	Stand Age (yrs)	No. of Trees/ha	Mean DBH (cm)	Commercial Height (m)	Mean Total/ Height	Commercial Volume (m^3/ha)	Elevt. (m)	Bearing	Incl. (°)	Topography	Soil Type	Plot Area (ha)	Survey Date	Field note No.
1	3	4	15	1,090	18.7	6.3	14.5	136.30	2,270	S	33°	Straight Slope	Bh	0.10	1990.2	Previous 1
2	3	4	15	1,090	20.0	7.4	18.3	191.20	2,300	N 70 E	35°	Straight Slope	Bh	0.10	1990.2	Survey 2
3	2	3	10	1,470	13.4	4.2	10.0	71.50	2,420	S 80 E	25°	Convex Slope	Tm	0.10	1990.2	〃 3
4	4	4	17	1,520	16.4	5.9	15.3	148.10	2,220	N 70 E	20°	Straight Slope	Tm	0.10	1990.2	〃 7
5	4	3	16	1,030	16.4	6.7	17.7	105.40	1,960	E	27°	Complex Slope	Tm	0.10	1990.2	〃 8
6	3	4	17	2,090	13.8	6.8	13.5	188.20	1,960	S 60 E	28°	Straight Slope	Tm	0.10	1990.2	〃 10
7	4	4	17	1,050	19.0	8.9	15.7	186.60	2,100	N 20 W	27°	Convex Slope	Tm	0.10	1990.2	〃 12
8	4	4	16	1,330	17.9	10.6	18.5	238.20	2,520	S 30 E	20°	Complex Slope	Gm	0.10	1990.2	〃 14
9	4	4	17	840	22.8	9.6	19.7	221.20	2,030	S 30 E	25°	Straight Slope	Tm	0.10	1990.2	〃 17
10	4	4	17	740	22.5	9.2	20.4	185.70	1,940	S 70 E	25°	Complex Slope	Tm	0.10	1990.2	〃 18
11	3	3	11	1,050	17.4	8.4	14.5	148.80	2,120	S	28°	Straight Slope	Tm	0.10	1990.2	〃 19
12	4	3	16	650	21.0	10.2	19.6	155.90	1,900	N	20°	Convex Slope	Tm	0.10	1990.2	〃 23
13	4	4	16	910	18.7	9.1	15.9	167.50	2,080	W	34°	Complex Slope	Th	0.10	1990.2	〃 25
14	4	3	16	800	16.4	9.3	17.3	108.00	1,860	S 80 W	30°	Straight Slope	Tm	0.10	1990.2	〃 26
15	4	4	14	1,425	19.9	7.3	15.0	248.00	2,340	SE	23°	Complex Slope	Tm	0.20	1989.2	Previous Year 6
16	3	4	14	1,070	21.3	7.8	14.6	211.80	2,450	SE	23°	Complex Slope	Tm	0.20	1989.2	Previous Year 7
Av.	—	—	—	1,135	18.5	8.0	16.3	169.53	—	—	—	—	—	—	—	—

(7) Pensilvania Model Area (Every Tree Measurement Results for Man-Made Ciprés Forests)

Plot No.	Tree Height (A)	Crown Dens. (D)	Stand Age (yrs)	No. of Trees/ha	Mean DBH (cm)	Commercial Height (m)	Mean Total/ Height	Commercial Volume (m^3/ha)	Elevt. (m)	Bearing	Incl. (°)	Topography	Soil Type	Plot Area (ha)	Survey Date	Field note No.
1	4	4	19	850	23.6	8.8	20.6	211.90	2,020	N	17°	Complex Slope	Tm	0.10	1990.2	Previous Survey 4
2	4	2	18	390	23.6	10.7	15.9	99.00	2,060	N 80 W	20°	Complex Slope	Tm	0.10	1990.2	〃 5
3	3	2	19	1,340	17.6	5.1	11.4	119.20	1,980	S 80 E	34°	Convex Slope	Tm	0.10	1990.2	〃 6
4	4	4	16	1,250	19.8	13.6	19.1	301.20	1,960	N 50 W	13°	Complex Slope	Tm	0.10	1990.2	〃 9
5	4	3	19	380	27.2	12.6	17.5	151.10	2,020	N 30 W	20°	Convex Slope	Tm	0.10	1990.2	〃 11
6	4	4	18	1,190	19.9	13.1	19.3	277.00	2,280	S 30 E	36°	Complex Slope	Th	0.10	1990.2	〃 13
7	4	4	18	1,230	20.2	9.7	16.0	236.80	2,280	S 40 E	24°	Concave Slope	Tm	0.10	1990.2	〃 15
8	3	3	18	1,500	17.2	6.1	11.9	154.20	2,200	S 60 E	32°	Convex Slope	Tm	0.10	1990.2	〃 16
9	4	3	17	640	21.7	11.1	15.8	157.70	2,040	S 30 E	14°	Complex Slope	Tm	0.10	1990.2	〃 20
10	4	3	18	1,170	16.5	9.4	15.9	140.70	2,000	S 20 W	27°	Convex Slope	Tm	0.10	1990.2	〃 21
11	4	4	17	730	21.6	11.3	18.3	170.40	2,140	E	36°	Concave Slope	Tm	0.10	1990.2	〃 24
12	3	4	17	1,830	19.1	7.3	13.6	245.05	2,280	NE	38°	Straight Slope	Tm	0.20	1989.2	Previous Year 5
Av.	—	—	—	1,042	20.7	9.9	16.3	188.69	—	—	—	—	—	—	—	—

with the volume (V), a regression analysis was conducted to estimate the stand volume. Various equations were conducted with different combinations of C or A with D to obtain the value of V.

The formulas shown in Table 2-2-11 were thought to show the best correlation coefficients and, therefore, significance. As a result, it was decided to use these formulas to obtain approximate values for the real stand volumes.

Table 2 - 2 - 11 Stand Volume Estimation Formulas

Forest Type	Estimation Formula	Correlation Coefficient
Natural	V = 19.7572 x C x D + 0.33561	0.840132
P. patula	V = 12.5174 x A x D + 7.58141	0.739272
Ciprés	V = 13.0506 x A x D + 26.6422	0.770764
Aliso	V = 11.8523 x A x D - 1.03723	0.814847

Note: V: volume A: tree height C: crown diameter D: crown density

The aerial photograph-based volume table is shown in Table 2-2-12.

Table 2 - 2 - 12 Aerial Photograph-Based Volume Table

(Unit: m^3/ha)

Stand Type		Forest Type			
C/A	D	Natural	P. patula	Ciprés	Aliso
1	1	20.1	20.1	39.7	10.8
1	2	39.9	32.6	52.7	22.7
1	3	59.6	45.1	65.8	34.5
1	4	79.4	57.7	78.8	46.4
2	1	39.9	32.6	52.7	22.7
2	2	79.4	57.7	78.8	46.4
2	3	118.9	82.7	104.9	70.1
2	4	158.4	107.7	131.0	93.8
3	1	59.6	45.1	65.8	34.5
3	2	118.9	82.7	104.9	70.1
3	3	178.2	120.2	144.1	105.6
3	4	237.4	157.8	183.2	141.2
4	1	-	57.7	78.8	46.4
4	2	-	107.7	131.0	93.8
4	3	-	157.8	183.2	141.2
4	4	-	207.9	235.5	188.6
5	1	-	70.2	91.9	58.2
5	2	-	132.8	157.2	117.5
5	3	-	195.3	222.4	176.7
5	4	-	257.9	287.7	236.0

Note: A: tree height C: crown diameter D: crown density

② Estimation of Forest Resources (Stand Volume)

The stand volume by forest stand was estimated by multiplying the stand area obtained by the forest type and vegetation survey by the stand volume per ha obtained from the aerial photograph-based volume table. The resulting values are shown in Table 2-2-13. The estimated stand volumes are 1,077,931m^3 for all natural and secondary forests in the 3 Models Areas (135m^3/ha), 203,838m^3 for P. patula forests (175m^3/ha), 43,767 m^3 for Ciprés forests (171m^3/ha) and 778m^3 for Eucalipto forests (195m^3/ha) (the volume table for Aliso was also used for Eucalipton).

Table 2 - 2 - 13 Volume by Forest and Stand Types

(1) Model Area Total

(Unit: m^3/ha)

Stand Type		Natural	Secondary	Forest Type			
C/A	D	Forest	Forest	P. patula	Ciprés	Aliso	Eucalipto
1	1	-	623	-	-	1,253	-
1	2	1,715	1,835	-	-	-	-
1	3	14,423	10,191	-	-	-	-
1	4	57,010	9,607	-	-	-	-
2	2	29,934	-	-	-	-	-
2	3	751,132	-	1,571	-	1,262	-
2	4	476	-	5,600	-	1,782	-
3	2	4,985	-	662	9,336	-	-
3	3	38,934	-	5,770	4,755	2,746	-
3	4	-	-	73,693	7,145	5,648	-
4	3	-	-	5,523	6,046	9,884	-
4	4	-	-	111,019	16,485	25,838	-
5	2	-	-	-	-	1,528	-
5	3	-	-	-	-	15,550	-
5	4	-	-	-	-	89,444	-
6	2	-	-	-	-	-	141
6	3	-	-	-	-	-	637
Total		1,055,675	22,256	203,838	43,767	154,935	778

(2) Río Tapias Mode Area

(Unit: m^3/ha)

Stand Type		Natural	Secondary	Forest Type			
C/A	D	Forest	Forest	P. patula	Ciprés	Aliso	Eucalipto
1	1	-	623	-	-	1,253	-
1	2	40	1,835	-	-	-	-
1	3	1,848	2,324	-	-	-	-
1	4	50,340	8,337	-	-	-	-
2	2	26,202	-	-	-	-	-
2	3	16,170	-	-	-	-	-
2	4	497,534	-	-	-	-	-
3	2	476	-	-	-	-	-
3	3	4,985	-	-	-	-	-
3	4	29,675	-	-	-	-	-
5	4	-	-	-	-	-	-
6	2	-	-	-	-	11,328	141
6	3	-	-	-	-	-	637
Total		627,270	13,119	-	-	12,581	778

(3) Manizales Model Area

(Unit: m^3/ha)

Stand Type		Natural	Secondary	Forest Type			
C/A	D	Forest	Forest	P. patula	Ciprés	Aliso	Eucalipto
1	2	1,436	-	-	-	-	-
1	3	9,953	-	-	-	-	-
1	4	4,764	-	-	-	-	-
2	3	10,582	-	-	-	1,262	-
2	4	253,598	-	-	-	1,782	-
3	3	-	-	-	-	2,746	-
3	4	9,259	-	-	-	5,648	-
4	3	-	-	-	-	9,884	-
4	4	-	-	-	-	25,838	-
5	2	-	-	-	-	1,528	-
5	3	-	-	-	-	15,550	-
5	4	-	-	-	-	78,116	-
Total		289,592	-	-	-	142,354	-

(4) Pensilvania Model Area

(Unit: m^3/ha)

Stand Type		Natural	Secondary	Forest Type			
C/A	D	Forest	Forest	P. patula	Ciprés	Aliso	Eucalipto
1	2	239	-	-	-	-	-
1	3	2,622	7,867	-	-	-	-
1	4	1,906	1,270	-	-	-	-
2	2	3,732	-	-	-	-	-
2	3	130,314	-	1,571	-	-	-
2	4	-	-	5,600	-	-	-
3	2	-	-	662	9,336	-	-
3	3	-	-	5,770	4,755	-	-
3	4	-	-	73,693	7,145	-	-
4	3	-	-	5,523	6,046	-	-
4	4	-	-	111,019	16,485	-	-
Total		138,813	9,137	203,838	43,767	-	-

Note: C: crown diameter A: tree height D: crown density

2.2.4 Soil Survey

A soil survey was conducted to obtain knowledge on the distribution of soil types and their characteristics in the Model Areas and to prepare soil maps. The survey method and survey findings are described below.

(1) Survey Method

① Survey Sites

A soil profile survey was carried out mainly at each forest inventory plot and simple trial pits were also dug at the changing points of the topography to supplement the soil profile survey. The soil profile survey was conducted at 43 sites while simple trial pits were dug at 44 sites.

② Survey Items

The main survey items were the choice of the location of the soil profile, topography, bearing, inclination, elevation, parent materials, shape of soil profile, soil type, sedimentation mode and vegetation. In addition, a Yamanaka hardness tester and portable pH meter were used to determine the soil consistency and soil pH value respectively.

(2) Survey Findings

The soil types so far identified in the Intensive Area are shown in Table 2-2-14. There are 11 soil types based on the FAO/Unesco classification system and 15 types based on the Japanese classification system. 10 types of the FAO/Unesco system and 14 types of the Japanese system were identified in the Model Areas. In view of the facts that all the soil profiles were taken in the inventory plots for the forest resources survey and that the simple trial pits were not evenly distributed in the Model Areas due to a problem of access and were set up in places nearby the existing forest roads or paths.

Table 2 - 2 - 14 Soil Types

FAO/Unesco Classification system	Symbol	Japanese Classification System
Mollic Andosols	Tm	$B1_A$, $B1_B$, $B1_D$, $B1_F$, B_B, $B_D(d)$, B_E, dB_E, dB_F
Humic Andosols	Th	$B1_D$, $B1_F$, B_E, dB_E, dB_F
Ochric Andosols	To	$B1_D$
Humic Cambisols	Bh	B_B, B_C, $B_D(d)$, B_D, B_E, B_F
Gleyic Cambisols	Bg	G
Ferralic Cambisols *	Bf	R *
Mollic Gleysols	Gm	G
Humic Gleysols	Gh	G
Dystric Fluvisols	Jd	Im
Dystric Regosols	Rd	Im
Eutric Regosols	Re	Im

Note: * denotes a soil type distributed out

The data relating to the soil profiles and simple trial pits is summarised in Table 2-2-15 (1) - (2) and Table 2-2-16 (1) - (2) while their locations are shown in Fig. 2-2-2.

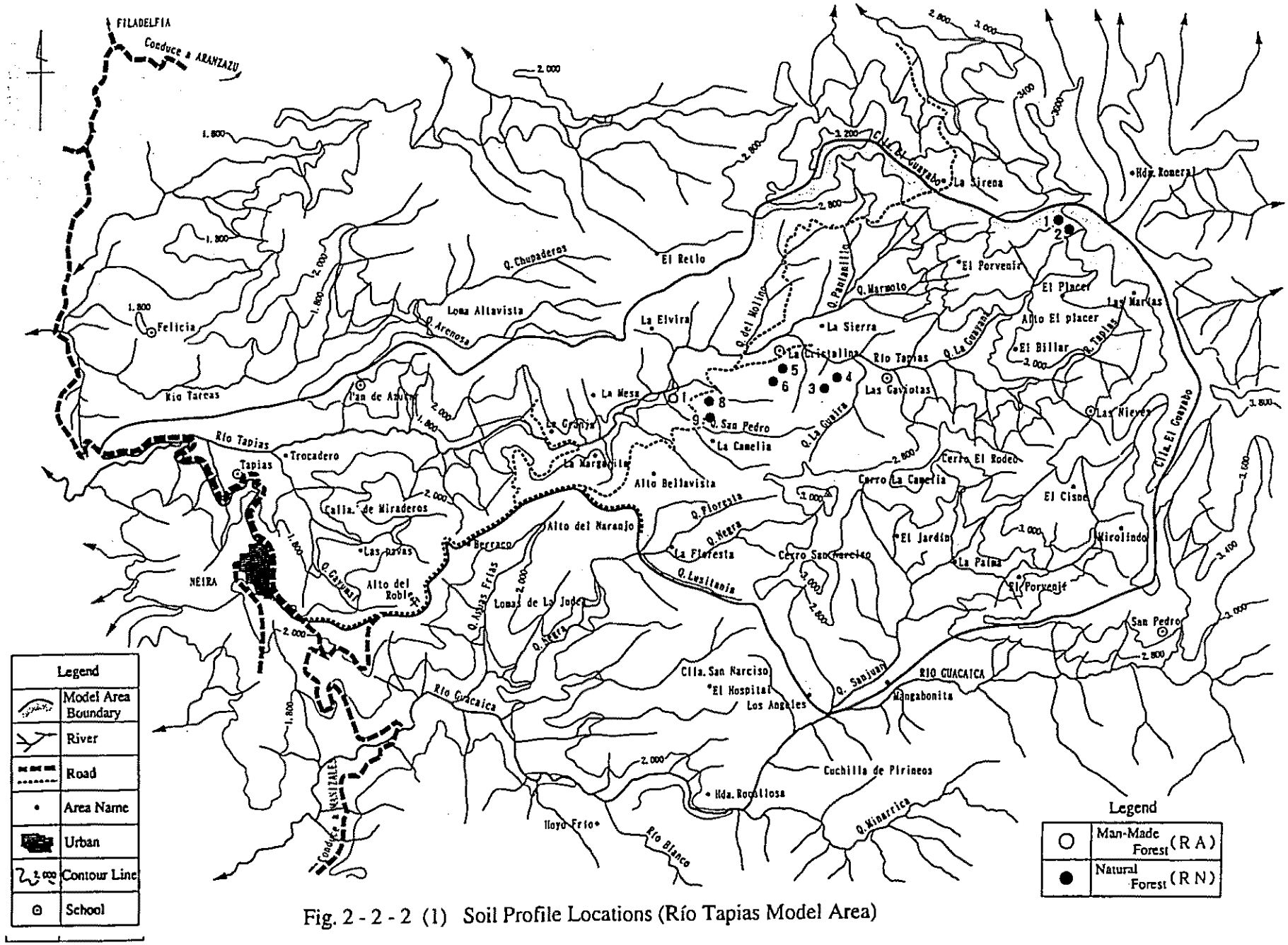


Fig. 2 - 2 - 2 (1) Soil Profile Locations (Río Tapias Model Area)

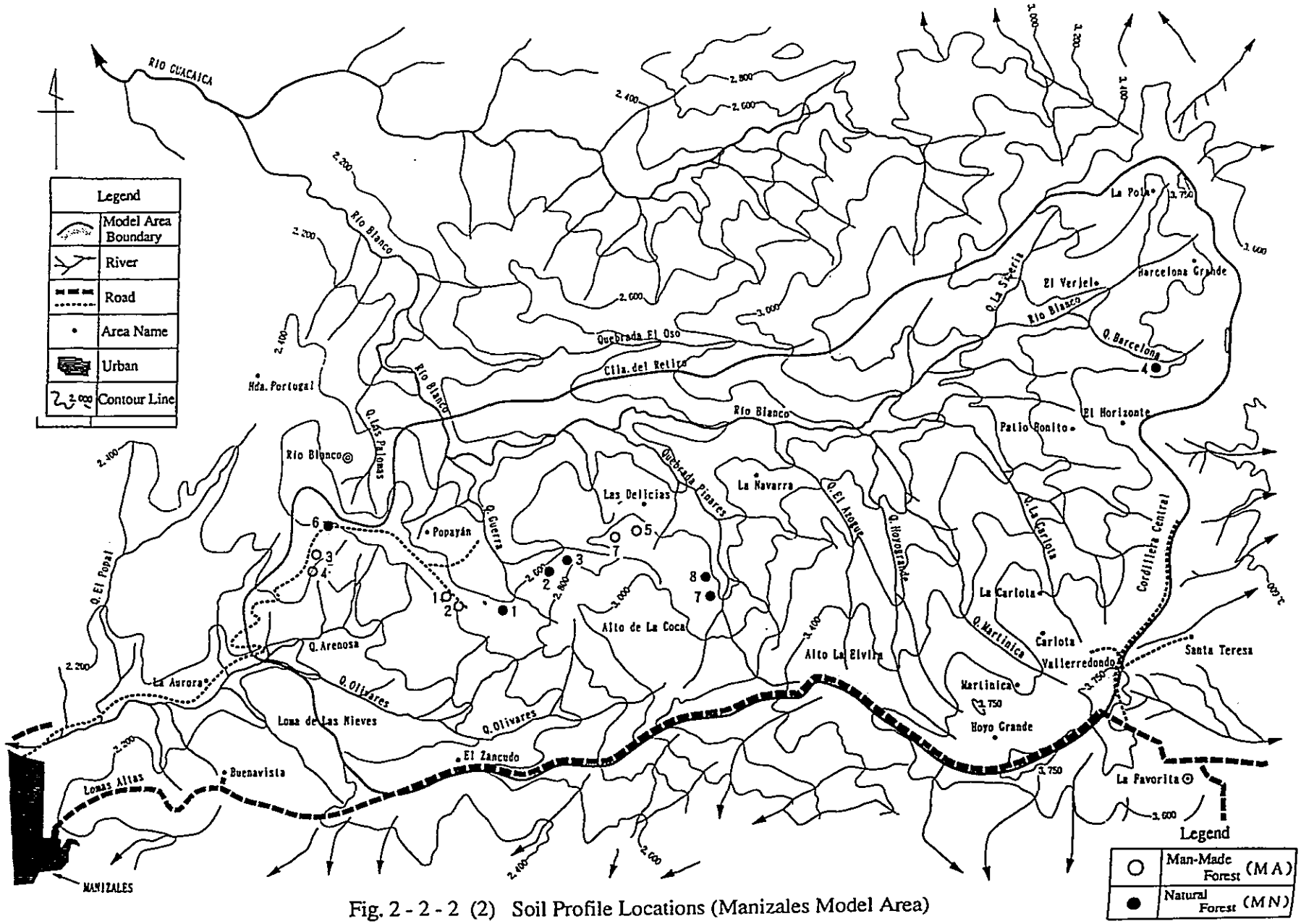


Fig. 2 - 2 - 2 (2) Soil Profile Locations (Manizales Model Area)

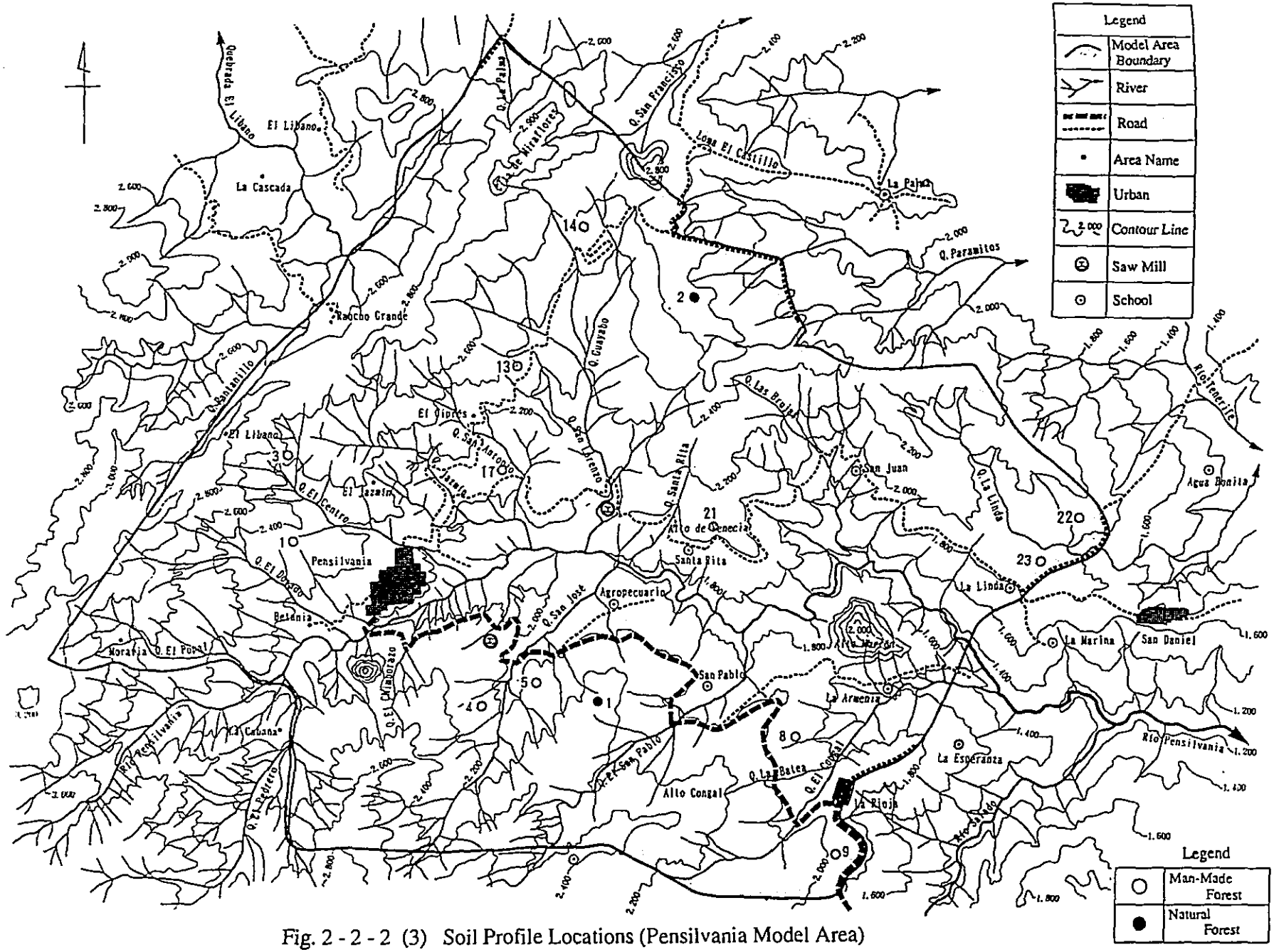


Fig. 2 - 2 - 2 (3) Soil Profile Locations (Pensilvania Model Area)

Table 2 - 2 - 15 (1) Summary of Soil Profiles

Fiscal 1989 Survey

Model Area	Profile No.	FAO Soil Type	Japan Soil Type	Elevt. (m)	Topography	Bearing	Inc. (°)	Sedimentation Mode	Parental Materials	Forest Type	Remarks
Manizales	1	Bh	BE	2,400	Complex Slope	S 30° W	22°	Residual soil (R/S)	Volcanic ejecta	Aliso	
"	2	Bh	BF	2,700	Straight Slope	N	16		"	Broad-leaf natural forest	
"	3	Bh	BE	3,440	Convex Slope	N 40° E	40	Creeping soil (C/S)	"	"	
Río Tapias	4	Bh	BD(d)	2,370	Straight Slope	S 70° W	35	"	"	"	
Pensilvania	5	Tm	Bld(m)	2,280	"	N 40° E	30	Residual soil (R/S)	Andesite Volcanic ejecta chrystalline schist	Ciprés	
"	6	Tm	Bld(m)	2,340	"	N 60° E	15	"	"	P. patula	
"	7	Tm	BlF	2,450	"	S 50° E	24	"	Volcanic ejecta	P. patula	
Río Tapial	8	Bh	BD(d)	2,770	Minor ridge with Straight Slope	N 50° W	40	"	Andesite	Broad-leaf natural forest	
"	9	Bh	BE	2,260	convex part of a complex slope with many folds	N 30° W	22	"	Volcanic ejecta	Aliso	

Table 2 - 2 - 15 (2) Summary of Soil Profile

Fiscal 1990 Survey

Model Area	Profile No.	FAO Soil Type	Japan Soil Type	Elevt. (m)	Topography	Bearing	Inc. (°)	Sedimentation Mode	Parental Materials	Forest Type	Remarks
Pensilvania	1	Bh	BE	2,250	Straight Slope	S 10° E	33°	C/S	Metamorphic rock	P. patula	
"	3	Tm	B1F	2,470	Convex Slope	S 40° E	36	"	Volcanic ejecta	"	
"	4	Tm	B1D(m)	2,030	Gentle Slope	N 50° E	17	R/S	Eruptive rock	Ciprés	
"	5	Tm	B1D(m)	2,060	Convex Slope	N	20	"	Volcanic ejecta	"	
"	8	Bh	BE(m)	1,950	"	N 20° E	27	C/S	Metamorphic rock	P. patula	
"	8A	Tm	B1D(m)	1,950	"	N 20° E	26	"	"	"	
"	9	Tm	B1F	1,950	Straight Slope	N 80° E	13	R/S	Volcanic ejecta/ metamorphic rock	Ciprés	
"	13	Th	B1D	2,360	Concave Slope	S 20° E	36	C/S	"	"	
"	14	Gm	G	2,540	Ridge with convex slope	S 30° E	20	R/S	"	P. patula	
"	17	Tm	B1D	2,020	"	S 20° E	25	C/S	"	"	
"	17A	Tm	B1D	2,020	"	S 45° E	20	"	"	"	
"	21	Tm	B1A	2,000	Straight Slope	S 80° E	27	R/S	Volcanic ejecta	Ciprés	
"	22	Tm	B1D(m)	1,940	Ridge with Straight slope	S 10° W	29	C/S	Volcanic ejecta/ metamorphic rock	P. oocarpa	
"	23	Tm	B1B	1,890	"	S 40° E	20	R/S	"	P. patula	
"	BN 1	Tm	B1D	2,270	Straight Slope	S 50° E	30	"	"	Broad-leaf natural forest	
"	2	Tm	dBF	2,650	Concave slope	S 80° W	44	C/S	"	"	
"	2A	Tm	dBF	2,650	"	S 20° W	42	"	"	Aliso.	
Manizales	MA 1	Th	dBF	2,720	"	N 20° W	27	"	Volcanic ejecta	"	
"	2	Th	dBF	2,710	Ridge with Convex slope	N 10° W	32	R/S	"	"	
"	3	Bh	BD(d)	2,385	Convex Slope	S 20° E	18	"	"	"	
"	4	Tm	BD	2,420	Valley with concave slope	N 30° W	20	C/S	"	"	
"	5	Bh	BF	2,780	Gentle slope	N 20° W	25	"	"	"	No. of trees is decreasing
"	7	Bh	BF	2,775	Straight Slope	N 20° W	8	R/S	"	Broad-leaf natural forest	Thin sand with tall trees req.
"	MN 1	Bh	BC	2,670	Straight Slope	N 30° W	32	C/S	"	"	
"	2	Tm	BE	2,720	"	N 50° W	37	"	"	"	
"	3	Tm	BE	2,730	"	N 60° W	41	"	"	"	
"	4	Th	dBF	3,425	Slope on shallow V-shape valley	N 40° E	65	"	"	"	
"	6	Bh	BE	2,470	Straight Slope	N 70° W	41	"	"	"	
"	7	Bh	BF	2,890	"	N 30° E	32	"	"	"	
"	8	Tm	BE	2,840	Straight Slope along valley	S 30° E	30	"	"	Aliso	
Río Tapias	RA 1	Bh	BD	2,230	Convex Slope	N 30° E	35	"	"	Broad-leaf natural forest	
"	RN 1	Tm	BE	3,270	Straight Slope	S 40° W	37	"	"	"	
"	2	Bh	BD(d)	3,160	"	S 20° E	44	"	Quartz diorite	"	
"	3	Bh	BD(d)	2,440	Ridge with Straight Slope	S 80° W	34	R/S	Volcanic Ejecta	"	
"	4	Bh	BC	2,420	Straight Slope	S 40° W	38	C/S	"	"	
"	5	Bh	BB	2,450	Ridge with Straight Slope	N 60° E	42	R/S	"	"	
"	6	Th	dBE	2,490	Straight Slope	N 50° E	70	C/S	"	"	
"	8	Bh	BC	2,480	"	N 20° E	40	"	Andesite	"	
"	9	Bh	BC	2,480	"	N 10° E	35	"	"	"	
Pensilvania	PN1	Bh	BD(d)	2,450	"	S 80° W	40	Colluvial soil	Metamorphic rock	"	
"	3	Bh	BD(d)	2,460	"	N 50° E	42	"	"	"	
Salamina	SA1	Tm	BC	2,120	"	N 80° E	30	C/S	Volcanic ejecta	P. patula	Outside Model Areas
Pacora	PC1	Tm	BD(d)	2,170	"	S 70°E	25	"	"	"	

Note: All numbers correspond to the plot numbers in the forest resources survey. The numbers followed by A indicate a different soil profile but in the same plot.

Table 2 - 2 - 16 (1) Summary of Simple Trial Pits

Fiscal 1989 Survey

Model Area	Profile No.	FAO Soil Type	Japan Soil Type	Elevt. (m)	Topography	Bearing	Inc. (°)	Sedimentation Mode	Parental Materials	Forest Type	Remarks
Manizales	2-1	Th	dBE	2,700	Concave Slope	N 15° W	30°	Creeping soil (C/S)	Volcanic ejecta	Aliso	
"	2-2	Th	dBE	2,730	Ridge with complex slope	N	16	Residual soil (R/S)	"	Broad-leaf natural forest	
"	3-1	Th	B1F	3,630	ridge with convex slope	N 30° E	27	"	"	Paramo	
"	3-2	Th	B1F	3,590	"	S 30° E	25	"	"	"	
"	3-3	Th	dBE	2,600	"	N 80° W	38	"	"	Broad-leaf natural forest	
Río Tapias	4-1	Tm	BD(d)	2,400	Ridge with Straight Slope	N 10° W	40	"	"	"	
"	8-1	Bh	BF	2,760	Straight Slope along valley	S 20° W	41	C/S	Andesite	"	
"	9-1	Bg	G	2,250	Concave part of compelx slope with many folds	N 30° W	17	R/S	Andesite/volcanic ejecta -sita	Aliso	

Table 2 - 2 - 16 (2) Summary of Simple Trial Pits

Fiscal 1990 Survey

Model Area	Profile No.	FAO Soil Type	Japan Soil Type	Elevt (m)	Topography	Bearing	Inc. (°)	Sedimentation Mode	Parental Materials	Forest Type	Remarks
Pensilvania	1	Bh	BE(m)	2,200	Straight Slope	N 60° W	22	R/S	Metamorphic rock	P. patula	
"	2	Jd	Im(BE)	2,030	Straight Slope along valley	N 20° E	22	Fluvial soil F/S	"	Ranch	
"	3	Th	B1D(m)	2,020	Protruding ridge	S 70° E	20	R/S	Volcanic ejecta	P. patula	
"	4	Jd	Im(BE)	1,920	"	N 10° E	12	F/S	Metamorphic rock	Ranch	
"	5	To	B1D(m)	1,810	Straight Slope	N 30° W	32	C/S	Volcanic ejecta	"	
"	6	Th	B1D	2,000	Gentle Slope at mountian foot	S 10° E	17	R/S	"	"	
"	7	To	B1D	1,940	Straight Slope along valley	E	35	C/S	"	P. patula	
"	8	Tm	BD	1,960	Straight Slope	S 20° W	30	Colluvial soil	Metamorphic rock	"	
"	9	Tm	B1D(m)	1,880	"	S 20° W	34	R/S	Volcanic ejecta	Coffee plantation	
"	10	Th	B1D	1,920	Convex slope	S 30° W	38	C/S	"	Ranch	
"	11	Th	B1D	1,740	Ridge with straight slope	S 40° W	20	R/S	"	Coffee Plantation	
"	12	Th	B1D	1,630	Straight Slope	S 40° W	37	C/S	"	"	
"	13	Bh	BE	1,450	Convex slope	S 30° W	40	"	Metamorphic rock	" banana plantation	
"	14	Gh	G	2,580	Ridge with convex slope	S 20° E	30	"	"	Ranch	
"	15	Tm	BF	2,530	Convex Slope	S 50° W	30	"	"	"	
"	16	Gm	G	2,450	Straight Slope	S 10° E	32	"	"	Broad-leaf natural forest	
"	17	Tm	BF	2,400	"	S 50° W	28	"	"	P. patula	
										Ciprés	
"	18	Tm	B1D	2,280	Gentle slope	S 60° E	18	R/S	Volcanic ejecta		
"	19	Re	Im	2,240	Ridge with Straight Slope	S 30° E	40	C/S	Metamorphic rock	P. patula	
"	20	Tm	B1D	2,200	Straight Slope	S 10° E	35	"	Volcanic efecta	Ranch	
"	21	Tm	B1D	2,100	"	S	30	"	"	"	
"	22	Bh	BE(m)	2,270	Straight slope along valley	N 20° W	34	"	Metamorphic rock	"	
"	23	Bh	BF(m)	2,160	Gentle slope at mountain top	N 40° W	6	R/S	"	P. patula	
"	24	Bh	BF	2,020	"	S 20° W	25	"	"	"	
	25	Tm	B1D	2,150	Ridge with Straight Slope	S 10° E	25	"	Volcanic ejecta	Ranch	Outside Model Area
El Páramo	26	Th	B1D(d)	3,100	Gentle slope at mountain top	S 20° W	15	"	"	"	Main peak in Andes Mountains
Cores	27	Bf	R	2,000	"	S 20° W	22	"	Metamorphic rock	Coffee plantation	Outside Model Area
SE Aguadas	28	Tm	B1D(m)	2,500	"	N 70K W	10	"	Volcanic ejecta	Ranch	"
Encimadas	29	Tm	yBD(d)	2,460	Ridge with Straight Slope	N 20° E	15	"	"	"	"
N Salamina	30	Bh	BE	1,300	Straight slope along valley	N	42	Colluvial soil	Metamorphic rock	Sugarcane field	"
S Neira	31	Th	B1D(m)	1,700	Gentle slope at mountain foot	N 20° W	20	C/S	Volcanic ejecta	Banana/Coffee plantation	"
Manizales*	32	Rd	Im	3,630	Straight slope	N 10° E	32	"	"	Ranch	"
"	33	Gh	G	3,410	Gentle slope	S 80° E	15	R/S	"	"	
"	MAP1	Bh	BE	2,850	Ridge with straight slope	N 30° W	37	R/S	"	Aliso	
"	2	Bg	G	2,820	Straight Slope	N 50° W	27	C/S	"	"	
"	MNP1	Tm	dBF	2,850	Ridge with Straight Slope	N 40° E	20	R/S	"	Broad-leaf natural forest	
"	5	Gh	G	3,350	Concave slope	N 40° W	7	"	"	"	Buenos Aires
Río Tapias	RAP1	Bh	BE	2,290	Ridge with convex slope	N 30° W	17	"	"	Aliso	
"	2	Bh	BE	2,350	Concave Slope	N	30	C/S	"	"	
"	RNP6	Th	dBF	3,600	Ridge with straight slope	N 80° W	35	R/S	"	Broad-leaf natural forest	Main peak east of Buenos Aires
"	RPP1	Bh	BD	2,470	Concave slope	N 20° E	33	C/S	Andesite		Buenos Aires
										Ranch	
"	2	Bh	BE	2,450	Concave slope along valley	N 10 °E	27	"	"	"	
"	4	Tm	B1F	3,500	Ridge with flat top	N 70° W	10	R/S	Volcanic Ejecta	"	
Pensilvania	PCP1	Th	B1D(m)	1,680	Ridge with straight slope	N 20° E	40	"	"	Broad-leaf natural forest with coffee undergrowth	

The draft soil maps were prepared this year based on the data so far obtained and the findings of the survey to be conducted in the next fiscal year will be added to complete the final soil maps. The soil types of the FAO/Unesco classification system are used in the draft soil maps.

① Distribution of Soil Types

In terms of the soil type distribution, the Model Areas are largely divided into two types. The first consists of the Río Tapias and Manizales Model Areas where cambisols re prominent in areas of high elevation while andosols are prominent in areas of low elevation. In the case of the second type, i.e. Pensilvania Model Area, andosols are promient throughout the area. As a wide distribution of gleysols or gleyic cambisols is observed in high elevation areas of the Pensilvania Model Area, it is inferred that regional differences in terms of the relative humidity have affected the distribution of soil types. The Pensilvania Model Area which is located between the middle of the eastern slope and the foot of the Central Mountains generally has a lower elevation than the elevations of the other two Model Areas which are located on the western slope of the same Central Mountains. Consequently, it mainly belongs to the warm-temperature zone or the lower part of the cool-temperate zone. In fact, the proportion of the cool-temperate zone in the Pensilvania Model Area is comparatively small, the annual rainfall, however, is as high as 3,000 - 4,000mm, resulting, in an extremely humid climate which in turn has affected the soil formation.

a. Soil Formation Environment Seen From Vertical Soil Type Distribution Conditions

The vertical soil type distribution for the above two types of Model Areas based on the Japanese soil classification system is shown in Fig. 2-2-3 (1)-(2) on the basis of the soil profile and simple trial pit survey results.

Brown forest soil, dark brown forest soil and black soil have been distributed in these figures along the axis of the abscissas from left to right to represent dry, moderately wet and wet soils respectively. Gleysols formed under excessive water supply and poor drainage conditions are placed further to the right and the correlation between the soil type and elevation has been examined. In each type of Model Area, the plotted points tend to concentrate from the bottom left corner to the top right corner of the graphl Dry soils tend to appear in relatively low elevation areas while wet soils and gleysols tent to appear in high elevation areas.

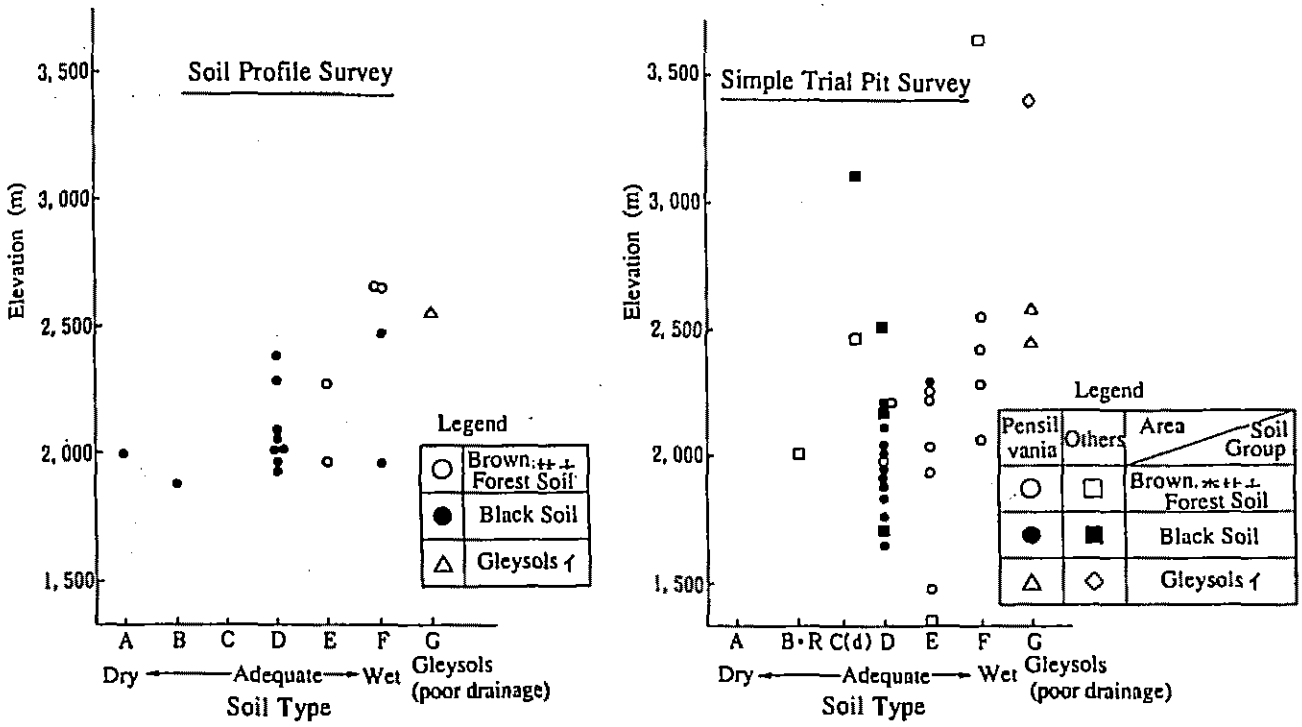


Fig. 2 - 2 - 3 (1) Vertical Distribution of Soil Types (Pensilvania Model Area)

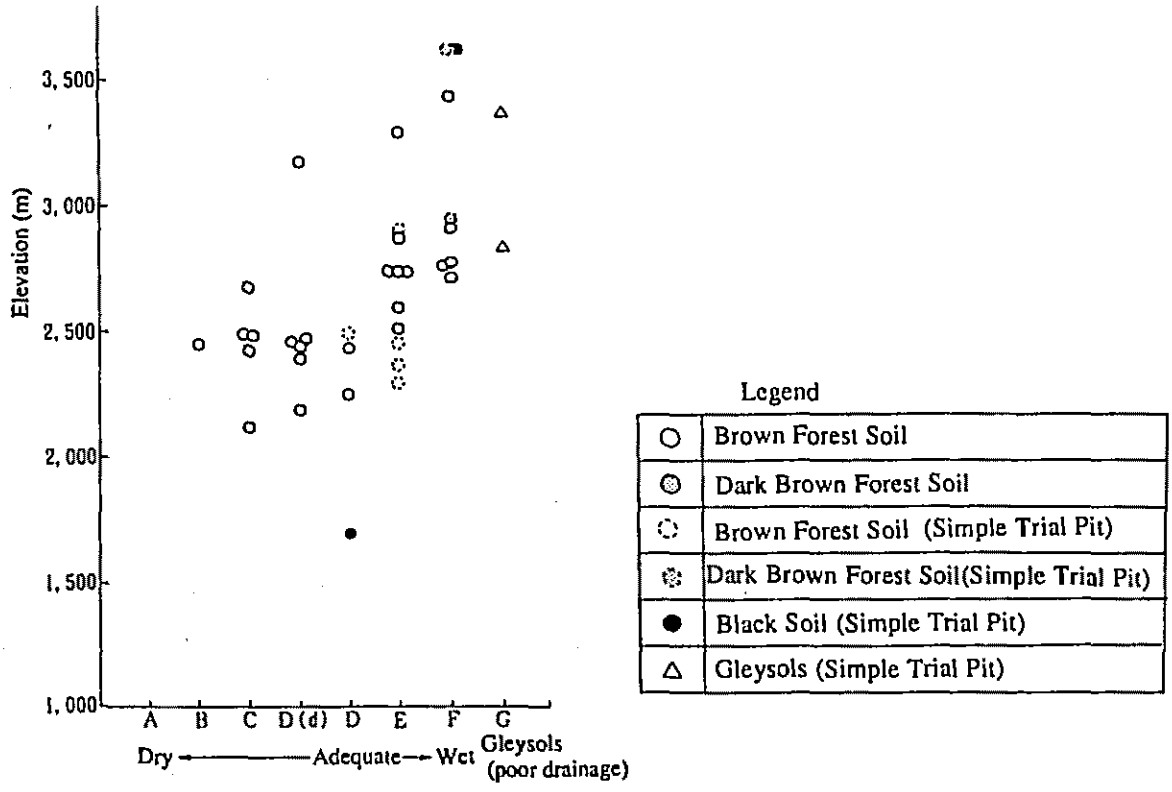


Fig. 2 - 2 - 3 (2) Vertical Distribution of Soil Types
(Rfo Tapias and Manizales Model Area)

In addition, there seems to be an elevation which forms a boundary between the dry soils and wet soils/gleysols despite some exceptions and this is approximately 2,700m above sea level in the Río Tapias and Manizales Model Areas and approximately 2,500m above sea level in the Pensilvania Model Area.

The reason for the existence of this demarcation line is that the areas above the elevation in question generally maintain a fairly wet soil formation environment throughout the year despite a large fluctuation between the major rainy season and minor dry season. Frequent heavy rain, low evapotranspiration due to the relatively low temperature and the frequent formation of cloud belts due to the area being located in the equator low pressure zone have all contributed to the creation of the wet soil formation environment above the demarcation line, especially in the Pensilvania Model Area. In other words, the elevation in question indicates the average cloud bottom altitude.

② Soil Type Distribution in each Model Area

a. Río Tapias Model Area

With the demarcation line at an approximate elevation of 2,700m, humic andosols and humic cambisols are widely distributed above and below the line respectively. Humic andosols are dominant in most areas covering ridges and mountain slopes, mostly consisting of dark brown forest soil of the Japanese soil classification system. Mollic andosols are observed at some grassland forming part of the ridges which continue from the main Andes ridges. Small areas of humic gleysols are found along valleys with gentle concave slopes above an elevation of some 3,500m. Dystric regosols and rocky ares are found in steep slope areas. Hardly any dry soils are found at this elevation and even B_E, B_F, dB_F and Bl_F can be found at ridges. $B_D(d)$ is occasionally seen at mountain slopes with an inclination as steep as 45°. Humic cambisols are dominant in the lower areas. Based on the Japanese classification system, such dry and semi-dry soil types as B_B, B_C and B_D (d) are found along ridges while B_D and B_E are found mid-slope. B_E and B_F are found at the lower parts of slopes and along valleys. Gleyic cambisols are sometimes found at gentle concave slopes and dystric regosols are occasionally found at steep slopes.

The parent materials are very often such volcanic ejecta as pumice and volcanic ash. Andesite and quartz diorite are also found in many places.

b. Manizales Model Area

As in the case of the Río Tapias Model Area, the soil distribution is markedly different above and below an elevation of approximately 2,700m. Gently sloping mountainsides above this elevation show the common existence of humic andosols, especially at páramos and grassland. In the lower areas, humic cambisols are commonly distributed. Humic gleysols are observed at gentle concave slopes above an elevation of some 3,000m. Humic cambisols are distributed at steep slopes with an inclination of 40° or more with dystric regosols being found in some areas.

Humic camibosols are dominant below an elevation of 2,700m while humic andosols and mollic andosols are mainly found at ridges. Gleyic cambisols are sometimes found at some flat valleys.

The distribution of the soil types classified on the basis of the Japanese system is very similar to that in the Río Tapias Model Area.

The parent materials are mainly such volcanic ejecta as pumice and volcanic ash and outcrops of the bedrock, i.e. crystalline schist, are observed in some areas. One of the soil distribution characteristics of the Manizales Model Area is the wide distribution of soil, the parent materials of which are volcanic ejecta which have deposited over different geological periods, reflecting requent volcanic activity. A mixed layer of pumice and volcanic ash is found several tens of centimetres below the ground in many places.

c. Pensilvania Model Area

Mollic gleysols and humic gleysols/mollic andosols are distributed above the demarcation line which has an elevation of approximately 2,500m. Gleysols cover steep mountain slopes as well as ridges. The humic andosols are mainly of the wet type, such as B_F and dB_F in the Japanese classification system, indicating the fact that the area has an exceptionally wet environment. Mollic andosols are dominant in areas below the demarcation line and humic cambisols are only found southwest of urban Pensilvania along Pensilvania River and in eastern parts of the left bank. Small areas of ochric andosols are found at lower mountainsides on the right bank and some parts of the left bank.

Dystric fluvisols are found at areas of concave slopes at lower mountainsides on the right bank of Pensilvania River while small areas of dystric regosols are found at steep slopes.

In terms of the Japanese classification system, various types of black soil, such as Bl_A, Bl_B, Bl_D (d), Bl_D, Bl_D (m) and Bl_F, are found in areas from ridges to mid-mountainside. Such types of brown forest soils as B_D, B_E and B_F are also found. The appearance of Bl_A and Bl_B is local. Bl_D, Bl_F and B_F, etc. are found along valleys and on gentle slopes.

The parent materials are mainly volcanic ejecta, such as volcanic ash containing a small amount of pumice. Crystalline schist is also found with or without volcanic ash.

③ Common Characteristics

The soil types distributed in the Model Areas are mainly those which are widely found in a temperate zone with high rainfall at an intermediate latitude (for example, Japan). In the tropics, these soil types ar found in a warm-temperate or cool-temperate zone with high rainfall in areas of high elevation, such as the Model Areas.

One characteristic common to all the Model Areas is the prominence of tight, massive structure, except some surface horizons. However, it is difficult to determine the causes based on the available data.

The leaching of clay to lower horizons is suspected in some parts. As this has not been confirmed, no algillics B horizon is mentioned in the present report.

Ferralic cambisols are distributed in the Intensive Area at Cores (El. 2,000m) where a simple trial pit was dug, Enmcimadas (El. 2,400m) and cut slopes along the trunk road between Aguadas and Manizales. The same type of soil is also between Aguadas and Manizales. The same type of soil is also found at La Linda (El. 1,700m) facing Pensilvania River and Esperanza (El. 1,680m) on the other side of Pensilvania River from La Linda. These are not indicated on the map as their respective areas of distribution have not been confirmed. This soil type corresponds to red soil (R) of the Japanese classification system. In Japan, it is regarded as fossil soil which was formed under a hotter climate than the present climate. In the Intensive Area, its distribution is widely observed but is limited to

areas between the upper part of the warm-temperate zone to the lower part of the cool-temperate zone and the possibility of it being fossil soil cannot be denied.

2.2.5 Appropriate Afforestation Site Survey

An appropriate afforestion site survey was conducted at man-made forests in and outside the Model Areas. The feasibility of afforestation in the Pensilvania Model Area, of which a model afforestation plan for a man-made forest will be prepared, was particularly emphasized. The survey findings are described below.

(1) Current Conditions of Afforestation

The findings of both the field survey and interview survey are outlined below.

① Pensilvania Model Area

The Pensilvania Model Area and its surrounding sites has some 2,400ha of afforestation sites which are mainly owned by Pro-oriente S.A and Maderas de Oriente S.A. The species used are mainly P. patula and Ciprés. Pinus oocarpa and Aliso are also planted in small area.

None of the sites were originally intended to create an industrial plantation. Afforestation commenced at former pastureland which was sold on the grounds of deteriorated soil fertility. The immediate objective was to create employment opportunities for those farmers who had sold their farmland. The afforestation sites are located somewhere between El. 1,800m and El. 2,800m, i.e. above the coffee plantation zone and in the pastureland zone. No site for afforestation was created immediately after the felling of a forest. The early afforestation sites are now 18 years old and usable stands have begun to emerge.

The main species, their planting elevations and suitable sites are as follows.

Pinus patula (P. patula)	2,000 - 2,800m	mountainside - ridge
Pinus-oocarpa	1,800 - 2,200m	mountainside
Cipressuss lusitanica (Ciprés)	2,000 - 2,400m	valley - mountainside
Alnus jorullensis (Aliso)	1,800 - 2,500m	mountainside

Only Aliso grows as native species in the Model Area. Although all the sites are classified as large-scale uniform afforestation sites, various types of forestry work

are conceivable from the long-term perspective. Several types of Eucalyptus have also been planted but the planting area is too small to be listed.

Harmful insects vis-a-vis these species have so far been identified as Lepidopler geometridae and Phasmidae which eat the leaves of P. patula.

② Río Tapias and Manizales Model Areas

Aliso is planted in some 750ha of the Manizales Model Area and some 160ha of the Río Tapias Model Area. In a suburb of Manizales, Compañía Forestal de Colombia S.A. and Maderas y Celulosa A.S. are engaged in some 2,000ha of afforestation, mainly using P. patula and Ciprés. The planting elevations and suitable sites for these species are the same as those in the Pensilvania Model Area. A comparison of directly obtained data on afforestation sites in the Pensilvania Model Area and those of Compañía Forestal de Colombia S.A. shows that the plant growth has so far been slightly better in suburban Manizales than in neighbouring areas of Pensilvania.

③ Afforestation Sites Outside Model Areas

As described later in the forest resources management survey, Reforestadora Andina S.A. (Armenia) which manages 9,000ha of forests in the Caldas and Quindio Provinces has set the following planting standards.

P. patula (from South Africa)	El. 2,000 - 3,000m
P.kesiya (from Asia)	El. 1,400 - 2,200m
P.maximinoi (from Honduras)	El. 2,000 - 2,400m

(while P.maximinoi produced by countries other than Honduras is planted at EL. 1,800 - 1,900m in some places,damage due to fox tail is likely at low elevation sites.)

P.tecunumanii (from Nicaragua)	El. 1,400 - 2,000m
P.oocarpa (from Guatemala)	El. 1,400 - 2,100m
E.grandis (from tropical islands)	El. 1,000 - 2,200m
E.globulus (from tropical islands)	El. 2,000 - 3,000m

(2) Appropriate Afforestation Sites in View of Natural Environment

The dominant thinking in the selection of appropriate afforestation sites which correspond to the characteristics of the natural environment of each Model Area is summarised here.

Of various growth factors, temperature is the most dominant factor. As the temperature is affected by the elevation, an appropriate planting area for each species is roughly determined n terms of elevation. In the actual selection of species, however, the soil conditions and relative topographic conditions should also be examined to result in a careful conclusion.

In the case of the Pensilvania Model Area for example, the annual rainfall far exceeds that of the other Model Areas, creating an excessively wet climate. As a result, gleysols are formed in areas above El. 2,500m due to poor drainage and are also fond at flat land along valleys, low land at valley bottoms and concave sites, etc. Gleysols are unsuitable for afforestation purposes and the healthy growth of planted trees can hardly be expected with this type of soil. If such a site is already occupied by a natural forest, natural regeneration can be expected. If such a site is not occupied by a natural forest, however, the other alternative could be a gradual invasion of the site by natural vegetation.

No soil types other than gleysols particularly impede plant growth. However, careful attention should be paid to afforestation with such low productivity soils as B_{IA}, B_{IB}, B_B dystric regosols and ferralic cambisols. The felling of trees and the replacement of a forest with grassland should be avoided in the case of steep slopes (with an inclination of 40° or more) from the view point of soil and water conservation.

2.2.6 Forest Physiognomy Improvement Standards Survey

The forest conditions in the Model Area and surrounding areas were surveyed and the definitions of forest types in Colombia and other related aspects of forest physiognomy were examined to obtain the necessary data for the preparation of forest physiognomy improvement standards. The survey findings are described below.

(1) Forest Criteria

For forest physiognomy improvement, it is important to classify forests and to select a combination of species as well as tree size classes to achieve the target forest physiognomy. In the course of this, it is essential to understand the objectives of forest categories in Colombia. The definitions of forests in Colombia which are relevant to the present Study are given by the National Act on Environmental Protection and Renewable Natural Resources (April, 1986). The

forest categories are defined in the following articles and the forest physiognomy improvement standards will be prepared in accordance with these categories.

National Act on Environmental Protection and Renewable Natural Resource

Article 45 e) Special Conservation Area

Colombia will be delineated into special management zones in order to ensure the development of policies regarding the environment and the natural resources. At the same time, priority will be given to implementation of programmes in zones which have serious environmental and resources management problems.

Article 204 Protected Forest Area

The protected forest zones are to be conserved permanently until natural or man-made forests for the protection of these resources as well as other renewable resources are established. The first priority of protected forest areas is to maintain their protective function although the obtainment of secondary forest products from these areas is permitted.

Article 205 Protected Production Forest Area

Those areas to be permanently conserved by means of natural forests or man-made forests to protect renewable natural resources are designated protected production forest areas when they are also subject to production activities which assist the preservation of the protective function.

Article 203 Production Forest Area

The production forest zones are understood to be the areas that must be conserved permanently by means of natural forests or man-made forests which will be exploited for commercial and self consumption purposes.

(2) Forest Physiognomy in Model Areas

① Natural Forests

The top 10 species indicated by the forest resources survey are shown in Table 2-2-17 (1) by both Model Area and height grade (5m scale). The findings of the natural regeneration survey are similarly compiled in Table 2-2-17 (2). The data in these 2 tables are made into graphs in Fig. 2-2-4.

Table 2 - 2 - 17 (1) Top 10 Species in Natural Forests by Height Class

Río Tapias Model Area (14 Plots, 17ha)

NO.	ESPECIE F G B	0=<A< 5	5=<A<10	10=<A<15	15=<A<20	20=<A<25	25=<A<30	30=<A<35	35=<A<40	40=<A<45	45=<A<50	TOTAL	%
1	35 05 01	0	7	47	87	58	11	0	0	0	0	210	17.44
2	12 01 03	0	36	45	31	12	0	0	0	0	0	124	10.30
3	35 04 01	1	14	42	40	9	0	0	0	0	0	106	8.80
4	12 01 02	0	25	59	17	1	0	0	0	0	0	102	8.47
5	16 01 02	0	7	37	30	12	0	0	0	0	0	86	7.14
6	17 01 02	11	15	28	5	1	0	0	0	0	0	60	4.98
7	27 02 01	0	1	12	27	18	0	0	0	0	0	58	4.82
8	14 02 01	0	6	15	16	8	4	0	0	0	0	49	4.07
9	35 04 04	2	2	7	19	16	0	0	0	0	0	46	3.82
10	58 02 01	0	0	2	15	19	6	0	0	0	0	42	3.49
	Others	21	65	106	80	47	2	0	0	0	0	321	26.66
	Total	35	178	400	367	201	23	0	0	0	0	1,204	100.00

Manizales Model Area (10 Plots, 1.3ha)

NO.	ESPECIE F G B	0=<A< 5	5=<A<10	10=<A<15	15=<A<20	20=<A<25	25=<A<30	30=<A<35	35=<A<40	40=<A<45	45=<A<50	TOTAL	%
1	06 01 01	0	5	26	34	32	16	2	0	0	0	115	11.53
2	17 01 02	27	43	18	2	0	0	0	0	0	0	90	9.03
3	14 04 01	1	17	20	9	6	0	0	0	0	0	53	5.32
4	16 01 02	0	4	26	12	3	1	0	0	0	0	46	4.61
5	12 01 03	0	7	20	12	0	0	0	0	0	0	39	3.91
6	55 01 02	1	12	15	8	1	0	0	0	0	0	37	3.71
7	51 01 02	0	15	17	4	1	0	0	0	0	0	37	3.71
8	05 02 02	1	4	24	7	1	0	0	0	0	0	37	3.71
9	35 04 04	0	4	11	16	2	1	0	0	0	0	34	3.41
10	22 02 02	0	6	19	6	2	0	0	0	0	0	33	3.31
	Others	6	92	223	115	35	4	1	0	0	0	476	47.74
	Total	36	209	419	225	83	22	3	0	0	0	997	100.00

Pensilvania Model Area (8 Plots, 0.44ha)

NO.	ESPECIE F G B	0=<A< 5	5=<A<10	10=<A<15	15=<A<20	20=<A<25	25=<A<30	30=<A<35	35=<A<40	40=<A<45	45=<A<50	TOTAL	%
1	13 01 01	0	0	8	23	11	0	0	0	0	0	42	9.70
2	03 02 01	0	0	2	16	5	0	0	0	0	0	23	5.31
3	35 04 01	1	1	6	5	9	0	0	0	0	0	22	5.08
4	51 04 01	0	3	8	5	2	0	0	0	0	0	18	4.16
5	27 01 01	0	2	6	4	4	1	0	0	0	0	17	3.93
6	35 04 04	0	1	6	5	4	0	0	0	0	0	16	3.70
7	23 01 01	0	1	7	3	4	0	0	0	0	0	15	3.46
8	17 01 02	2	7	5	1	0	0	0	0	0	0	15	3.46
9	17 01 01	1	7	7	0	0	0	0	0	0	0	15	3.46
10	51 01 02	0	1	3	5	3	0	0	0	0	0	12	2.77
	Others	0	32	87	75	43	1	0	0	0	0	238	55.00
	Total	4	55	145	142	85	2	0	0	0	0	433	100.00

Table 2 - 2 - 17.(2) Top 10 Naturaly Regenerated Species by Height Class

Río Tapias Model Area (14 Plots, 780m2) 14

NO.	ESPECIE			GE	NUMERO DE ARBOLES (/HA.)					
	F	G	E		A=< 0.3M	0.3M< A<1.3M	1.3M=<ALT. D<5CM	5CM=<D<10CM	TOTAL	%
1	44	3	1		144	95	35	12	286	22.20
2	51	5	3		34	67	24	8	133	10.33
3	56	1	1		44	26	32	2	104	8.07
4	26	1	1		2	48	42	7	99	7.69
5	35	4	4		27	28	13	7	75	5.82
6	35	4	1		29	36	9	1	75	5.82
7	35	1	1		12	32	10	3	57	4.43
8	56	3	1		15	25	12	1	53	4.11
9	51	1	2		15	4	10	2	31	2.41
10	5	2	2		14	7	5	0	26	2.02
	Others				59	122	118	50	349	27.10
	Total				395	490	310	93	1,288	100.00

Manizales Model Area (10 Plots, 560m2)

NO.	ESPECIE			GE	NUMERO DE ARBOLES (/HA.)					
	F	G	E		A=< 0.3M	0.3M< A<1.3M	1.3M=<ALT. D<5CM	5CM=<D<10CM	TOTAL	%
1	35	4	1		45	92	51	10	198	13.03
2	51	5	3		56	84	50	0	190	12.50
3	35	4	4		49	107	26	1	183	12.04
4	12	1	3		17	18	73	15	123	8.09
5	26	1	1		26	78	15	2	121	7.96
6	56	3	1		61	15	15	0	91	5.99
7	12	1	2		16	23	26	0	65	4.28
8	35	4	2		16	26	10	4	56	3.68
9	16	1	1		0	0	44	2	46	3.03
10	53	1	1		15	14	11	0	40	2.63
	Others				148	130	103	26	407	26.78
	Total				449	587	424	60	1,520	100.00

Pensilvania Model Area (8 Plots, 320m)

NO.	ESPECIE			GE	NUMERO DE ARBOLES (/HA.)					
	F	G	E		A=< 0.3M	0.3M< A<1.3M	1.3M=<ALT. D<5CM	5CM=<D<10CM	TOTAL	%
1	34	2	1		46	63	39	0	118	13.83
2	51	5	3		49	39	6	1	95	11.14
3	51	5	1		45	24	16	0	85	9.96
4	35	4	3		29	30	16	1	76	8.91
5	51	1	1		40	16	3	0	59	6.92
6	40	3	2		22	15	4	0	41	4.81
7	53	1	1		21	14	2	1	38	4.45
8	35	4	1		13	8	10	0	31	3.63
9	51	4	1		19	7	4	0	30	3.52
10	35	3	1		6	6	11	0	23	2.70
	Others				70	103	76	8	257	30.01
	Total				360	325	157	11	853	100.00

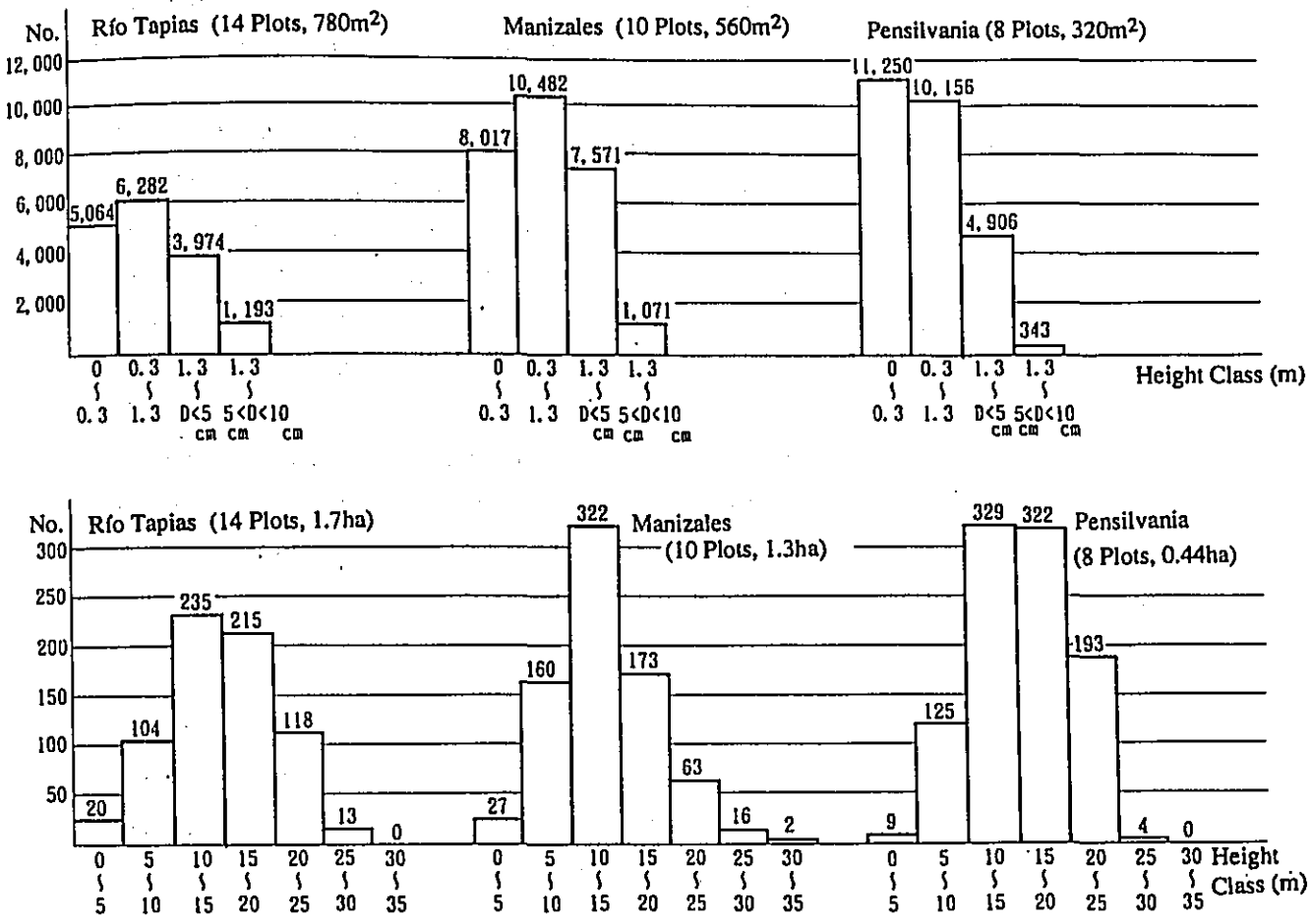


Fig. 2 - 2 - 4 Number of Trees by Height Class in Natural Forests

It is observed that the prominent family in all the Model Ares is Melastomataceae, followed by Chloranthaceae, Betulaceae, Clethraceae and Cyatheaceae. The forest resources survey identified 67 species in the Río Tapias Model area, 68 species in the manizales Model Area and 72 species in the Pensilvania Model Area. The number of trees with a diameter breast height of 10cm or more is highest in the height class of 10 - 15m. Taking the fact that trees with a diameter breast height of below 10cm are not counted in the lower height classes into consideration, it can be observed that the natural forests are well balanced in terms of height classes as the number o trees decreases in accordance with a higher height class.

In general, commercially useful large diameter trees are not numerous in the natural forests while the total area of these forests is comparatively small. Nevertheless, hardly any natural forests can be described as failing to perform its beneficial functions, especially the headwater conservation function, due to deterioration of the forest physiognomy.

② Man-made Forests

The Río Tapias Model Area and Manizales Model Area have Aliso man-made forests while the Pensilvania Model Area has P. patula and Ciprés man-made forests. The forest physiognomy has deteriorated in some places due to the lack of adequate care. In the case of the Aliso forests, the physiognomy has not necessarily deteriorated although some forests have almost resemble natural forests due to the failure to win the regeneration competition with invading trees, in turn caused by inadequate care.

The deterioration of the physiognomy of P. patula forests is mainly caused by damage due to Phasmidae as described in the forest resources management survey findings later. The huge propagation of Phasmidae which prefer dark places is assumed to have been stimulated by the delay of thinning, suggesting the crucial importance of implementing appropriate forest work in view of future healthy growth.

Some Ciprés forests have a number of stem breakages due to strong wind, probably resulting from the implementation of excessive thinning. The implementation of appropriate forests work is also important for these forests.

2.2.7 Denuded Land Survey

A denuded land survey was conducted to obtain basic data for the preparation of the denuded land restoration standards. The denuded sites were interpreted using aerial photographs and the field verification survey was conducted on accessible denuded land. During the field survey, minor devastations which were not identified during the aerial photograph interpretation were found. The survey findings are described below.

(1) General Conditions of Denuded Land

Any denuded land with an area of 40m^2 or more can be identified on an aerial photograph of the scale 1/20,000. Three types of devastation were mainly identified, i.e. torrent stream (vertical erosion type), bank erosion (horizontal erosion type) and hillside collapse (surface slide). The types of man induced devastation identified include collapse caused by road construction work, collapse at a limestone quarry of Cementos Caldas S. A. and collapse at a quarry in the Pensilvania Model Area. In addition, small-scale devastation sites confirmed by the field survey include collapsed sites (surface slide) due to topographical changes (observed at pastureland) and sites of accelerated erosion due to the uncontrolled discharge of sewage (observed in all residential districts of the Intensive Area).

The size of devastation in the Intensive Area is generally small with a low frequency despite the steep topography, indicating relative stability of both the topography, indicating relative stability of both the topographical and geological conditions of the Intensive Area.

The Erosion and Devastation Map in "Suelos y Bosques de Colombia" published in 1988 by the IGAC shows no sites in the upper part of the Central Mountains in the Intensive Area and only refers to minor or medium degree erosion in mountain-side areas. The Intensive Area is, in fact, designated one of the least eroded areas in Colombia.

The survey on the devastation conditions of the same sites in the one year period from 1989 to 1990 found that no substantial change has taken place in the naturally devastated areas in terms of erosion and that the vegetation cover is progressing in most places, indicating the rapid speed of natural restoration. In those areas of artificial devastation, vegetation cover appears several months after the initial erosion caused by road construction work. In some places, ligneous plants have begun to grow among the herbacea. In the case of 3 - 5 year old road construction-

inflicted landslide sites, the entire surface is covered with vegetation, presenting almost stable slopes.

The water in the main streams of Magdalena River and Cauca River, for both of which the Intensive Area is the catchment area, is muddy and show a high degree of turbidity. The reason for this is the discharge of sediment from severely eroded lowland located within a 10 - 20km wide belt on both banks of the rivers as clearly indicated on the IGAC map mentioned earlier. A comparison of such lowland with the Intensive Area reveals the latter to have higher land stability where the land fertility of ranches of more than 100 years of age is still maintained.

(2) Analysis of Devastation Conditions

① Natural Devastation

The sites and corresponding areas of torrent stream, bank erosion and landslide are shown in Table 2-2-18 and the denuded land factors for each Model Area are shown in Table 2-2-19.

Table 2 - 2 - 18 Natural Devastation Sites by Model Area

Type of Devastation	Model Area						Total		Average
	Río Tapias		Manizales		Pensilvania				
	No. of site	ha	No. of site	ha	No. of site	ha	No. of site	ha	ha
Torrent Stream	11	2.68	34	3.16	6	1.00	51	6.84	0.13
Bank Erosion	4	0.36	0	—	0	—	4	0.36	0.09
Collapse	6	0.36	3	0.28	0	—	9	0.64	0.07
Total	21	3.41	37	3.44	6	1.00	68	7.84	—
Average Area	—	0.16	—	0.09	—	0.16	—	0.12	0.12
Subject Area	10,617 ha		4,429 ha		5,659 ha		20,705 ha		—
Rate of Devastation	0.032 %		0.078 %		0.018 %		0.038 %		—
Highest Elevation	3,849 m		3,792 m		3,134 m		——		—
Lowest Elevation	1,510 m		2,160 m		1,300 m		——		—
Relief Ratio	0.083		0.114		0.107		——		—

Note: Erosion types other than the ones mentioned in the table do not exist in the Model Area

Table 2 - 2 - 19 Factors of Denundation (1) Río Tapias Model Area

No.	Mesh		Collapse Type	Length (m)	Area (ha)	Micro Topography	Bearing	Incl. (°)	Soil Type	Forest Type	Elevation (m)
	Vertical	Horizontal									
1	3	29	torrent stream	20	0.04	V	E	34°	Bh	N24	2,830
2	3	30	collapse	10	0.04	凹	SE	36°	〃	〃	2,800
3	4	26	torrent stream	100	0.12	V	SE	44°	Th	N24	2,740
4	4	31	〃	200	0.12	V	SE	38°	Bh	N24	2,920
5	5	26	〃	300	0.32	V	E	44°	〃	N24	2,600
6	5	30	collapse	40	0.08	凹	SE	36°	〃	〃	2,560
7	5	32	torrent stream	200	0.12	V	SW	34°	〃	〃	2,800
8	6	29	〃	20	0.04	V	S	42°	〃	〃	2,440
9	6	32	〃	80	0.12	V	W	44°	〃	〃	2,860
10	6	33	torrent stream	80	0.12	V	W	40°	Th	P	3,160
11	7	31	collapse	100	0.08	V	SW	34°	Bh	N24	2,600
12	8	40	torrent stream	100	0.08	V	SW	40°	Th	N14	3,350
13	9	31	collapse	20	0.04	凹	SE	46°	Bh	P	2,500
14	9	35	torrent stream	250	1.28	V	NW	44°	Th	N24	2,920
15	9	36	collapse	30	0.08	凹	W	34°	〃	P	3,160
16	10	33	〃	10	0.04	凹	W	38°	Bh	〃	2,630
17	10	39	torrent stream	100	0.04	V	NW	50°	Th	N14	3,360
18	12	24	〃	350	0.40	V	SW	34°	Bh	P	2,250
19	14	26	collapse	30	0.08	凹	S	40°	〃	N24	2,680
20	15	26	torrent stream	100	0.12	V	S	44°	〃	〃	2,600
21	19	28	〃	50	0.04	V	W	34°	〃	〃	2,820

(2) Manizales Model Area

No	Mesh		Collapse Type	Length (m)	Area (ha)	Micro Topography	Bearing	Incl. (°)	Soil Type	Forest Type	Elevation (m)
	Vertical	Horizontal									
1	4	21	torrent stream	100	0.04	凹	NW	34°	Th	P	3,500
2	6	14	〃	〃	0.12	V	SW	28°	〃	P	3,040
3	6	15	〃	70	0.16	V	SW	22°	〃	P	3,160
4	7	8	〃	70	0.08	凹	SE	40°	Bh	N22	2,500
5	7	9	〃	30	0.08	V	SE	40°	〃	〃	2,520
6	7	9	〃	30	0.04	凹	S	40°	〃	〃	2,550
7	7	9	〃	170	0.32	V	NE	45°	〃	N24	2,500
8	7	11	〃	100	0.08	V	SW	42°	Bh	N22	2,750
9	7	12	〃	120	0.12	V	SW	40°	Bh	N22	2,750
10	7	12	〃	120	0.08	V	SW	42°	Th	N22	2,660
11	8	8	〃	200	0.28	V	NW	42°	Bh	N24	2,650
12	8	11	〃	20	0.04	V	E	36°	Bh	N24	2,620
13	8	11	〃	20	0.04	V	E	36°	〃	〃	2,630
14	8	11	〃	60	0.04	V	NE	32°	〃	〃	2,620
15	8	12	〃	150	0.08	V	N	36°	Bh	〃	2,700
16	8	13	〃	200	0.08	V	NE	34°	〃	〃	2,760
17	8	13	〃	250	0.12	V	NE	32°	〃	〃	2,800
18	9	6	〃	100	0.16	凹	NE	26°	〃	N22	2,400
19	9	9	〃	200	0.08	V	NE	28°	〃	N24	2,650
20	9	9	〃	200	0.08	V	NE	28°	〃	〃	2,660
21	9	11	〃	20	0.04	V	NE	35°	〃	〃	2,650
22	9	11	〃	80	0.16	V	NE	24°	〃	〃	2,700
23	9	11	collapse	40	0.12	凹	NE	26°	〃	〃	2,620
24	10	8	torrent stream	150	0.16	V	S	36°	〃	〃	2,720
25	10	9	〃	100	0.12	V	WE	26°	〃	〃	2,780
26	10	12	collapse	20	0.04	凹	NE	40°	〃	〃	2,720
27	11	10	torrent stream	50	0.04	V	N	22°	Th	〃	2,830
28	11	12	〃	80	0.04	V	E	24°	Bh	〃	2,750
29	12	5	〃	100	0.08	V	SW	28°	Bh	- 〃	2,720
30	12	11	collapse	80	0.12	凹	E	22°	Bh	N24	2,060
31	12	12	torrent stream	80	0.04	V	E	26°	Bh	N24	2,950
32	12	12	〃	80	0.04	V	NW	26°	〃	〃	2,880
33	12	14	〃	150	0.08	V	NW	40°	Th	〃	3,450
34	12	17	〃	100	0.04	V	NE	36°	Bh	〃	3,440
35	13	10	〃	100	0.08	V	S	34°	〃	〃	2,960
36	13	10	〃	100	0.04	V	SW	40°	〃	〃	2,920
37	15	5	〃	50	0.08	凹	N	16°	〃	〃	2,380

(3) Pensilvania Model Area

No	Mesh		Collapse Type	Length (m)	Area (ha)	Micro Topography	Bearing	Incl. (°)	Soil Type	Forest Type	Elevation (m)
	Vertical	Horizontal									
				m	ha						
1	6	19	torrent stream	50	0.08	V	S	38°	Tm	N23	2,420
2	7	20	〃	100	0.16	V	SE	42°	〃	Ba	2,240
3	8	19	〃	100	0.12	V	S	32°	〃	Ba	2,080
4	12	23	〃	150	0.12	V	SW	28°	Th	Ba	1,680
5	14	9	〃	400	0.40	V	N	30°	Bh	P	2,350
6	18	17	〃	120	0.12	V	NE	40°	Tm	P34	2,160

a. Conditions of Devastation in Each Model Area

(a) Río Tapias Model Area

21 devastated sites with a total area of 3.40ha were found in the Río Tapias Model Area with elevations ranging from 2,250m to 3,360m. Torrent stream is the most frequent type of devastation although sites of bank erosion and collapse also exist, showing the most complicated causes of devastation among the 3 Model Areas. Torrent stream generally means a relatively short but steep stream occurring in the upperstream of a river where the water flow substantially increases with rain to cause a rapid discharge of sediment and gravel. The devastation length varies from 20m to 350m and the average area is 0.24ha. Excluding one large torrent stream area of 1.28ha, however, the average area of 0.14ha is relatively small. This large torrent stream area of 1.28ha which is, in fact, the largest of its kind in the Intensive Area, is located in the upperstream of La Guayana Valley. However, the field survey failed to determine whether this area is on the increase or decrease.

The inclination of the existing torrent streams ranges from 34° to 50° with a mean inclination of 40.5°, indicating the presence of steep slopes. Since this degree of inclination is the one along the bearing of the torrent streams, the inclination of both banks of well over 50° is much steeper.

Table 2-2-20 shows the number of devastated sites by land use category. It is observed that most of the devastated sites are located in natural forests. The reason for this is that the most developable land in the Río Tapias Model Area has already been developed, leaving only steep slopes covered by natural forests liable to the appearance of torrent streams.

4 bank erosion sites were identified with an erosion length ranging from 20m to 200m (average of 100m) along valleys. The area per site varies from 0.08ha to 0.12ha with an average of 0.09ha. The inclination of the eroding surface varies from 34° to 44° with an average of 38.5°. This type of erosion has also occurred in natural forests in this area.

Most of the collapsed sites are in a circular shape with an area ranging from 0.04ha to 0.08ha (average of 0.06ha) and are very small. The inclination of the collapsed surface varies from 34° to 46° (average 38.3°). It is worth noting that half of these sites are located in pastureland.

Table 2 - 2 - 20 Number of Devastated Sites by Land Use Category

Model Area/ Collapse Type	Natural Forest		Man-made forest of P.patula		Farm Forest (Ba)		Pasture-land (P)		Total		%	
	No. of Sites	ha	No. of Sites	ha	No. of Sites	ha	No. of Sites	ha	No. of Sites	ha	No. of Sites	ha
Río Tapis		ha		ha		ha		ha		ha		ha
Torrent Stream	9	2.16					2	0.52	11	2.68		
Bank Erosion	4	0.36							4	0.36		
Collapse	3	0.20					3	0.16	6	0.36		
Total	16	2.72					5	0.68	21	3.40		
Manizales												
Torrent Stream	31	2.84					3	0.32	34	3.16		
Bank Erosion	-						-		-			
Collapse	3	0.28							3	0.28		
Total	34	3.12					3	0.32	37	3.44		
Pensilvania												
Torrent Stream	1	0.08	1	0.12	3	0.40	1	0.40	6	1.00		
Bank Erosion												
Collapse												
Total	1	0.08	1	0.12	3	0.40	1	0.40	6	1.00		
Total												
Torrent Stream	41	5.08			3	0.40	6	1.24	51	6.84	79.7	87.2
Bank Erosion	4	0.36							4	0.36	6.2	4.6
Collapse	6	0.48					3	0.16	9	0.64	14.1	8.2
Total	51	5.92			3	0.40	9	1.40	64	7.84	100.0	100.0
%	79.6	75.5	1.6	1.5	4.7	5.1	14.1	17.9	100.0	100.0		

(b) Manizales Model Area

37 devastated sites with a total area of 3.44ha were found in the Manizales model Area with elevations ranging from 2,400m to 3,500m. These comprise 34 torrent stream sites and 3 collapsed sites. The length of the torrent streams ranges from 20m to 200m with an average length of 104.4m. The area per site varies from 0.04ha to 0.28ha with an average area of 0.09ha which is much smaller than in the case of the neighboring Río Tapias Model Area. The inclination of the devastated surface varies from 16° to 45° (average of 32.9°) and the number of torrent streams is high, reflecting the high forest ratio of this Model Area. The area of the collapsed sites varies from 0.04ha to 0.12ha. The average figure of 0.09ha is the same as that for torrent streams but the shape is somehow circular as in the case of the Río Tapias Model Area.

(c) Pensilvania Model Area

Only 6 torrent streams were found in the Pensilvania Model Area with an elevation ranging from 1,680m to 2,420m, the lowest elevation recorded in all 3 Model Areas. The length of the torrent streams varies from 50m to 400m (average of 153.3m). The area per site varies from 0.08ha to 0.40ha (average of 0.17ha). The inclination of the devastated surface varies from 30° to 42° (average of 35°). The largest torrent stream with an area of 0.4ha is found in the upperstream of El Chimborazo Valley which is located some 1.5km south of Pensilvania.

② Man induced Devastation

The main types of man induced devastation are collapse following road construction, collapse at the limestone quarry of Cementos Caldas S. A. and collapse at the quarry in the Pensilvania Model Area.

a. Collapse Caused by Road Construction

The construction of a national road connecting La Cristalina with Marulanda is in progress in the Rfo Tapias Model Area and has almost reached the ridge of the Central Mountains. On both sides of a some 15km section of this new road from La Cristalina to the ridge, the collapse of the slopes is continuing due to cutting and the disposal of the cut soil. The inadequate road construction method is responsible for the collapse and large collapses have occurred in the upper mountainside where the deposit of volcanic ash is prominent. The rapid growth of vegetation, however, has achieved a general stability over the entire road construction sites with older sites enjoying better stability than newer sites. The aerial photograph interpretation results of these sites are shown in Table 2-2-21 (1).

Slopes in the Pensilvania Model Area are gentler than in the other Model Areas. However, 9 sites of collapse following the construction of roads (settlement roads, farm roads and work roads) have been identified through interpretation of the aerial photographs as shown in Table 2-2-21(2). The collapse is presumed to have been caused by heavy rain as the Model Area is located at the foot of the eastern slope of the Central Mountains coupled with busy farming activities in areas mostly covered by volcanic ash.

b. Collapse Caused by Industrial Activities

Various activities, including land excavation, are being conducted to promote local industries and 2 denuded sites as large as 52.5ha resulting from such activities which are identifiable on the aerial photographs are shown in Table 2-2-22.

The quarry in the Pensilvania Model Area is rather small and, therefore, there is little danger that the collapsed site will rapidly expand. In comparison, the limestone quarry in the Río Tapias Model Area has the largest cement factory in Caldas Province. With the recent adoption of the underground mining method instead of open-air mining, there is again little danger than the collapse will extend excepting the possible collapse of disposed slag.

c. Other Types of Collapse

A number of collapses are caused by the local inhabitants living in the Andes Mountains characterized by steep slopes. The main cause is the flow of sewage water on the land surface due to the lack of a sewage system. The area affected by each incident, however, is small. As those people who have migrated into the suburban areas are mainly responsible, the CRAMSA and other organizations have been implementing various remedial measures with little success.

Table 2 - 2 - 21 (1) Collapse Caused by Road Construction
- Pensilvania Model Area -

No.	Mesh No.		Length	Micro	Bearing	Incl.	Soil	Forest	Elevt.
	Vertical	Horizontal	(m)	Topography		(°)	Type	Type	(m)
1	4	13	40	凹	W	42°	Tm	N23	2,370
2	4	14	50	凸	S	30°	Gm	N13	2,480
3	4	16	100	凹	S	36°	Gh	P	2,640
4	9	7	100	凸	E	38°	Tm	P24	2,360
5	9	7	50	凸	E	38°	Tm	P24	2,390
6	9	19	200	凸	SE	20°	Tm	P	1,910
7	10	7	50	凸	NE	30°	Bh	P34	2,340
8	13	12	20	凹	E	28°	Tm	P	1,970
9	14	16	60	凹	N	24°	Jd	P	1,950

Table 2 - 2 - 21 (2) Collapse Caused by Road Construction
- Río Tapias Model Area -

No.	Mesh No.		Length	Micro	Bearing	Incl.	Soil	Forest	Elevt.
	Vertical	Horizontal	(m)	Topography		(°)	Type	Type	(m)
1	9	29	10	凹	SW	40°	Bh	N22	2,340
2	9	29	10	straight	S	44°	Bh	N22	2,280
3	10	28	10	〃	NE	38°	Bh	N22	2,280
4	12	26	10	〃	S	42°	Bh	N24	2,400
5	14	16	80	凸	SW	36°	Bh	P	2,100
6	14	21	80	凸	N	40°	Bh	C11	2,220

Table 2 - 2 - 22 Collapse Caused by Industrial Activities

Model Area	Type of Activity	Affected Area (ha)
Pensilvania	quarrying of gravel for concrete blocks	0.50
Río Tapias	quarying of limestone for cement	52.00

2.2.8 Forest Conservation Survey

An interview survey was conducted at various forestry-related agencies and organizations in view of obtaining the basic data required for the preparation of the forest conservation standards. In addition, the actual conditions of forest conservation was surveyed in the Model Areas.

(1) Survey Findings

Determination of the scope of forest conservation is difficult. Here, the objectives of forest conservation are defined as the preservation of the natural environment, prevention of disasters and conservation of forests which serve public interests such as the preservation of water sources as suggested in the forest conservation standards to be described later.

The survey in question was, in fact, conducted together with the other surveys on the natural and social conditions and the existence of the following areas was particularly examined.

① areas requiring special measures to conserve the forest ecosystem because of high elevation and/or other reasons

② areas providing a habitat for scientifically important fauna and flora
③ forests serving health, cultural and educational purposes
④ sites of possible devastation due to topographical and/or geological conditions
⑤ important headwaters
⑥ buffer zones

As the handling of these areas is closely related to the findings of the other surveys as well as those of the soil survey to be conducted in the next year, the basic ideas of conservation are stated in this report as part of the forest conservation standards to be described later.

2.2.9 Forest Resources Management Survey

A forest resources management survey was conducted to obtain the basic data required for the preparation of the forest resources management standards. The survey findings are described below.

(1) Survey Method

The following companies which are engaged in forest resources management in the Intensive Area as well as neighboring areas were interviewed to learn about their management methods, especially those relating to forest operation.

Pro-oriente S.A.	(Pensilvania)
Maderas de Oriente S.A.	(Pensilvania)
Agropeculaia betania S.A.	(Pensilvania)
Compañía Forestal de Colombia S.A.	(Manizales)
Maderas y Celulosa S.A.	(Manizales)
Reforestadora Andina S.A.	(Arumenia)

(2) Survey Findings

While the present management conditions naturally vary from company to company, a fair amount of data on these companies and their operation was obtained. The findings on the 3 companies in Pensilvania, Maderas y Celulosa S.A. and Reforestadora Andina S.A. are described below.

① Companies in Pensilvania

a. Objectives of Company Establishment and Subsequent Management Performance

Pro-oriente S.A. and Maderas de Oriente S.A. were established more than 10 years ago while Agropecualia Betania was only recently incorporated. The two older companies were not specifically established to carry out industrial plantation but were aimed at creating employment opportunities for local farmers and at utilising surplus funds, materials and land. In subsequent years, the trees planted 18 years ago became ready for felling and there was also a need to thin younger stands, resulting in log production. The companies established saw mills 3 years ago (1987) to start timber production. To their delight, there has been a stable demand and some 600m^3 of sawn timber, mainly for bed manufacture, is being produced monthly. They hope to sell timber to Table Mac S.A. which will be established in Manizales next year to manufacture particle boards.

The afforestation area around Pensilvania is as large as some 2,400ha with Pro-oriente S.A. and Maderas de Oriente S.A. owning some 1,150ha and some 1,100ha respectively. The main planted species are P. patula and Ciprés.

b. Forest Work

(a) Seeds

- Purchase of Seeds

None of the companies are engaged in new afforestation work and, therefore, they do not purchase seeds. In past years, they used to buy seeds from an agent which imported them from the Republic of South Africa.

seed price in 1988 -	P. patula	125,000 pesos/kg
	Ciprés	100,000 pesos/kg

- Seed Storage

None of the companies have seed storage facilities.

(b) Nurseries

Only Agropecualia Betania S.A. has 2 nurseries, i.e. one in Pensilvania and one in Manzanares with seed bed area of 50m^2 and 250m^2, respectively. These nurseries use pots to grow seedlings and water is obtained from a nearby river. In the past, the production of seedlings was conducted at mountainside nurseries near afforestation sites because of the difficulty to transport seedlings to the sites.

(c) Nursery Practices

- Seeding
  - The seeds are immersed in water for 48 hours as a pre-treatment prior to sowing.
  - some 300 seeds/m^2 are sown in the seed beds.
  - The seeds start germinating after 12 days and are then transferred to pots. Transplantation from the pots is conducted 22 days after the transfer from the seed beds to the pots.
  - The pot size in use is 5cm in diameter and 10cm in height. The seed growth is faster if larger pots are used.
  - The soil used in the pots is black soil collected from fields.
- Lighting

  Plenty of sunshine is required for both P. patula and Ciprés after sowing.

(d) Planting

Planting is conducted at abandoned ranches in accordance with the following procedure.

1 Trazado (decision on planting points)
2 Plateo (weeding)
3 Ahoyado (digging of planting holes)
4 Siembra (planting)
5 Abonada (manuring: twice at the time of planting and 6 months later)

(e) Tending

- Weeding

  Weeding is only conducted in the first and second years (1 - 3 times/year)
- Thinning

  Thinning commences in the second year and a thinning ratio of 60% in terms of the number of trees is currently adopted to eventually leave 400 trees/ha.
- Felling Period

  The target felling period is 20 years with a diameter breast height of 40cm. Given the present state of tree growth, the target completion appears to have been slightly delayed.

(f) Felling/Hauling

A chain-saw is used for felling. The trees are manually hauled if the site is within 50m of a nearby road. Cables are used to haul the trees in the case of those sites which are far from a nearby road. The use of a winch is anticipated in the near future to replace the current cable logging system using gravity.

(g) Forest Protection

- Forest Fires

  Forest fires hardly occur due to the high humidity.

- Wind Damage

  Wind damage has occurred at several Ciprés afforestation sites due to rapid thinning to 400 trees/ha.

- Insect Damage

  There are 2 types of harmful insects in the case of P. patula. One is controllable but the other which has wildly raged since late 1989 is not yet under control. The former is Glena bisula, a kind of moth, which lays eggs on the bark, delaying tree growth. 2 natural enemies of Glene bisula have been found, one of which is a black fly called Siphoniamya malaene which lays eggs on the larva of Glena bisula while the other is a bee called Telenomus alsophile which lays eggs on the eggs of the Glena bisula. With these natural enemies, the ecological prevention of damage due to Glena bisula is now possible. In comparison, Cyphocrania aestuans which bites pine leaves to suck the sap was first discovered 4 years ago. An outbreak commenced in the second half of 1989 and some stands have lost all their leaves. Not many trees are dead, however, and many trees are now showing new leaves. The damage prevention measures currently in use are liberation cutting, fastening of a tape at the breast height and the use of resin oozing out of the removed bark of trees to be thinned to catch climbing larva.

② Maderas y Celulosa S.A. (Manizales)

a. Objectives of Company Establishment

The company was originally established to procure paper materials as it was planned to establish a paper mill in Manizales (which failed to materialise). At present, the company aims at producing paper materials and timber.

b. Owned Afforestation Site

- The company owns some 800ha near Manizales (hopes to increase this to 1,000 ha in the future).
- Natural forests: 300ha (mostly along rivers and valleys which have been designated protected areas)
- Man-made forests: 500ha (former pastureland)

c. Details of Man-Made Forests
   - P. patula: approximately 325ha (65%); felling of 10 year old stands in progress; 100% for paper production
   - Ciprés: approximately 175ha (35%); felling of 16 year old stands in progress: 60% for paper production and 40% for timber
   - Planting density: originally 2,000 trees/ha; at present, 1,100 trees/ha (with pruning)
   - Species: P. patula only for reforestation sites and a mixed planting of P. patula and Ciprés for new sites

d. Forest Work for Man-Made Forests

   Adjustment of Planting Density

   Initial planting - 1,100/ha

   6 years later - 750/ha (thinning of 350 trees/ha; thinned trees have no specific use)

   8 years later - 600/ha (thinning of 150 trees/ha; thinned trees are used as piles for mining use)

   10 - 12 years later - 500/ha at main felling (after 10 years, thinned trees are used to produce timber)

e. Agroforestry

   2 years after the initial planting, cattle raising starts with a density of 1 head/ha. Cattle raising is considered possible upto 3 - 10 years after the initial planting. Tree tomatoes are planted as intermediate farming. Experiments show that tomatoes grow in a year and give yields in the following 2 years. Therefore, the growth of tomatoes is the best use of the stands until the stands become closed.

   Planting Example at La Florida Blanca

   P. patula - 1,100 trees/ha (10 months old); tree height of 1m; manuring twice a year for 10 years

Tree tomatoes - 700 trees/ha (4 - 5 months old): tree height of 80cm; manuring every 20 days

f. Soil

The soil is brown forest soil with a high volcanic ash content. Given the annual rainfall of 2,000 - 2,500mm and the poor water retension ability of the soil due to the relatively minute grain structure, Ciprés trees are liable to fall because of their shallow roots.

g. Work Roads

At present, work roads are constructed at a rate of some 6km per 350ha. It is planned to improve this rate in the future to provide better working conditions. Details of the work roads are as follows.

- width : 4m
- maximum inclination : 10 - 12%
- construction cost : 5,000 dollars/km
- gutter depth : approximately 15cm
- timber-lined gutter with for surface drainage work : approximately 15cm
- Hume concrete pipe for cross-sectional drainage work : diameter - 30 - 40cm
  interval - approx. 200m

h. Employment Conditions

- afforestation workers : 15 workers daily wage
- orchard/cattle raising workers : 10-15 workers (minimum wage plus α)
- logging workers : 15-20 workers (piecework payment; 5 U.S. dollars/ton; monthly logging volume of 500-700 tons)
- sawing workers : 2 workers (piecework payment; 2 circular saws and 1 cutter)
- drivers : when required (piecework payment inclusive of vehicle cost)
- produced volume conversion rate : 1 ton = 1.8 - 2.0m^3
- details of logging work

felling, trimming, peeling, cable transportation and truck transportation: 5 U.S. dollars/ton

manual transportation inside forest : 2 U.S. dollars/ton

hauling by horse : 2.5 U.S. dollars/ton

felling at a site without an access road : 4.5 - 5.0 U.S. dollars/ton

Note: Those workers on the piecework payment arrangement take out unemployment insurance as a group.

③ Reforestadora Andina S.A.(Arumenia)

a. Objectives of Company Establishment

- The company is a 100% subsidiary of Cartón de Colombia S.A.
- Of the 30,000ha of mountain forests owned by Cartón de Colombia S.A., the company manages some 9,000ha in Quindieo and Calda Provinces with a view to producing raw materials for the parent company.
- The company began business under its present name 8 years ago but adopted a self-supporting accounting system in September, 1987.
- number of employees : 22 for office work
  500 for forestry work
- wages : slightly higher than the minimum wage level with the provision of managerial benefits; all daily wages except for trimming and weeding work
- sales volume : currently 47,000 tons/year (increase to 80,000 tons in 1994 is hoped for)
- operation size : currently 9,000ha (increase to 15,000ha in the future is hoped for)

b. Land Purchase

- Only well-managed ex-ranch sites are considered for purchase.
- A prospective site must have established roads.
- The paid land price is 200,000 - 300,000 pesos/ha on average.
- The sellers are mainly small landowners. Formers leaving the area sell their land. (They know that Cartón de Colombia S.A.is willing to purchase land and believe that they will not be cheated by such a large company).
- No large farms are considered for purchase.

c. Selection of Planting Species

Species	Elevation of Subject Sites
P. patula (South Africa)	2,000 - 3,000m
P. kesiya (Asia)	1,400 - 2,200m
P. maximinoi (Honduras)	2,000 - 2,400m
(These are planted at El. 1,800 - 1,900m in other countries but planting at lower elevation areas risks damage due to fox tail.)	
P. tecunumanii (Nicaragua)	1,400 - 2,000m
P. oocarpa (Guatemala)	1,400 - 2,100m
E. grandis (tropical islands)	1,000 - 2,200m
E. globulus (tropical islands)	2,000 - 3,000m

Ciprés was once planted at El. 1,300 - 3,000m. However, no planting of Ciprés is currently conducted because its short fibre is unsuitable for paper manufacture. All Ciprés seeds in stock were sold 2 years ago for 8,000 pesos.

Although some P. patula seeds are products of Antioquia, their growth performance is generally poor. Consequently, the P. patula seeds currently used are mostly produced in South Africa. P. patula is originally from Mexico. The fast growing seeds are developed in South Africa and are imported by Colombia.

d. Work Method

(a) Planting

- 2 planting seasons/year : April - May and September - October (possibly upto November depending on the year)
- annual rainfall : approximately 2,000mm (over 3,000mm/year at Pereira)
- controlled burning at time of land preparation
- planting density
  - P. patula : 1,276 trees/ha
  - Eucalyptus : 1,330 trees/ha for directly seeded seedlings (2.5 x 3.0m)
    1,100 trees/ha for pot seedings (3.0 x 3.0m)
- planting method : square plot planting using a lining rope
- manuring
  - P. patula : DAP 40g and Borax 10g applied 30cm deep
  - Eucalyptus : DAP 40g and Borax 10g in the planting hole

(Both DAP and Borax are product names.)

(b) Weeding

Standard frequency : 2 - 4 time sin first year
2 - 3 times n second and third years
once in fourth year

Method:

Machetes, herbicides and/or grass cutters are used. While their respective costs are the same, a method requiring many workers is preferred.

(c) Climber Cutting

Climber cutting is conducted n those places where damage to the planted trees may occur in view of growing vegetation.

(d) Improvement Felling

In principle, improvement felling is not conducted.

(e) Thinning

	Area	Planting Density	Thinning	Felling Cycle
Previously	7,000ha	1,400-2,000/ha	50% in 8th year	15 years
Present	2,000ha	1,280/ha	none	12 years

Thinning Method:

The thinning of 50% of the planted trees in the eighth year produces 30 tons of timber per ha although no thinning is conducted for Eucalyptus. The thinning criterion is to reduce the basal area from $30m^2$/ha to 20 - $22m^2$/ha. At present, thinned wood is sold as timber wood.

(f) Pruning

Pruning is only conducted for P. patula upto a ground height of 2.2m to prevent forest fires.

(g) Manuring

Additional fertiliser is used in the eighth year at those stands where the tree growth is not favourable. In the case of P. patula, 15g of Borax is used per tree. 40g of DAP is used for those trees of especially poor growth. In the case of Eucalyptus, 60g of DAP is used.

(h) Felling and Hauling

In general, a chain-saw is used to fell the trees and the felled trees are carried on the back of the workers or animals upto a distance of 30m. Cable is used where the slope inclination is 30° or more.

(i) Transportation

- short distance (some 4km) : 10 ton truck
- long distance : 30 - 35 ton trailer truck

(j) Disease and Insect Damage Prevention Measures

An external specialist is invited 4 times a year to diagnose the damage/disease situation.

(k) Fire Prevention Measures

Fire prevention organization: A person responsible for fire prevention is appointed for each of the 3 areas and the following equipment and tools are provided.

fire prevention kit (spades and ploughs, etc.)	1 set
radio and portable wireless apparatus	1 set
truck and bulldozer	1 each

Note: The use of this equipment and tools is only permitted for fire-fighting purposes.

e. Product Cost

raw wood cost	: 3,200 - 3,300 pesos/ton
transportation cost	: 2,000 - 2,500 pesos/ton

f. Afforestation Cost

The average cost is 140,000 pesos/ha but this increases to 250,000 pesos/ha when the land use cost over a long period of time is taken into consideration.

2.2.10 Forest Road Survey

Both an interview survey and a field survey were conducted to obtain the basic data required for the preparation of the forest road standards. The survey items included the national road construction standards and legal regulations relating to road construction work, current road conditions in the Intensive Area and constraints on forest road construction in the Model Areas. The survey findings are described below.

(1) Legal Framework of Forest Roads

The main objectives of exploiting national land in Colombia are the encouragement of settlement and the promotion of agriculture. As a results, forests have been used to serve for people's requirements and no forest resources management has been put into practice.

As roads have been constructed to serve agricultural purposes or to connect urban areas, there is no definition of forest work and no regulations pertaining to forest roads have been enforced.

(2) Current Road Conditions in Intensive Area

The main industry in the Intensive Area is stock raising coupled with agriculture and the road network has been developed on the basis of farm roads. In recent years, however, with the expansion of local cities and the development of transport methods, national and provincial roads capable of mass transportation have begun to provide the main routes with farm roads and footpaths playing an auxiliary role. Historically speaking, there has been little need for the mass transportation of forest products in the Intensive Area with felled trees being hauled via farm roads and animal paths. With the decline of the forest area, the need for forest roads was further reduced to the extent that no forest road worthy of examination by the survey team exists.

In recent years, however, those companies engaged in afforestation work have occasionally constructed work roads for hauling felled trees as described below.

The work roads made by these companies in the Pensilvania Model Area were simply created by bulldozing forest areas. While a road width of 2.6 - 3.0m was secured, no special attention was paid to the construction method, resulting in poor road conditions. In comparison, Maderas y Celulosa S.A. has constructed a total length of some 6km of work roads in its afforestation area of 350ha and intends to

construct a more dense road network in the future. These work roads are of a good standard which is similar to that of second class forest roads in Japan. The maintenance system appears to be excellent as evidenced by the laying of gravel at the bottom of sloping sections to prevent slippage. Their main specifications are as follows.

Width	: 4m
Maximum Inclination	: 10 - 12%
Gutter Depth	: approx. 15cm
Gutter Width	: approx. 20cm
Wood Gutter Diameter for Surface Drainage Work	: 15cm
Sub-Base Course Work	: at swamps
Gutter Inlet Size and Depth	: approx. 60cm x 60cm x 1m
Hume Concrete Pipe for Cross-Sectional Drainage Work	: diameter - 30 - 40cm interval - 200m

It is said that the construction cost of these work roads is 5,000 US. dollars/km. They have been constructed by a far-sighted company manager who is aware of the necessity for an adequate infrastructure for afforestation work with a short rotation period.

(3) Constraints in Model Areas

It is judged that such environmental factors as topography, geology and climate are very similar in all the Model Areas although each area has its own characteristics in terms of land use and other aspects. Consequently, there is no need to prepare forest road construction standards for each Model Area and one set of standards will apply to the entire Intensive Area. The survey on possible constraints on road construction work in the Model Areas found no specific constraints.

In general, the construction of a new road as part of the local infrastructure requires the permission/authorisation of the INDERENA. Since there are no specific prohibition clauses to be referred to in granting such permission/ authorisation, the necessary adjustments or coordination is made on a case by case basis.

No special topographical features, such as landslide areas, fracture zones and marshland, requiring special topographical and geological attention exist in the Model Areas. Nevertheless, in view of the fairly progressive degree of dissection with numerous V-shape valleys and steep slopes and also the existence of volcanic

ash deposits, the construction of an excessive forest road network should be restrained. In addition, there appears to be room for improvement of the construction method.

2.2.11 Concessions Survey

An interview survey was conducted at the INDERENA to obtain the data required to examine whether or not the felling authorisation criteria used by the INDERENA vis-a-vis felling application of private companies are appropriate. In addition, the concession site of Cartón de Colombia was surveyed. The survey findings are described below.

(1) Felling Authorisation

① Basis of Felling Authorisation Criteria

Act No. 29 of 1975 (Acuerdo 29 de 1975)

② Required Documents for Application

Felling Application Form	1
Land Ownership Certificate	1
History of Subject Site Ownership	1
Site Location Map	1

③ Authorisation Criteria

a. Selective Felling (Persistentes)

Class	Volume Involved	Person Responsible for Authorisation
A	10,000m^3 or more	Director General of INDERENA (Bogotá)
B	2,000m^3 - 10,000m^3	Director General (Bogotá) or Bureau Chief (Antiochia)
C	200m^3 - 2,000m^3	Director General (Bogotá) or Bureau Chief (any large bureau)
D	less than 200m^3	Director General (Bogotá) or Chief of INDERENA's Provincial Bureau

b. Clear Felling (Unico)

The authorisation to enter a natural forest is essentially given by the Director General in Bogotá despite the descriptions below.

Class	Volume Involved	Person Responsible for Authorisation
A	10,000m^3 or more	Director General (Bogotá)
B	less than 10,000m^3	Director General (Bogotá) or Bureau Chief (Antioquia)

c. Felling for Domestic Use (Domestico)
Any individual can apply and obtain authorisation. However, sale is not permitted. The volume involved is less than 20m^3 and authorisation is granted by a bureau chief.

④ Types of Authorisation

Concession: felling authorisation for a volume of 10,000m^3 or more (only 2 companies have so far obtained concessions in Colombia, i.e. Cartón de Colombia A.S. and Pisano S.A.)

Permission: felling authorisation for a volume of less than 10,000m^3 excluding authorisation for domestic use

⑤ Authorisation Procedure

i) submission of documents specifying site location, area, subject species, number of trees to be felled, anticipated volume and reasons for felling, etc. to an office of the INDERENA
ii) examination of the application documents by a lawer commissioned by the INDERENA office
iii) filed verification by INDERENA staff after document examination, i.e. (ii) above
iv) public announcement of the application for 15 days at a police station overseeing the applied for site in accordance with the commencement of the field verification
v) acceptance and examination of any objections to the intended felling (in general, the issues of water pollution and site boundaries are most frequently raised)
vi) authorisation of the felling with the clearance of the above procedure.

⑥ Conditions of Authorisation

In the authorisation of felling, the land classification of the proposed felling site is sometimes conducted to limit the felling to certain categories of area.

- production area

- protected area (for example, a slope with an inclination of 45° or more; no felling is authorised)
- coexisting area (partially a production area and partially a protected area)

Note: This classification is conducted on paper and no relevant boundaries are indicated on the site. See the forest physiognomy improvement standards survey (2.2.6) for further details of such classification.

⑦ Authorisation in Action

- Authorisation is granted to most applications relating to man-made forests throughout Colombia.
- Since it is always clear who originally planted the trees in the case of man-made forests, the INDERENA has so far authorised all applications.
- The ownership of a natural forest is sometimes unclear. As no investment is made by the legal owner, illegal felling without authorisation frequently occurs.
- The designation of the land category vis-a-vis for example, concessions, is not enforceable in practice as no boundaries are indicated on the site (the opinions of those responsible for field verification and the fellers may vary considerably).
- Only the Antioquia Bureau, the largest bureau in the country, is entitled to authorise Class B applications. However, 90% of all the applications are made by individuals requesting permission for felling of less than 200m^3.

⑧ Authorisation in Action in Caldas Province

- Some 80% of the authorised felling involves Guadua (bamboo).
- Street trees and garden trees are also subject to the authorisation procedure.
- In the case of Guadua, the applicant is visited by an official who teaches the correct felling method.
- In the case of such trees as Cedrela, trees subject to authorisation must have a diameter of 40cm or more at a height of 1.3m.
- The authorised volume indicates the stem volume upto the effective height.

(2) Concessions

The survey on the concession of Cartón de Colombia S.A. in Buena bentura found that the felling authorisation criteria pose few problems. It is the social conditions relating to the concession which are problematic and these cannot be solved imply by tightening the authorisation criteria.

① Outline of Concession

The company obtained the concession for natural forests along the Pacific coast 15 years ago. The concession allows the felling of a volume of 3 million m^3 in an area of 60,000ha over a 30 year period in exchange for the payment of the concession fee.

② Natural Conditions of Concession Area

- The area is long and narrow in the north-south direction along the Pacific coast and has many undulations and a changing elevation from 50m to 120m.
- The mean annual temperature and relative humidity are 27° and 89° respectively while the main annual rainfall is as high as 7,400mm. The average number of rainy days a year is 250.
- The entire 60,000ha consists of tropical forests owned by the central government. The surface soil is shallow with an extremely thick, heavy clay layer beneath. The bedrock is deep with no instant recognition and swamp like conditions prevail due to very poor drainage.
- Although the forests are classified as tropical rain forests, the maximum diameter breast height is as small as some 50cm due to the poor soil conditions. The maximum tree height is 25 - 30m and the average volume of 100 - 140m^3/ha suggests poor stands.
- 252 usable species have been identified. Since more than 10 species have been identified as upper story trees, the species composition can be described as relatively rich.

③ History of Development

- Cartón de Colombia S.A. commenced development efforts in 1959 by obtaining Class B authorisation. At first, small-scale felling and logging was conducted with the logs being carried on the backs of workers or animals.
- Tractors were then introduced and round wood was laid on the ground for sliding the logs.
- The first work road was constructed in 1960. Timber, logs and gravel were all tried to pave the road to prevent it from becoming muddy. Finally, the paving method of using cloth with a gravel cover was invented.
- The company obtained a 30 year concession agreement to obtain paper wood in 1974. The company has since been operating in the area but

intends to terminate operation in 2004 when the concession agreement expires.

④ Work Method

Company research on the work method found that natural regeneration would provide a better result than artificial planting. As a result, only those trees with a diameter breast height of 13cm or more are subject to felling. A 30 year circulation period has been adopted. The entire area is divided into 30 blocks by the area yield regulation method with one block consisting of 60ha. Cables are used to haul the felled trees to avoid unnecessary damage to stands in view of the successful regeneration of natural stands.

2.2.12 Environmental Impact Assessment

It was decided to conduct an environmental impact assessment in accordance with the understanding and procedure described in Progress Report I.

(1) Survey Method

The stages upto④Status Investigation as shown in Fig. 2-2-5 has been cleared at the time of the completion of the Basic Study. The succeeding stages, i.e.⑤ Establishment of Environmental Protection Targets onwards, will be conducted once the survey for the preparation of the forest resources management plan (to be conducted in fiscal 1991) has been completed. The flow of the environmental impact assessment is outlined in Fig. 2-2-5.

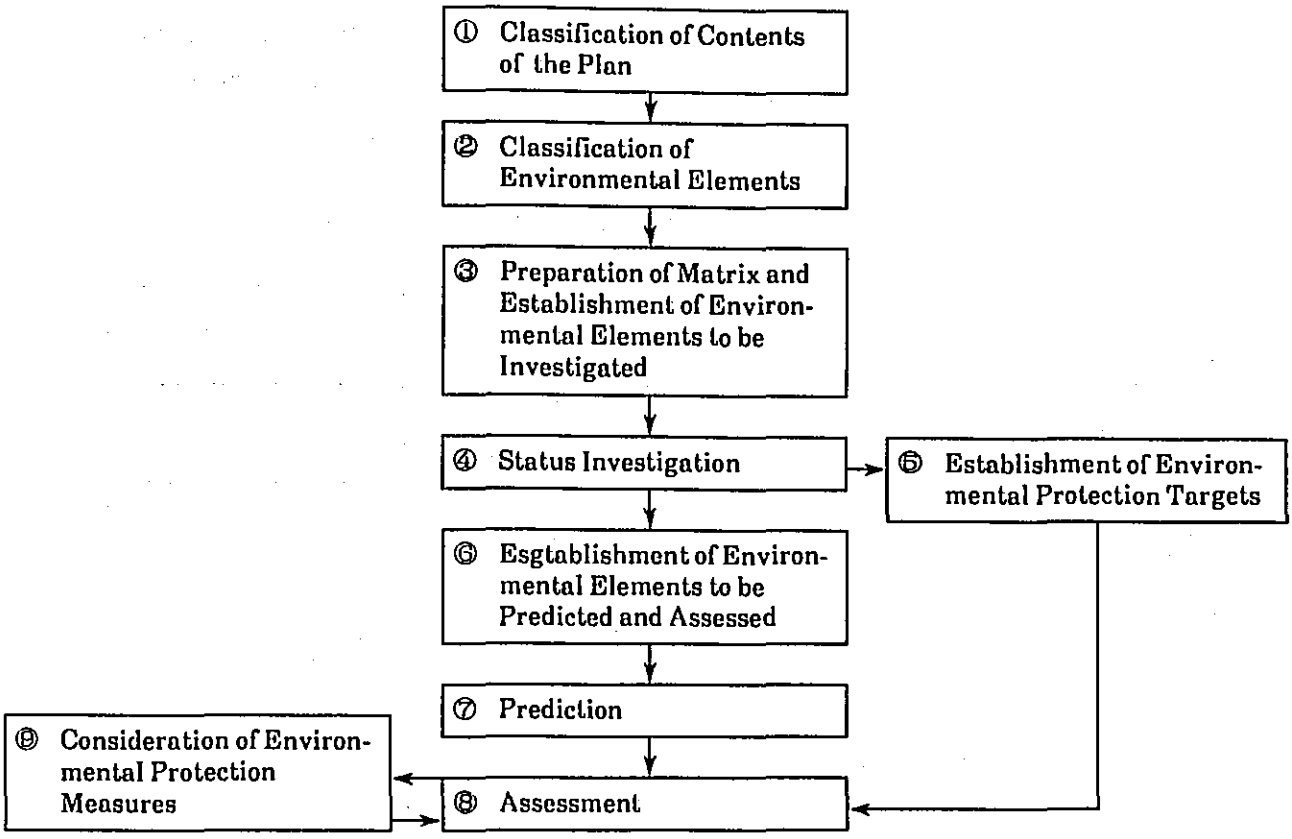


Fig. 2 - 2 - 5 Flow of Environmental Impact Assessment

① Causative Factors of Environmental Impact

The findings of the examination of causative factors of environmental impact for each Model Area are compiled in Table 2-2-23.

② Environmental Elements

The environmental elements affected were decided through the same examination process as follows.

a. Natural Elements

water quality, climate, soil, rivers, lakes, flora, fauna, landscape, recreation (outdoor)

b. Socioeconomic Elements

land use, land ownership, agriculture, forestry and fisheries, employment, water use, traditional customs, religion

③ Preparation of Matrix

The matrix table combining the above factors and elements is shown in Table 2-2-24. Those factors which may adversely affect the environment are indicated by a circle (o) in the respective columns, indicating those factors subject to the status investigation.

Table 2 - 2 - 23 Causative Factors of Environmental Impact

Model Area / Related Field	Río Tapias	Manizales	Pensilvania
Forest Conservation	- designation of subject area - suspension of felling	- designation of subject area - suspension of felling	-
Forest Physiognomy Improvement	-	- suspension of felling - additional planting in stands - improvement felling	-
Denuded Land Restoration	- sediment discharge prevention work - collapsed site restoration work	- sediment discharge prevention work - collapsed site restoration work	- sediment discharge prevention work - collapsed site restoration work
Forest Resources Management	- designation of subject area - planting - felling - forest protection measures	- designation of subject area - planting - felling - forest protection measures	- designation of subject area - planting - felling - forest protection measures
Forest Road Construction	- opening of forest road - use of forest road	- opening of forest road - use of forest road	- opening of forest road - use of forest road
Others	- creation of communal forest - creation of pastureland and/or farmland	- installation of various facilities - fire-fighting measures - creation of farmland for government staff	-

Table 2 - 2 - 24 Environmental Impact Matrix

Environmental Element \ Environmental Impact Factor		Forest Conservation		Forest Physiognomy Improvement			Denuded Land Restoration		Forest Resources Management				Forest Road Construction		Others				
		Designation of Subject Area	Suspension of Felling	Abandonment of Felling	Additional Planting in Stands	Improvement Felling	Sediment Discharge Prevention Work	Collapsed Site Restoration Work	Designation of Subject Area	Planting	Felling	Forest Protection	Forest Road Construction	Use of Forest Road	Creation of Communal Forest	Creation of Pasture-land and/or Farmland	Installation of various Facilities	Fire-Fighting Measures
Natural Environment	Water Quality						○	○					○					
	Climate										○							
	Soil										○							
	Rivers						○	○					○	○				
	Lakes						○	○										
	Flora				○	○							○			○		
	Fauna												○			○		
	Landscape									○	○	○	○					○
	Recreation	○							○			○						
Socioeconomic Environment	Land Use	○							○				○			○		
	Land Ownership	○							○				○			○		
	Agriculture, Forestry and Fisheries		○															
	Employment		○	○														
	Water Use												○					
	Traditional Customs	○							○									
	Religion																○	

(2) Study Findings

The findings of the status investigation are compiled in Table 2-2-25 where the characteristics of each environmental element are described by Model Areas.

Table 2 - 2 - 25 Environmental Impact Study

① Natural Environment

a. Water Quality

Model Area	Current Water Quality Conditions
Río Tapias	The river water is clear upstream of the limestone quarry of Cementos Caldas S.A. The river water downstream, however, could be characterised as relatively highly muddy.
Manizales	The water obtained from the headwaters forest is of good quality and the forest is one of the main water sources for Manizales.
Pensilvania	The river water is clear and no contaminated rivers were found. All the water sources are located in high elevation areas, posing no problems in regard to the quality of the suplied water. The water downstream is unfit for drinking due to the discharge of cattle excrement into their rivers.

b. Climate

Model Area	Range of Elevation (m)	Mean Annual Temperature (°)	Annual Rainfall (mm)	Remarks
Río Tapias	1,420 - 3,850	5.7 - 20.3	1,600 - 2,000	The annual temperature flucturation is very small to the extent that the same temperature prevails throughout the year. The annual rainfall is higher on the east side (Pensilvania) than the west side (Río Tapias and Manizales) of the Central Mountains.
Manizales	2,140 - 3,780	6.1 - 16.5	1,800 - 2,000	
Pensilvania	1,300 - 2,990	10.1 - 20.2	3,000 - 4,000	

c. Soil

Model Area	Parent Materials	Distributed Soil Types
Río Tapias	Volcanic ejecta consisting of pumice and volcanic ash, crystalline schist, andesite, qauartz diorite	humic cambisols, humic andosols, mollic andosols, humic gleysols, dystric regosols, gleyic cambisols
Manizales	Volcanic ejecta consisting of pumic and volcanic ash, crystalline schist	humic cambisols, humic andosols, humic gleysols, dystric regosols, gleyic cambisols
Pensilvania	volocanic ejecta consisting of pumice and volcanic ash, crystalline schist	mollic gleysols, mollicandosols, humic camibols, humic andosols, humic gleysols, dystric regosols, gleyic cambisols

d. Rivers

Model Area	Parent Materials	Distributed Soil Types
Río Tapias	Tapias River, Negura Valley	Negura Valley is used as a water source
Manizales	Blanco River	used as headwaters forest
Pensilvania	Pensilvania River	used as headwaters forest

e. Lakes

There are no lakes in the Model Areas.

f. Flora

The relevant descriptions can be found in 2.2.2 Forest Type and Vegetation Survey. Pasiflora spp. (a climber and the flower of the city) is found at Río Dulce and at a site some 4 - 5km towards Via Arboleda in the Pensilvania Model Area.

g. Fauna

Those fauna said to inhabite the Model Areas in the interview survey are listed in Table - g.

h. Landscape

Model Area	Current Conditions
Río Tapias	There are no natural parks. The scenery is spectacular from the ridge area of the Central Mountains.
Manizales	as above
Pensilvania	There are no natural parks. Cairn butte topography is observed at Pia Monte (south of Pensilvania) and Alto Morrón (west of Pensilvania) with excellent views. A ruined site (with stone carvings) of ancient inhabitants was found at Alto Morrón.

i. Recreation

No specific areas have been designated for recreational activities.

② Socioeconomic Environment

a. Land Use

The relevant description can be found in 2.2.1 Land Use Survey.

b. Land Ownership

Model Area	Ownership Status
Río Tapias	all privately owned
Manizales	some 70% owned by the municipal authority and 30% privately owned
Pensilvania	all privately owned

c. Agriculture, Forestry and Fisheries

Model Area	Main Farm Products	Main Domestic Animals	Main Livestock Products	Forestry	Fisheries	Others
Río Tapias	coffee sugar cane bananas cacao maize beans Yuca	dairy cattle beef cattle pigs chickens horses sheep	milk beef pork eggs chicken mutton wool	firewood charcoal timber piles matches	none	beekeeping
Manizales	potatoes	none	none	none	none	some farm products for own consumption
Pensilvania	same as Río Tapias	same as Río Tapias	same as Río Tapias	same as Río Tapias	trout culture	beekeeping

Table - g (1) List of Fauna (Based on Interview Survey: July - August, 1990)

Clasificación	Nombre Científico	Nombre Vulgar	Model Area			CITE
			Río Tapias	Manizales	Pensilvania	
Mamíferos	*Dasypus novemcictus*	*Armadillo(Gurre)*	○	○	○	
	Mazama rufina	*Venado*	○	○		
	Dynomis branikii	*Guagua*	○	○	○	
	Potos flavus	*Perro de monte*	○	○		
	Didelphis marsupialis	*Chucha*		○	○	
	Echinoprocta selenideira	*Erizo*	○	○		
	Sciurus granatensis	*Ardilla*	○	○	○	
	Mustela frenata	*Comadreja*	○	○	○	
	Syvilagus brasiliensis	*Conejo*	○	○	○	
	Felis tigrina	*Tigrillo*		○		List (II)
	Nasua nasua	*Cusumbo*	○	○	○	
	Cerdocyon thous	*Zorro(Lobo)*	○			
	Aotus trivirgatus	*Marteja*	○			List (II)
	Dasyprocta aguti	*Guatín*	○		○	
Aves	*Chamaepetes goudoti*	*Pava*	○	○		
	Columba fasciata	*Paloma(Torcaza)*	○	○	○	
	Momotus momotus	*Barraquillo*		○		
	Turdus fuscater	*Mirla*	○	○	○	
	Buteo magnirostris	*Gavilán*		○	○	List (II)
	Colinus cristatus	*Perdiz*	○	○		
	Buteo albicaudatus	*Aguila*	○	○	○	List (II)
	Zonotrichia capensis	*Afrechero*		○	○	
	Forpus passerinus	*Perico*	○			List (II)
	Egretta ibis	*Garza*	○			
	Icteus nigrogularis	*Turpial*	○			
	Ramphocelus dimidiatus	*Toche*			○	
	Coragyps atratus	*Gallinazo*			○	
	Tyrannus tyrannus	*Tijereta*			○	

Table - g (2) List of Fauna (Based on Interview Survey: July - August, 1990)

Clasificación	Nombre Científico	Nombre Vulgar	Model Area			CITE
			Río Tapias	Manizales	Pensilvania	
Aves	*Trochilidos*	*Chupaflor*			○	List (I)
	Zonotrichia capensis	*Gorrión(Pinche)*			○	
	Falco sparverius	*Aguililla*			○	List (II)
	Thraupis episcopus	*Azulejo*		(Aguadas)		
	Mimus gilvuss	*Cinzonte*		(Aguadas)		
	Melanerpes formicivorus	*Carpintero*		(Pacora)		
	Amazona ochrocephalo	*Lóra*		(Aranzazu)		List (II)
	Ara sp.	*Guacamayo*		(Aranzazu)		List (I) & (II)
		Tortola	○	○		
Culebras	*Chironius carinatus*	*Jueteadora*		○		
	Lampropeltis micropnolis	*Coral falsa*			○	
	Clelia clelia	*Guarda caminos*			○	
Peces	*Salmo gardnieri*	*Trucha*	○	○		
	Eremophilus mutisii	*Capitancito (Sabaleta)*			○	
		Tilapia		(Salamina)		
		Cachama		(Salamina)		
Insectos	Culicidae Culex spp.	Zancudo		○		
	Tabanidae Tabanus sp.	Tábano		○		
	Orden lepidoptera hay 14 familias	Mariposas	○	○	○	

d. Employment

Model Area	Main Employment Types
Río Tapias	temporary employment during coffee bean harvesting season, employment at Cementos Caldas S.A.
Manizales	temporary employment during potato planting and harvesting seasons
Pensilvania	employment by such forestry companies as Maderas Oriente S.A., Pro-oriente S.A. and Agropecuaria S.A., temporary employment during coffee bean harvesting season

e. Water Utilisation

Model Area	Water Utilisation
Río Tapias	Domestic water supply is secured from small streams in the Central Mountains by using water hoses for both individual and communal use. Negra valley is the water source for Neira.
Manizales	The headwaters forest acts as the water source for Manmizales.
Pensilvania	Domestic water is supplied to urban residents via water pipes from 3 streams in high elevation areas. Farmers use the same system as those in the Río Tapias Model Area.

f. Traditional Customs

Model Area	Traditional Customs
Río Tapias	U-turn festival
Manizales	none
Pensilvania	Ax festival, horse show, domestic animal auction

g. Religion

Model Area	Religion
Río Tapias	catholic
Manizales	catholic
Pensilvania	catholic

3. PRELIMINARY DRAFT GUIDELINES FOR FOREST MANAGEMENT PLAN

The preliminary draft guidelines for the forest management plan have been prepared based on the findings so far described. The final guidelines will be prepared based on the preliminary draft guidelines following the completion of the survey for the preparation of the forest management plant.

3.1 Forest Conservation Standards

(1) Background of Standards

Forest conservation referred to here means the conservation of those forests which have such public functions as the preservation of the natural environment, disaster prevention and water conservation. To be more precise, it means the conservation of the natural environment represented by a forest (consisting of standing trees and land), the conservation of stands from any disaster (including the conservation of land which should preferably be used for stands) and the prevention of the deterioration of the public functions of forests, including water conservation.

The standards in question, in fact, consist of 2 sets of standards (criteria), i.e. selection criteria for conservation forests (including land which should preferably be used for stands) and forest handling standards for areas designated as conservation forests.

Forest conservation standards in general are presumably decided by the natural conditions (climate, topography, soil and vegetation, etc.) and socioeconomic conditions (industry, land use and public functions of forests, etc.) The crucial factors are considered to be elevation, land inclination, vegetation and agricultural land use. With regard to elevation, the Intensive Area is approximately located between El. 1,000m and El. 4,000m and the temperature and rainfall play a decisive role in the creation of the natural environment and in its conservation. In the case of land inclination, most slopes in the Río Tapias Model Area have an inclination of somewhere between 34° and 35° although steep slopes of 45° or more can also be found.

Because of the lage elevation range, the Intensive Area has extremely colourful vegetation with varying plants from the temperate zone to the frigid zone. This extensive variety represents the varying climates based on different elevations, further indicating the importance of elevation.

Also, restrictions in connection with agricultural land use by elevation have been analysed in remorte sensing report and progress report I.

(2) Selection Criteria for Conservation Forests

As the selection of conservation forests is closely related to both the natural and socioeconomic conditions as described in (1) above, the selection criteria must incorporate these conditions.

Conservation Forest Selection Criteria

① Areas where the preservation of the forest ecosystem is required in view of high elevation and other reasons: these are forests where alpine or sub-alpine natural forests are dominant. In view of the prevailing climatic conditions, once the ecosystem of these forests has been artificially disturbed, the restoration of the original forests requires a long time or is difficult.

② Areas where scientifically important flora and fauna are found: these are forests where scientifically important rare flora and fauna are found. They are also forests surrounding important sites, including historical or archaeological ruins.

③ Areas serving health, cultural or educational purposes: these are areas and/or forests which have important value from the viewpoint of living flora and fauna, secenery and history, culture and archaeology and which are suitable for health, cultural or educational purposes.

④ Areas liable to devastation due to specific topographical and/or soil conditions: these are steep slope areas (40° or more) where sediment discharge or collapse could occur depending on the soil and vegetation cover conditions and the areas surrounding the above.

⑤ Important headwaters areas: these are areas which are required to play a water conservation function due to the existence of an urban area downstream.

⑥ Buffer zones: these areas which can be expected to act as buffer zones for areas①-⑤above to protect the forest functions from natural or artificial damage. When a site is a forest, it can be described as a protected tree zone when small and as a buffer forest when large. Any area which is hoped will

play such a function can be designated as a buffer zone even if its present status is not a forest.

(3) Forest Handling of Standards

Standards on how to handle forests once they have been designated as conservation forests must also be introduced. The draft standards are given below although these must be carefully examined based on the findings of the relevant field investigation.

① Areas where the preservation of the forest ecosystem is required in view of high elevation and other reasons: these forests must be protected from artificial damage and, therefore, forest work is prohibited in these areas.

② Areas where scientifically important flora and fauna are found: in principle, forest work is also prohibited in these areas except for felling for research purposes and the disposal of trees which have been damaged by insects, etc.

③ Areas serving health, cultural or educational purposes: these are forests serving health, cultural or educational purposes on the grounds that favourable natural conditions and social requirements should be worked upon to fulfil such purposes. As these forests consist of various categories, the handling standards may vary from one category to another. For example, landscape felling and planting, etc. will be conducted in the case of those forests which are expected to provide beautiful scenery at tourist and/or recreational sites.

④ Areas liable to devastation due to specific topographical and/or soil conditions: the present forests will be conserved and active afforestation efforts will be made in the case of bare land to prevent sediment discharge and collapse, etc. Standards relating to the species to be planted, number of trees and tending method, etc. will be decided to assist such efforts.

⑤ Improvement headwaters areas: forest work which will improve and maintain the forest soil with high permeability and water retaining capacities will be implemented. For existing forests, the work will include timber production where appropriate (by means of selective felling or small area clear felling). Appropriate species and the number of trees to be planted, etc. will be decided for bare land.

⑥ Buffer zones: forest work which will assist the achievement of the objectives of a buffer zone will be implemented if the subject site is a forest. If the subject site is pastureland which is expected to produce timber in the future, active afforestation efforts should be made. The relevant standards for these efforts (afforestation standards on the method, species, number of trees to be planted and tending method) will be prepared.

3.2 Forest Physiognomy Improvement Standards

(1) Background of Standards

These standards will be prepared to improve those stands which are extremely poor due to poor tree growth or disasters in protected forest areas, protected production forest areas and production forest areas as designated by the National Act on Environmental Conservation and Renewable Natural Resources.

(2) Selection Criteria for Stands for Improvement

① Stands of extremely poor growth mainly due to artificial reasons, including the wrong selection of the species to be planted, and stands where healthy growth appears difficult due to a drastically reduced living tree density, in turn caused by poor survival.

② Stands of poor growth due to wind, water and insect damage, etc., stands where more than half of the standing trees are unusable as timber and stands where healthy growth cannot be expected due to the drastically reduced living tree density.

(3) Improvement Method Standards

The appropriate improvement should be selected taking the causes of stand deterioration into consideration and the possible improvement methods are as follows.

a. replanting (in principle, different species)
b. supplementary planting (in principle, same species)
c. ploughing
d. fertiliser application (including supply of organic fertiliser)
e. planting of soil improving trees

In those places where root growth has been hampered by residual water, drainage of the excessive water or the planting of Eucalyptus species with a high water absorption capability should be conducted.

(4) Guidance and Recommendations

The INDERENA will provide technical guidance for the owners or caretakers of those forests where the stands require improvement work and assistnace measures so that the latter can implement appropriate forest work. Despite the provision of such guidance and assistance measures, necessary measures will be recommended and taken to remove any obstacle to the implementation of such measures if the owners do not commence or are unwilling to carry out improvement work.

3.3 Denuded Land Rehabilitation Standards

(1) Background of Standards

The situation of devastation in the Intensive Area is summarized as follows.

① extremely low devastation rate with mostly stable land throughout
② no specific area likely to be devastated
③ only 4 types of devastation, i.e. torrent stream, bank erosion, mountainside collapse and artificially inflicted collapse
④ similar collapse frequency in different land use categories

The above survey findings indicate the lack of parameters to judge dangerous areas and no characteristics of frequently devastated areas were obtained. As a result, the necessary conditions to establish criteria/standards are discussed here including various possibilities in the future.

(2) Selection Criteria for Denuded Areas for Rehabilitation

All the denuded areas in the Intensive Area are of a minor scale with similar features and it is highly unlikely that exceptionally damaging devastation will occur in the near future. Consequently, the preventive approach is replaced by a rehabilitation approach in the preparation of the selection criteria.

① Types of Denuded Land for Rehabilitation

Rehabilitation priority will be given to the existing sites of mountainside collapse, torrent stream and bank erosion together with those sites where landslides, falling rocks and surface erosion may occur.

② Designation of Rehabilitation Subjects

The denuded land designated for rehabilitation must have conservation subjects which will be directly affected by devastation and rehabilitation priority will be decided based on the conservation priority of these subjects. The conservation subjects will include settlements (houses), public facilities including roads, railways, water supply systems, power transmission lines, schools and hospitals, production facilities including farmland and ranches, churches and parks, etc.

③ Designated Rehabilitation Area

The rehabilitation area will at least cover an area where the protection of the subjects described in②above from any devastation can be achieved.

(3) Denuded Land Rehabilitation Standards

① Judgement of Urgency of Rehabilitation Work

Standards relating to the judgement of the urgency of implementing rehabilitation work will be prepared. These standards will take the scale and state of devastation and the degree of impact of such devastation on the local community into consideration.

② Selection of Rehabilitation Method

A concrete method to rehabilitate denuded land will in general be selected from the methods listed below.

a. Rehabilitation of Mountainside Collapse
   retaining wall, terrace work, hillside planting
b. Rehabilitation of Eroded River Banks
   revetment, spur dyke, terrace work, hillside planting
c. Rehabilitation of Torrent Stream
   simple dam, groundsel, revetment
d. Rehabilitation of Areas Affected by Surface Erosion
   simple retaining wall, reforestation, forest conservation (reservation)
e. Rehabilitation of Landslide Areas

soil removal, water drainage, soil ceep prevention, erosion prevention, terrace work

f. Rehabilitation of Falling Rock Devastation
protective net, slope spraying work

The selection of a method which suits the environmental conditions of the subject denuded land is essential. As many devastation occurrences in the past were caused by steep inclination, priority will be given to those types of work which involve a slope protection measure.

3.4 Forest Management Standards

(1) Background of Standards

Forest functions, which forest management tries to maintain, are as diverse as (i) national land conservation, (ii) water conservation, (iii) timber production, (iv) recreation and (v) preservation of living environment. All these functions are essential for the life of inhabitants. These functions are, in fact, only materialised by trees which have grown over a long period of time and, therefore, those people living at present have a responsibility to conduct appropriate forest management so that the forest resources can be duly handed down to the next generation. The forest management standards will be based on the land use categories and definitions of forest types stipulated by the National Act on Environmental Conservation and Renewable Natural Resources.

(2) Land Use Categories, Forest Categories and Forest Management

Appropriate forest management will be implemented in suitable areas based on the land use and forest categories adopted in Colombia (see 2.2.6 Forest Physiognomy Improvement Study for the description, including definition, of forest categories).

a. Special Conservation Areas

Based on the environmental policy in force, forest work will be limited to improving the forest physiognomy in the area and forest management will not be conducted.

b. Protected Forest Areas

These are areas generally with an elevation of 3,000m or above which are not classified as special conservation areas and which are to be permanently conserved

by either natural or man-made forests. In these areas, priority will be given to the protection of forests. Since felling to maintain the healthy state of the forests is permitted, however, there is a possibility of forest management despite it being negative.

When the afforestation of pastureland where the soil fertility has declined is planned, consideration must be given to creating a grazing forest in view of coexistence with grazing activities.

c. Protected Production Forest Areas

Areas located between El. 2,000m and El. 3,000m with forests serving agricultural and/or grazing purposes can be considered farm forests and can be managed together with farming activities. Active efforts should be made in these areas to create grazing forests to expand the forest area.

d. Production Forest Areas

These are areas other than a) - c) above. Active forest management will be implemented in the case of gentle slopes with an inclination of 30° or less to achieve the efficient production of timber. Since these areas are also suitable for farming, prior coordination with farming and grazing use should be arranged. The afforestation efforts will concentrate on farmland where extensive farming is predominant due to poor soil fertility in view of avoiding competition between forest use and farming/grazing use.

(3) Types of Operation Systems

① Clear Cutting Forest Operation

This system is adopted when efficient timber production and regeneration are intended. Attention should be paid to preventing the appearance of an even-aged uniform pure forest over an extensive area.

② Grazing Forest Operation

When the grazing of dairy or beef cattle on grass is intended, the number of standing trees may be regulated to secure a relatively light density to simulate the growth of grass.

③ Agroforestry Operation

When the planting of fast growing fruit trees (such as lulo and tree tomatoes, etc.) is feasible between dominant trees to produce auxiliary ash income at an

early stage to assist the stabilisation of forest management, the fruit trees should be planted at the time of the initial planting of the dominant trees.

(4) Operation Method

① Species to be Planted

The species given in Table 3-1 will be planted based on the elevation, soil type and climatic zone.

Table 3 - 1 (1) Suitable Species for Planting

Elevation (m)	Soil Type	Species to be Planted
1,000 - 2,000	Cambisols	P. patula
	Andosols	Eucalyptus varieties
		Aliso
2,000 - 3,000	Cambisols	P. patula
	Andosols	Ciprés
		Miconia sp.
		Aliso
3,000 - 4,000	Andosols	P. radiata*, P. patula

* P. radiate has the best survival rate at an experimental site at El. 3,800m
* Except Gleyic Cambisols in Cambisols

Table 3 - 1 (2) Suitable Species for Planting

Climatic Zone	Suitable Species
humid	
sub-humid	P. patula, Ciprés
very-humid	Eucalyptus spp.
Arid	P. radiata
semi-arid	

② Thinning

In view of the tree growth process, the following thinning standards are adopted for P. patula.

Table 3 - 2 Thinning Standards

(Unit: Trees)

Initial Planting	4 Years Old	6 Years Old	8 Years Old	Final Age
1,250 /ha.	50% 300 / ha	30% 180 / ha	20% 120 / ha	650 / ha

③ Hauling Method

The hauling operation consists of 2 stages.

First Stage: transportation of rough timber from felling site using simple cable system or horse

Second Stage: transportation by vehicle to main collection point collection point along a public road via a forest road for further transportation to final destination.

3.5 Forest Road Construction Standards

(1) Background of Standards

Few of the forests in the Intensive Area require the construction of a major forest road for forest management purposes. Moreover, the construction of many forest roads is undesirable from the viewpoint of forest conservation because of the steep topography. Consequently, the anticipated forest road construction standards will address those afforestation sites at the foot of the mountains.

(2) Forest Road Distribution Standards

① Forest Road Density

The basis of any discussion on forest roads for forest management purposes is the forest road density which can be calculated by dividing the aggregate length of forest roads by the area of the subject forest. As there are currently no forest roads in the Intensive Area, the work road network of the company engaged in afforestation work in a suburb of Manizales can be used to examine the requisites for a forest road network in the Model Areas. The current density of 17m/ha is considered inadequate by the company and, therefore, it is judged that the required forest road density for the Model Areas will be approximately 20m/ha.

② Locations

Routes with a low construction cost and high usability must be selected for the efficient locationing of the forest roads. In general, routes along ridges which enjoy a good view and which are easy to construct will be selected. However, the construction of mid-slope or valley roads may be unavoidable depending on the size of a subject forest and the complexity of the topography. In the case of these types of roads, efficient location selection criteria must be established while many aspects of the road construction, including the necessary avoidance of swamp areas and the optimal route on a long slope, etc., must be carefully examined. The criteria will be decided following the completion of the study on the topographical characteristics of the Intensive Area in the next year.

③ Forest Road Standards

Although the Intensive Area tends to have severely dissected topography near mountain foot areas, the vehicles to be used will not be particularly heavy. Therefore, the adoption of standards similar to Japanese 2nd class forest road standards should prove appropriate.

Design Vehicle Speed	:	20 - 30km/hr
Road Width	:	3.0m
Shoulder Width	:	0.5m (0.25m) / side
Curve Radius	:	30m (20m) for 30km/hr 15m (10m) for 20km/hr
Curve Inclination	:	8% or less
Curve Widening	:	

Curve Radius (m)				Widening Width (m)
10m or more	-	less than	11m	2.75
11m	"	-	" 12m	2.50
12m	"	-	" 13m	2.25
13m	"	-	" 15m	2.00
15m	"	-	" 16m	1.75
16m	"	-	" 19m	1.50
19m	"	-	" 25m	1.25
25m	"	-	" 30m	1.00
30m	"	-	" 35m	0.75
35m	"	-	" 45m	0.50
45m	"	-	" 50m	0.25

Visible Distance	:	30m (15m) for 30km/hr 20m (15m) for 20km/hr
Longitudinal Slope	:	8% (12%) for 30km/hr 9% (14%) for 20km/hr
Vertical Curve	:	no consideration is required for vertical curve when the longitudinal slope is 5% or less

(Vertical Curve Radius		250m for 30km/hr 100m for 20km/hr
(Vertical Curve Length		30m for 30km/hr 20m for 20km/hr
Crossfall	:	gravelled road - 5% or less paved road - 2% or less
Combined Slope	:	12% or less (16% or less)
Passing Place	:	every 500m or less (road width - 5.0m or more, effective length - 20m or more)
Drainage Facilities	:	gutters and catch basins, etc.

④ Construction Method

Although the required construction method depends on such site conditions as the topographical and geological characteristics, the anticipated road construction standards will provide a standard construction method which will include the compulsory use of a retaining wall to stabilise a cut slope and the prohibition of the arbitrary dumping of soil.

⑤ Road Maintenance

Proper maintenance of the forest road network is required for the environmental conservation of the area in addition to providing a means of transportation. Therefore, appropriate maintenance measures should be implemented when deemed necessary. Measures to deal with rainwater are of special importance and the maintenance system, including the introduction of a responsible area for each maintenance office (and staff member), should be consolidated.

4. PRELIMINARY DRAFT MODEL FOREST MANAGEMENT PLAN

The preliminary draft model forest management plan is prepared by applying the forest management guidelines to the 3 Model Ares so that they can act as models for the forest management plan for the Study Area. The forest management guidelines described in Chapter 3 of the present report are preliminary draft guidelines which will be finalised after the completion of the survey for the preparation of the forest management plan. As a result, no final model plan can be presented here and basic ideas are instead put forward to describe the framework of the model plan.

4.1 Río Tapias Model Area

(1) Basic Direction

The 15km wide zone on each side of the ridge of the Central Mountains is designated a central conservation forest by Act No. 2 (1959). In reality, however, the entire area is privately owned and most parts upto the ridge have been transformed to either farmland or pastureland with little forest remaining. The area is generally stable despite the existence of many steep slopes. Collapses can be seen at slopes of 30° or more and at the heads of torrents. The forest management plan of this type of forest area should cover diverse objectives ranging from the conservation of the natural environment (i.e. conservation of existing forests) to the reforestation of farmland or pastureland liable to devastation. In view of such diverse objectives, the division of the area into several zones is necessary so that an appropriate plan can be prepared for each zone.

(2) Current Conditions

Despite the complicated topography with many dissections, the land use in the Río Tapias Model Area is typical of the Central Mountains area where pastureland and grassland account for 34.6% of the land as shown in Table 2-2-3. The forest area accounts for 45.5%, indicating that agricultural development took place in this Model Area in the early years of Colombian history with the forests being driven out as obstacles to farming.

The expansion of the pastureland and grassland and the disappearance of the forests show a different degree of progress depending on elevation. Farmland and pastureland account for 30% each in the zone between El. 1,500m and El. 2,000m, both exceeding the forest ratio. The ratio of pastureland increases in the zone between El. 2,000m and El. 3,000m while the ratios of forest and high altitude

grassland increase in the zone between El. 3,000m and El. 3,500m. These land use conditions reflect the results of past industrial activities (agriculture and stock raising) and the fact that the conversion of forests to farmland (pastureland) has been necessarily regulated by the elevation of the land is clearly shown. The productivity of stock raising declines in accordance with the higher elevation.

(3) Zoning

① Basis for Zoning

Zoning is determined on the basis of the appropriateness of the subject land for forest use taking the current land use conditions into consideration.

a. Categories based on Forest Suitability

The following 3 categories are introduced based on the current conditions and the potential of existing forests and land.

I. Protected Forest Area

Areas where the protection of existing forests as well as the natural environment and the maintenance of the existing natural balance are appropriate.

II. Ordinary Forest Area

Areas where forests are partially utilised while improving the forest functions by conserving the forests. Areas currently without forests but with forest potential which includes acting as a buffer zone to protect protected forest areas (Category I).

III. Communal Forest Area

Areas where the utilisation of the forests while trying to harmonise with local industrial activities (farming and stock raising, etc.) is appropriate. Existing small forests are conserved and afforestation efforts are made in areas without trees.

b. Categories based on Land Use

The following 2 categories are introduced based on the findings of the basic survey for the forest management plan.

A. Present Forest Area

Areas with a reasonable size of forest(s).

B. Present Non-Forest Area

Areas other than A above and used for farming and stock raising, etc.

② Zoning

The following 4 zones are established based on the 2 groups of categories described in①above.

Zone IA

Zone where a forest and its natural environment must be protected.

Zone IIA

Zone which is protected as a forest but where timber is produced as part of efforts to improve the forest functions. The degree of forest utilisation depends on the current conditions of the subject sites.

Zone IIB

Zone which is currently non-forest and where active afforestation efforts should be implemented.

Zone IIIB

Zone where afforestation efforts should be implemented in harmony with local industrial activities such as farming and stock raising.

(4) Forest Management Plan

An appropriate forest management plan should be prepared for each zone in order to achieve maximum zoning effects.

① Zone IA

a. Forest Categories

The subject area is divided into compartments of a similar size. Priority is given to the boundaries of category b. (protected forest area) in the decision on the compartment boundaries. The compartmentation of the remaining area is based on the topographical characteristics.

b. Types of Protected Forests

Those areas classified as protected forests are further divided by means of protected forest type.

c. Operation Plan

An operation plan is prepared. While the degree of operation intensity depends on the protected forest type, the blanket prohibition of felling is in principle adopted. No special type of operation is implemented.

d. Management Plan

A management plan addressing the following subjects is prepared for the management of protected forests.

- boundary control, prevention of illegal felling and forest development, prevention of forest fires

② Zone IIA

a. Forest Categories

The subject area is divided into compartments of a similar size.

b. Operation Plan

An operation plan for existing forests is prepared (targets for forest utilisation, felling, regeneration and tending).

c. Denuded Land Rehabilitation Plan

Denuded land sites and sites with a high risk of devastation in existing forests are selected. The appropriate denuded land rehabilitation standards are applied depending on the degree of devastation and the degree of forest physiognomy deterioration, etc.

d. Management Plan

A management plan is prepared following the example of zone IA above.

③ Zone IIB

a. Forest Categories

The subject area is further classified into some 3 grades based on the degree of urgency for forest restoration. The classification criteria are determined based on the topographical conditions and the degree of devastation observed by the basic survey for the forest management plan.

b. Afforestation Plan

An afforestation plan (species and planting standards, etc.) is prepared for those compartments where forest restoration is deemed urgent.

c. Operation Plan

An operation plan will describe the operation method in terms of tending, thinning, cutting age and forest road construction for newly created forests.

d. Management Plan

A management plan is prepared following the example of Zone IA above.

e. Others

A proposal is made pertaining to the method to publicise the need to conserve newly created forests. A further proposal is made on possible measures (such as profit sharing forest) to secure the implementation of afforestation work.

④ Zone IIIB

a. Afforestation Plan

A plan is prepared to create grazing forests by means of planting trees in areas which have become grassland for grazing so that land conservation can be achieved in harmony with the existing farming practice.

b. Grazing Forests Operation Plan

A grazing forest operation plan is prepared addressing such subjects as the tending method, thinning, cutting age, grazing density, grass improvement and forest road construction.

c. Measures Vis-a-Vis Local Inhabitants

Measures to enlighten local inhabitants engaged in framing and/or stock raising on the benefits of creating a grazing forest (improved productivity and land conservation) are implemented. Possible measures include the afforestation of grassland by local inhabitants and the combined management of forest operation and stock grazing.

d. Management Plan

A management plan is prepared following the example of Zone IA above.

4.2 Manizales Model Area

(1) Basic Direction

The municipal owned land in the Río Balnco Basin which is part of the headwaters forest for the city of Manizales (population of approximately 320,000) covers some 3,000ha. Half of the city's water demand is met by water intake from this basin centering on the above municipal land. As a result, the water conservation function of forest management in this area is very important. A headwaters forest management plan for the Manizales Model Area must firstly be prepared to maintain this function.

(2) Current Conditions

The subject area is 4,429ha in the upperstream of Río Blanco and Q. Olivares which flow to the west. Natural forests account for 45% (1,992ha) while man-made Aliso forests account for a further 16.7% (742ha). The largest part of this Model Area consists of undisturbed, multi layered natural forests. Man-made Aliso forests have been created in municipally owned low elevation areas and the growth of Aliso has been quite favourable. High altitude grassland is prominent in areas with an elevation of 2,800m or higher.

(3) Zoning

The model plan will adopt the following 6 zone classifications taking the present land use in the headwaters forest area, distribution of forests and reforestation potential into consideration. If the area of a zone appears too small, it will be integrated to another similar zone.

① Natural Forest

a. Zone M-A

Stable forests which are naturally regenerated.

b. Zone M-B

Forests requiring some kind of improvement due to unstable nature of natural regeneration.

② Man-Made Forest

a. Zone M-C

Man-made forests with favourable tree growth due to good site conditions.

b. Zone M-D

Man-made forests rather resembling a natural forest due to poor site conditions.

③ Grazing Forest

a. Zone M-E

Areas which can be used as pastureland as well as a forest while the complete reforestation of the current pastureland/farmland is difficult to achieve.

④ Other

a. Zone M-F

Rocky areas, roads and rivers, etc. where reforestation by planting is difficult or even impossible.

(4) Forest Management Plan

An appropriate forest management plan should be prepared for each zone in order to achieve maximum zoning effects.

① Zone M-A

a. Forest Categories

The subject area is divided into compartments of a similar size.

b. Operation Plan

- Strict conservation is aimed at. Similar protective measures as those for Zone IA of the Río Tapias Model Area are adopted.
- In principle, any type for felling is prohibited regardless of a forest being a virgin forest or a secondary forest. However, improvement cutting may be conducted to remove damaged trees.

② Zone M-B

a. Forest Categories

The subject area is divided into compartments of a similar size.

b. Operation Plan

- Felling Method

  In principle, felling is prohibited. Improvement felling may be conducted depending on the degree of disturbance planted tree growth.

- Regeneration Method

  While natural regeneration is expected to sustain the forest, group or line planting is conducted to close open stands.

- Species to be Planted

  In principle, local species are planted. The planting of exotic species is considered depending on the seedling supply situation and growth situation of the planted trees in and around the Model Area.

- Tending Method

  Natural forest tending operation including climber cutting and improvement felling, are conducted mainly for planted trees.

③ Zone M-C

a. Forest Categories

The subject area is divided into compartments of a similar size.

b. Operation Plan

- Felling Method

  While no clear felling is in principle conducted, selective felling and thinning are conducted to maintain healthy stands.

- Regeneration Method

  The gradual replacement of current man-made forests by natural forests by means of natural regeneration is encouraged where possible. In places of poor ground cover, trees are planted using the contour planting method to facilitate early closure.

- Species to be Planted

  Fast growing local or exotic species are selected to achieve swift closure.

- Tending Method

  Tending work is conducted to maintain healthy stands by keeping crown closure.

④ Zone M-D

a. Forest Categories

The subject area is divided into compartments of a similar size

b. Operation Plan

- Felling Method

In principle, felling other than clear felling is conducted. Small-scale selective felling is also conducted to improve stands and to remove damaged trees.

- Regeneration Method

  The replacement of man-made forests by natural forests by means of natural regeneration is aimed at in the long-term. For the immediate future, however, stand improvement by means of replanting minus trees and supplementary planting is conducted. The creation of multi layered stands is also attempted by underplanting.

- Species to be Planted

  Priority is given to local species to improve current minus stands although exotic species may be selected depending on the growth situation of these species in the Model Area.

- Tending Method

  The tending method adopted for zone M-A is used.

⑤ Zone M-E

a. Forest Categories

The subject area is divided into compartments of a similar size.

b. Operation Plan

- Planting Method

  In the case of pastureland, the creation of thin stands which will not damage grazing is sufficient. As young trees are liable to damage, the adoption of the group or line planting method for easy management should be considered. In the case of farmland, it is recommended that planting be conducted na belt-like manner (windbreak forest style) with relatively wide intervals.

- Species to be Planted

  Priority is given to species of vigorous growth which are useful for timber or fruit production regardless of the origin.

- Tending Method

  The methods adopted for other zones are used. In view of the current site conditions of sporadic trees on almost bare land, such additional measures as covering planting trees with weeds, erection of protective fences at planting sites and the use of animal repellants should be considered to prevent damage due to the weather and animals.

- Forest Utilisation

As the target is the creation of grazing forests with the additional purpose of water and land conservation, the forests should be strictly conserved. However, the introduction of selective felling and harvesting of fruit should be considered to mazimise the effects of grazing forests.

⑥ Zone M-F

As this one consists of rocky areas, road sites, rivers and building sites, etc., it is difficult to store forests in this one. The target is the maintenance of the present conditions while trying to prevent any expansion of unproductive area.

⑦ Denuded Land Rehabilitation Plan

An appropriate rehabilitation plan should be prepared for denuded land in the headwaters forest in accordance with the denuded land rehabilitation standards which will apply equally to all the zones for water and land conservation purposes. In the preparation of the plan, the present level of local infrastructure should be taken into consideration.

⑧ Maintenance of Pastureland for Municipal Staff

The conservation standards and operation plan for Zone M-E will apply to the maintenance of pastureland reserved for the numicipal staff responsible for the management of the headwaters forest.

⑨ Road Construction Plan

The forest road construction standards will be adopted for the plan to construct roads for headwaters forest management purposes.

⑩ Miscellaneous

A headwaters forest protection and management plan will be prepared addressing such subjects as boundary control, prevention of illegal felling and theft of planting trees, prevention of arbitrary development or use of forests, prevention of forest fires and propriate communal use of grazing forests.

4.3 Pensilvania Model Area

(1) Basic Direction

Man-made forests in this Model Area are owned by Pro-oriente and Maderas de Oriente. There are a total of some 1,400ha of P. patula and Ciprés forests. As the relative location of the Model Area permits forest management for timber production, it has been decided that the plan should be prepared with a view to producing timber. The operation plan should be simple for easy understanding with due consideration paid to the existence of the source of municipal water supply.

(2) Current Conditions

The Pensilvania Model Area ha an area of 5,659ha, of which natural forests account for 1,365ha (34.1%), man-made forests for 1,427ha (25.2%) and pastureland and grassland for 1,748ha (30.9%). Other land use categories include coffee plantations and farmland. The subject area of the model plan will be the current (and feasible) man-made forests, grazing forests and agroforestry sites.

(3) Forest Categories

The subject areas, including suitable sites for man-made forests, will be divided into compartments taking the current land use conditions found by the soil survey and the appropriate plantation site survey into consideration.

(4) Forest Conditions

P. patula and Ciprés which are the two most prominent species in the man-made forests show favourable growth as shown in Tables 2-2-10 (6) and (7), having almost reached the stage where thinned wood can be used as timber. The average tree height of these species is 16.3m for both P. patula (10 - 17 years old) and Ciprés (17 - 19 years old). These trees have grown by an average of 1m per year.

The average diameter breast height is 18.5cm for P. patula (10 - 17 years old) and 20.7cm for Ciprés (17 - 19 years old), showing better growth in the case of Ciprés. In terms of the effective tree height, Ciprés (9.9m) exceeds P. patula (8.0m) by almost 2m. The reason for this difference is that P. patula branches out at a lower height with the branches growing large while the Ciprés stem is thick and straight with minor branches. This difference affects the timber yield rate but does not necessarily mean that Ciprés is superior to P. patula because the actual use of these species is based on their different qualities rather than on the yield rate.

(5) Production Target

Both P. patula and Ciprés are planted for producing timber. Because of the underdeveloped user market, including the lack of basic timber standards, the timber shape is decided to suit the requirements of individual users. Consequently, it is impossible to decide the desirable tree size class. In view of the expected tree growth conditions, the operation plan will be prepared based on the understanding that the first use stage will be reached when the average diameter brest height of 20cm is achieved. The second stage will be when the average diameter breast height reaches 30cm.

(6) Operation Plan

When the desirable tree class size for timber production consists of 2 stages, i.e. 20cm and 30cm, the relevant operations will be thinning for the former and final felling for the latter. Further examination of this point is required to determine whether or not the final age of 30 years is appropriate for both species. With regard to density control, the relative light intensity of 40% or more will be maintained to encourage the growth of ground vegetation so that forest grazing is possible. Similar density control will be required to secure the necessary light intensity when fruit trees are planted between the main species.

① Regeneration Plan

a. Cut-Over Site

When the decline of the tree growth speed is observed by analysing the growth of previously planted species, the planting of different species should be considered to avoid inferior tree growth due to the repetitive planting of the same species. The creation of mixed, multi layered forests with coniferous and broad-leaved trees should be also be considered.

b. Former Pastureland

In general, the conversion of pastureland to forest implies that the soil fertility of the site has seriously deteriorated. In planting trees at such sites, measures to improve soil fertility, including the use of fertiliser and planting of soil improving trees, are necessary. According to the past survey results, the use of 3 nutrients fertiliser is expected to achieve good results.

c. Sites with Useful Natural Species

The seeding of useful species should be given special attention of natural regeneration encouraged with supplementary improvement work being conducted.

d. Species to be Planted

The species to be planted are P. patula and Ciprés. Those species for which good growth can be expected will also be introduced following good results in the growth experiment.

② Tending Plan

The tending of the planted trees will include weeding, climber cutting, improvement felling and thinning, etc. The sites for these types of work should be properly determined along with the stand age and ratio for thinning work. In regard to weeding, climber cutting and improvement felling work, the minimum required work will be efficiently conducted in view of the state of ground vegetation growth at the subject sites. Thinning will be conducted pursuant to the relevant forest management standards.

③ Felling Plan

A felling plan should be prepared describing the final age, subject stands and felling method, etc. The conceivable types of felling are clear felling, selecting felling and pre-regeneration felling. In view of the subject being man-made forest, clear felling will be adopted where the soil fertility is favourable. Small area clear felling or selective felling, however, will be conducted in those places where clear felling may result in land devastation or the decline of the water conservation function due to the topographical conditions. The final age will be determined based on the demand trend and marketability of the timber to be produced to satisfy the management targets.

④ Conservation Plan

Through the implementation of the above plans, the conservation of forests should be attempted. In principle, the area yield regulation method will be employed to secure a continuous yield although the actual method will depend on the stand composition and tree growth as well as other factors.

⑤ Hauling and Forest Road Construction Plan

a. Hauling

The felling trees will be haulded to a nearby public road using a simple cable system or animals for both final felling and selective felling.

b. Forest Road Construction

The forest road construction standards will apply wherever such construction work is anticipated.

⑥ Miscellaneous

Stable boundaries will be essential for the basis of forest management as well as the basis of the operation plan devised on the grounds that forest continuity should be given priority. The invasion of alternation of boundaries once they have been set should be avoided. Local inhabitants should be informed of and instructed to adhere to the new boundaries and the prior application requirement for controlled burning. In addition, buffer zones (also acting as firebreaks) should be introduced around forests and should be properly managed with the understanding and cooperation of local inhabitants.

APPENDICES

1. List of Study Team Members

The composition of the study teams which have so far been sent to Colombia and their schedules are shown in Table A - 1.

Table A - 1 List of Study Team Members

① First Study Team (Preminary Study)

Field	Name	Responsibility	Field Survey Period	No. of Days
Forest Management Plan	Hiroshi Watanabe	supervision and plan standards	Feb.14 - Mar. 5, 1989	20
	Shigeki Koike	supervision assistance and forest management plan	Feb.14 - Mar.25, 1989	40
	Shinichi Hayashi	soil survey	"	"
	Hiroaki Masui	reforestation	"	"
	Sumio Ichikawa	socioeconomic survey	"	"
	Shuichi Kobayashi	forest survey	"	"
	Toru Sekine	vegetation survey	"	"
Remote Sensing Analysis	Iwao Nakajima	remote sensing analysis	"	"
	Kazuyoshi Kageyama	"	"	"
Aerial Photography	Yoshiro Hayash	aerial photography management	Feb.14 - Mar.30, 1989	45
Control Point Survey	Shun Takagi	control point survey supervision	"	"
	Mitsuo Saito	"	"	"
	Makoto Sueto	"	"	"
	Kazuhiro Harada	"	"	"

② Second Study Team (Basic Study)

Field	Name	Responsibility	Field Survey Period	No. of Days
Forest Management Plan	Shigeki Koike	supervision and forest management plan	Feb.2- Mar.15, 1990	37
	Shinichi Hayashi	soil survey	"	"
	Hiroaki Masui	reforestation	"	"
	Sumio Ichikawa	socioeconomic survey	"	"

③ Third Study Team (Basic Study)

Field	Name	Responsibility	Field Survey Period	No. of Days
Forest Management plan	Hiroshi Watanabe	supervision and plan standards	Jul. 2 - Jul. 21, 1990	20
	Shigeki Koike	supervision assistance and forest management plan	Jul. 2 - Aug 15, 1990	45
	Akira Kikuchi	forest conservation	"	"
	Shinichi Hayashi	soil survey	"	"
	Hiroaki Masui	reforestation	"	"
	Sumio Ichikawa	socioeconomic survey	"	"
	Kozo Kato	forest survey	"	"
	Toru Sekine	vegetation survey	"	"

Table A - 2 List of Advisory Team Members

① First Advisory Team

Name	Responsibility	Visiting Period	No. of Days
Kanji Koori	team leader/supervision	Feb.20 - Mar.3, 1990	12
Kunihiko Ishizaki	conservation	"	"
Kooji Makiguchi	work coordination	"	"

② Second Advisory Team

Name	Responsibility	Visiting Period	No. of Days
Toshiaki Nakajima	work coordination	Feb. 7 - Feb.17, 1990	11

③ Third Advisory Team

Name	Responsibility	Visiting Period	No. of Days
Mitsuo Uchigashima	supervision and forest resources	Jul.2 - Jul.14, 1990	13
Shinji Ogawa	work coordination	"	"

2. List of Main Related Persons in Colombia

① Embassy of Japan in Colombia

Name	Title
Chihiro Tsukada	Ambassador Extraordinary and Plenipotentiary
Hiroshi Takano	Councillor
Yoshitaka Nagashima	First Secretary
Rikio Shikama	Ex-Ambassador Extraordinary and Plenipotentiary
Hitoshi Miyamoto	Ex-First Secretary
Tadashi Iijima	Ex-First Secretary

② JICA Office in Colombia

Name	Title
Ikuo Gamo	Director
Yasuhiro Umezawa	Deputy Director
Iehiko Sato	Officer
Nobutetsu Enoshita	Ex-Director
Takashi Ito	Ex- Vice Councillor

③ DNP

Name	Title
Dra. Yolanda Pamirez	Director, International Technical Cooperation Division
Dr. Guillermo Augusto Correa Castañeda	Officer, International Technical Cooperation Division
Dra. Clara Gonzales G.	Natural Resources Section
Dr. Gustavo Herrera Ch.	Natural Resources Section
Dra. Martha Cecilia Bernal Arrieta	Ex-Director, International Technical Cooperation Division
Dr. Juan Molina	Agricultural Development Division

④ INDERENA

Name	Title
Dr. Felipe Pineda Aristizabal	Acting Director General
Dr. Germán Garcia Durán	Ex-Director
Dr. Pompilio Andrade Benilla	Driector, Forest and Water Administration Bureau
Dr. Alberto Ruiz Garcia	Director, Local Affairs Bureau, Caldas Province
Ing. Ernesto Jiménes López	Driector, Forest Administration Division
Ing. Alejandro Copete Perdomo	Manager, Natural Forest Department
Ing. David Yanie Díaz	Manager, Man-Made Forest Department
Ing. Eduardo Campos Campos	Forestry Promotion Division
Ing. Gustavo Valencia Rojas	Chief, Caldas Province Forest Project
Ing. Joaquín Mora Peralta	Chief, Cundinamarca Forest Project
Ing. Guillermo Gonzales Gomeż	Chief, Antiochia Forest Project
Ing. Gloria Tovar Jaramillo	Chief, Baje Forest Project
Ing. Fabio Restrepo B.	Chief, Pensilvania Office
Ing. Jose Miguel Orozco Muñoz	Ex-Director, Forest Administration Division
Ing. Edgar Otavo Rodriguez	Manager, Mapping Department
Ing. Francisco Posada Arredondo	Technician, Forest Administration Division
Ing. Lombardo Tibaquira C.	"
Ing. Edear Fernando Cortés Saens	Ex-Technician, "

⑤ Caldas Provincial Office

Name	Title
Dr. German Cardoma Gutierrez	Governor

⑥ Manizales Municipal Office

Name	Title
Dra. Victoria Eugenia Osorio de Mejía	Mayor