REPORT
ON
THE JOINT STUDY PROJECT
OF
PERFORMANCE TRIALS FOR REFORESTATION IN THE AMAZON AREA IN THE REPUBLIC OF PERU

(SILVICULTURAL MANUAL)

(I) OUTLINE OF THE PROJECT
(II) PARTICULARS

February, 1991

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)
INSTITUTO NACIONAL DE INVESTIGACIÓN AGRARIA Y AGROINDUSTRIAL
(INIAA)

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Preface

The joint project for regeneration trials on forestry development in Amazon in the Republic of Peru has been conducted in compliance with "Record of Discussions" that was signed on October 9, 1981. Its purpose has been to establish a systematic regeneration technology conducive to development in harmony with conservation of the Amazonian tropical rain forests. While the survey has achieved great results, it has been decided that this project will be completed on March 31, 1990 due to problems with security on the site.

This is a final report to collate the results of the field survey conducted over the past eight years.

We expect this report to be utilized by the private sector as a guideline for similar projects in the future.

We would like to express our appreciation for the cooperation shown by the Peruvian and Japanese workers involved in the preparation of this report.

March, 1990

Katsuyuki Ohmi
Director
Forestry and Fisheries Development
Cooperation Division
Japan International Cooperation Agency

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Staff List
Project for Verifying the Feasibility of Forestry Development
in Peru-Amazonia

November 1, 1989
(The writers of this report are circled.)

(Long-term Experts)

No.	Name	Period	Field	Current Post
1	Kenjiro Morita	Jan. 15 - Nov. 19, '82	Leader	Passed away (1983)
2	Noriyuki Anyoji	Jan. 15, '82 - Jun. 30, '84	Leader in planting	Director General Affairs Dept. Kumamoto Branch Forestry Agency
3	Santei Ohmori	Jan. 15, '82 - Jan. 14, '84	Nursery coordination	in Chile
4	Yoshitaka Enomoto	Mar. 8, '82 - Jul. 17, '83	Work coordination	
5	Yuzo Akutsu	Apr. 5, '82 - Apr. 4, '84	Reforestation	Management and Planning Division Forestry Agency
6	Toshio Takaku	Oct. 25, '82 - Feb. 11, '83	Forest ecology	Passed away on the site (Feb. 11, 1983)
7	Takakazu Tokuyama	May 30, '83 - May 29, '85	Reforestation	Director Kuroishi Office Aomori Branch Forestry Agency
8	Yoshitaka Uetsuki	May 30, '83 - May 29, '85	Nursery and forest ecology	Chief Researcher San'in Breeding Branch Branch Forestry Agency
9	Takamichi Shiozuru	Sept. 9, '83 - Dec. 10, '88	Work coordination	Japan International Cooperation System
10	Naoko Shiozuru	Sept. 9, '83 - Oct. 10, '86	Work coordination	
11	Yoneo Kitamichi	Jan. 27, '84 - Jan. 26, '86	Nursery	Technological Development Office Hakodate Branch Forestry Agency
12	Tadashi Ujiie	Apr. 6, '84 - Jun. 29, '86	Leader	Director Muroran Office Hakodate Branch, Forestry Agency

No.	Name	Period	Field	Current Post
13	Keisuke Taniguchi	Apr. 6, '84 - Oct. 25, '85	Reforestation	Wood Distribution Division Forestry Agency
14	Yasuo Ijima	May 17, '85 - May 16, '87	Reforestation	Forest Conservation Division Forestry Agency
(15)	Akihiko Yokota	May 17, '85 - May 16, '87	Forest ecology	Overseas Forestry Study Division Forestry and Forest Products Research Institute
16	Mitsuhiro Tokuda	Jan. 15, '86 - Jan. 14, '88	Reforestation	Planner Kumamoto Regional Forest Office Forestry Agency
17	Hideki Tsubo	Jan. 15, '86 - Mar. 14, '88	Nursery	Manager Management Division Wakinosawa District Forest Office Aomori Regional Forest Office Forestry Agency
(18)	Hideo Koike	May 18, '86 - May 17, '89	Leader	Director Matsumoto District Forest Office Nagano Regional Forest Office Forestry Agency
(19)	Kazuya Iizuka	May 3, '87 - May 2, '89	Forest ecology	Silviculture and Protection Division Forestry Agency
(20)	Takashi Sato	Aug. 16, '87 -	Reforestation	in Peru
(21)	Minoru Yoshida	Jan. 10, '88 -	Reforestation	in Peru
(22)	Keiji Watanabe	Mar. 3, '88 -	Nursery	in Peru
(23)	Saburo Yamazaki	Jul.11, '88 - Jul.10, '89	Forest insects	Forest Creatures Dept. Forestry and Forest Products Research Institute
24	Masahiro Mikami	Nov. 7, '88 -	Work coordination	in Peru

(Short-term Experts)

August 1, 1989

No.	Name	Period	Field	Current Post
1	Hideaki Hoshi	Feb. 1 - Feb. 28, '82	Forest road design	Forestry and Civil Engineering Consultant (Hokkaido)
2	Shoki Sakagawa	Feb. 1 - Feb. 28, '82	Forest road design	
3	Taiichi Narita	Feb. 1 - Mar. 28, '82	Forest road engineering	Forestry and Civil Engineering Consultant (Obihiro)
4	Kaname Yamazaki	May 31, - Oct. 29, '82	Forest road engineering	Forestry and Civil Engineering Consultant (Kochi)
5	Hayami Komatsu	Aug. 21, - Nov. 22, '82	Topographical survey	Forestry and Civil Engineering Consultant (Kochi)
6	Satohiko Sasaki	Sept.17 - Oct. 29, '82	Seeds	Professor Faculty of Agriculture Tokyo University
(7)	Kimiyasu Kawamuro	Sept.17 '82 - Oct. 29, '82	Regeneration test	Chief Kyushu Branch Soil Laboratory Forestry and Forest Products Research Institute
		Feb. 22 - Mar. 22, '87	Forest soil	
		Jun. 26 - Sept.22, '89	Computer	
8	Hiroyuki Teraya	Jul. 18, - Nov. 18, '83	Forest road engineering	Part-time technician Forestry and Civil Engineering Consultant
		Jun. 11 - Oct. 12, '84		
		Jun. 15 - Oct. 17, '85		
9	Kazushige Kanematsu	Jul. 18 - Nov. 18, '83	Topographical survey	Forestry and Civil Engineering Consultant (Nagoya)

No.	Name	Period	Field	Current Post
10	Toshitaka Yokoyama	Aug. 1 - Sept.9, '83	Seeds	Chief Species Ecology Laboratory Forest Research Institute
(11)	Mitsuma Matsui	Aug. 1 - Sept. 9, '83 Apr. 6 - May 4, '84 Oct. 13 - Nov. 4, '84 Apr. 8 - Apr. 28, '86 Apr. 5 - Apr. 22, '87 Jun. 27 - Jul. 9, '88	Study and research	Vice-chairman Dai-Nihon Sanrinkai
12	Teruji Nakamura	Aug. 1 - Oct. 31, '83 Jul. 20 - Oct. 12, '84	Soil	First Study Department Japan Forest Technical Association
13	Kimiya Kudo	Aug. 1 - Oct. 31, '83	Forest ecology	Japan Forest Technical Association (Hokkaido)
14	Taro Nagato	Feb. 20 - Mar. 19, '84	Forestry machinery	Nagato Corporation
(15)	Yasuo Ohsumi	Apr. 6 - May 4, '84	Study and research	Research Coordinator Tropical Agriculture Research Center
16	Hiroshi Katada	Jun. 11 - Oct. 12, '84	Topographical survey	
17	Koichi Narita	Jul. 20 - Oct.12, '84	Forest ecology	Japan Forest Technical Association (Hokkaido)

No.	Name	Period	Field	Current Post
18	Fujio Kobayashi	Oct. 13 - Nov. 9, '84	Forest entomology	Director General Forestry and Forest Products Research Institute
(19)	Saburo Yamazaki	May 17 - Jun. 14, '85 Sept.15 - Nov. 22, '85 Apr. 18 - May 23, '86 Jan. 18 - Mar. 13, '87 Oct. 18 - Dec. 25, '87	Forest entomology	Forest Biology Dept. Forestry and Forest Products Research Institute
(20)	Toshiya Ikeda	Sept.15 - Nov. 22, '85 Aug. 5 - Sept.30, '86 Jun. 21 - Aug. 21, '87	Forest entomology	Chief Insect Physiology Laboratory Forestry and Forest Products Research Institute
21	Takakazu Tokuyama	Nov. 22 - Dec. 21, '85	Reforestation	
22	Naoto Noda	Apr. 8 - Jun. 7, '86	Study and research	Long-term expert in Kenya
(23)	Kazuyuki Fujita	Jan. 18 - Mar. 10, '87	Forest entomology	Forest Biology Dept. Forestry and Forest Products Research Institute
24	Shinji Kaneko	Feb. 22 - Mar. 20, '87	Soil	Forest Environment Dept. Forestry and Forest Products Research Institute

No.	Name	Period	Field	Current Post
25	Hiroyasu Sakamoto	Aug. 9 - Oct. 7, '87	Forest road engineering	Forestry and Civil Engineering Consultant (Hokkaido)
	Masato Tamura	Apr., '85 -	Guidance in rice production	Japan International Cooperation System
	Yuzo Ishikawa	Nov., '85 - Nov., '88	Guidance in irrigation	Youth Association for Industrial Development and Technology
	Hidenori Kasai	May 30, '87 - May 29, '89	FAO's survey on tropical forests	Assistant Manager Forest Products Div. Forestry Agency

(Peruvian Staff List) 31 March, 1990

No.	Name	Period	Field	Current Post
1	Raul Romero Mejia	Jun. 83-Sept. 85	Coordinator in Lima	PNAF
2	Mario Quevedo Neyra	Oct. 81-Jun. 84	Chief of Pucallpa St.	
3	Gilberto Alvan Paino	Oct. 81-Oct. 87	Coordinator in Pucallpa	Agroforestry Project in Central Selva
4	Angel Salazar	Oct. 81-Feb. 86	Silviculture	Study off in US
5	Teodoro Trucios Remolino	Oct. 81-Apr. 89	Dendrology	Study off in Belgium
6	Andres Castillo Quiliano	Oct. 81-	Nursery	Director, Pucallpa St
7	Emilio Maruyama Higuchi	Apr. 83-Apr. 87	Silviculture	Study off in Japan
8	Martha Ugamoto Nakamura	Oct. 83-Jul. 87	Nursery	Study off in Japan
9	Fernando Carrera Gambeta	Oct. 83-Mar. 86	Silviculture	Study off in Costa Rica
10	Federice Castro Romas	Jul. 84-Jun. 85	Chief of Pucallpa St.	
11	Carlos Vasques Pacheco	Apr. 85-	Entomology	Entomology Section
12	Raul Parraga Solis	Sept. 85-Jun. 88	Coordinator in Lima	Director, For. Prods. Dept. DGFF in Lima
13	Pedro Reyes Inca	Jul. 85-Feb. 89	Chief of Pucallpa St.	Studying in La Molina Univ.
14	Janry Pinedo Vargas	May 86-May 89	Nursery	Pucallpa Reforest. Committee
15	Walter Angulo Ruiz	May 86-	Silviculture	Reforestation Sect.
16	Enrique Quitana Lagos	Jan. 87-	Silviculture	Reforestation Sect.
17	Hector Vidaurre Arevalo	May 87-	Silviculture	Reforestation Sect.
18	Violeta Colan Colan	Aug. 87-	Dendrology	Dendrology Sect.
19	Francisco Palmino	Jan. 87-Mar. 89	Entomology	MOSCAMED
20	Sonia salazar	Jan. 87-Feb. 88	Entomology	
21	Eduardo Cornejo Cano	Sept. 89-	Nursery	Nursery Sect.
22	Luis Cueto Aragon	Jul. 88-Mar. 90	Coordinator in Lima	Retired
23	Javier Matsudo Ikey	Aug. 87-Oct. 88	Nursery	
24	Loydi Angulo	Oct. 81-Jun. 88	Dendrology	
25	Ketty Koga Takisawa	Sept. 85 Aug. 86	Nursery	Studying in Japan

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Eduardo Cornejo	: ditto

I. Outline of the Project

1. Purpose of this Project and Progress of this Study

There is a huge area (60 million ha) of unexploited tropical rain forest in South American Amazonia, and its ecology as well as resources capture the attention of people worldwide. The Peruvian Government is deeply concerned over the development of this forest.

Japanese experts considered that conventional study systems were inadequate for immediate implementation of a development project to proceed in this region. Practical data on reforestation to secure forest regeneration are scarce, so it was felt to be essential that the feasibility of reforestation should be verified as part of the field survey. This will provide data that can be used to verify the feasibility study, and so enable us to give guidance to private companies in experimental projects based on the results of this study, and to encourage the Peruvian Government to recognize the sound development project.

Thus, the Japan International Cooperation Agency (JICA) sounded out the Peruvian Government's intentions of development, and INFOR, Agriculture Ministry, Peru not only welcomed our proposal but also suggested that the project must be implemented quickly.

In October, 1981, the joint project for regeneration trials and forestry development in Amazon in the Amazonia in Republic of Peru was established, based on the Minutes dated October 9, 1981 prepared by the study team jointly organized by JICA and INFOR.

The period of the study was extended to date in accordance with the Minutes dated October 6, 1986. At the same time, it was decided that the study findings would be summarized to ensure a contribution to the project's future progress.

The purpose of this project was to establish techniques of developing timber production in harmony with ecological conservation. In other words, to investigate and verify forest regeneration techniques which will enable commercial tree species to be utilized without causing substantial damage to existing natural forests, and to promote the regeneration of valuable indigenous species.

As a study plot, a natural forest with an area of about 1,500 ha was designated within the Von Humboldt National Forest located about 86 km of Pucallpa via the national road. The result of the field survey shows that while most part of this area was still densely forested, high quality and large diameter trees are scarce and this forest would be called as a secondary forest of low economic value.

Generally speaking, under projects for developing natural forests, trees are felled and utilized, and some of profits from logging are allocated to regeneration in order to secure sustainable yield. In the case of natural forests with low economic value, however, sufficient

profits cannot be expected, leading to a high risk of reckless exploitation. Therefore under this project, priority was given to the enrichment of forest by highly marketable indigenous species in order to enhance its value prior to the start of production activity.

For forest enrichment, we have adopted line planting as a method of artificial reforestation and the mid-layer tree cleaning-cutting method to facilitate natural regeneration of useful species so that the existing forests will be minimally disturbed. It is intended that as wide a space as possible will be left between lines, and existing large diameter trees will be untouched regardless of their current marketability, in anticipation of future development of their applications. This is due to precedents in which species formerly regarded as worthless in Southeast Asia gained high marketability as applications were found for them. We must be extremely careful not to simplify the composition of natural tropical forests consisting of multiple species.

We also planned to establish demonstration forests to investigate the characteristics of stands and to obtain data useful for future development as there are many indigenous species of unknown characteristics in Amazonia.

2. Scope of the Study

(1) Artificial Regeneration (line planting)

The Amazonian forest consists of a vast number of tree species. Following discussion on the results of past surveys by INFOR, and the progress of outturn to the market, we first chose 15 species to be used for reforestation from among 60 species which the Peruvian Forestry Department had selected. We intended to add other species if required during the course of the study.

Line planting is often attempted in Southeast Asia and Oceania, with mixed results, the main cause of mortality being shade due to inadequate tending. Hence, more importance was attached to determining the optimum line width for tending.

A survey was conducted on the growth characteristics of species under various soil and light conditions with the basic width of 5 m. A reserve zone of 15 m wide was maintained between the lines.

Line planting with a width of 30 m was also used to investigate differences in the light requirements of various species at the sapling stage. This will provide data on growth characteristics due to such differences; the part of the line adjacent to the reserve zone gets partial light, while the central part of the line receives full light.

Since it was expected that Caoba and Cedro (family: Meliaceae) would be vulnerable to Hypsipyla grandella, lines with a width of 10 m were set to attempt the nest planting method, which prevents such damage by surrounding these species with other fast growing and resistant species.

Because seeds for the nursery must be collected from natural forests, seedlings from which the seeds could be collected were raised and planted before others. At the same time, a soil survey was conducted by experts to produce a soil map. To compile accurate data on growth, soil types was related to differences in growth among species.

Luminosity in the lines was also measured regularly to assess relationship with the growth rate of the various species.

As a result of the survey, we found that Hypsipyla damage to Cedro and Caoba spp. was far more serious than anticipated. Since they are the most commercially valuable species, we urgently requested experts to conduct an additional survey on Hypsipyla's life history, behavioral characteristics, sequence of damaging, preventive measures and so on.

Moreover, a continuous survey was implemented to clarify the flowering and fruiting characteristics of the main species, which could provide the basis for collecting a large seed store for a future reforestation project. This reflects the irregular fruiting of many tropical species.

(2) Natural Regeneration

In the conventional management of tropical rain forests, trees above a certain diameter are selectively cut, and the succeeding trees are also selectively cut after a certain period of time. This process is repeated. However, the regeneration and growth of succeeding trees is commonly deficient. Various studies have shown that the natural regeneration seen in temperate zone forests is difficult and unprofitable even if it is not impossible in tropical rain forests. Nevertheless, natural regeneration remains the most desirable method as this project is designed to maintain timber production while protecting the ecology of tropical forest. Therefore, the suitability of several of the main species for this was examined.

3. Progress of the Study

The study was carried out by long-stay experts who lived on site for two years as a rule, short-term experts who assisted whenever required, and their Peruvian counterparts. A verification study of this kind required a supportive committee to be established in Japan to provide occasional advice when required, so the study could continue without interruption as and when experts were replaced.

To facilitate the verification study, work schedules were simplified, and work processes were clarified.

In the course of the project, forest roads and wooden bridges were constructed, and their designs were also evaluated.

4. Results Obtained

(1) Artificial Regeneration (line planting)

1) The selection of suitable species:

Few problems arose concerning acclimation due to the use of indigenous species in the study. Straight trunk species with no tendency to branching and with self-pruning are preferable for planting, and the survey showed that several of the indigenous species had these characteristics, as well as rapid growth and good timber quality.

2) Several soils of differing natures are distributed over this region, and species favoring each of these soils were found. This means the possibility of selection of suitable tree species for each type of soil.

3) It was also found that some of main species required adequate light during their sapling stage, while others required a certain degree of shade at this stage, but more light as they grew. This meant that some of the species were more suitable for line planting, while some required more luminosity during the tending stage of line planting.

4) For the main species, certain standards were established for seedling production, including seed collection, selection, storage, and problems associated with these. Additionally, methods and rate of sowing, nursery period, transplanting time, watering volume, and the degree and duration of shading were all standardized.

5) Our knowledge of planting out procedures for seedlings as well as instructions on planting them could be improved.

6) It was found that planting trees on a line 10m wide in a double row was better in terms of work efficiency and tending.

7) Each of the work processes was clarified.

8) It was found that Caoba and Cedro (family: Meliaceae) were severely infested by Hypsipyla, and although this damage could be reduced by planting under trees and spot planting in a small area, the planted trees grew very poorly under shade.

Within the framework of this study, the only possible solution was to use insecticides for several years after planting. Currently, we are continuing to study possible effective countermeasures while keeping chemical use to a minimum. Notably, the entomological findings of the study have made a great contribution to the academic world.

(2) Natural Regeneration

Clearing of bushes and surface raking in advance are required for natural regeneration, in order to facilitate the blossoming and fruiting of the expected species, the establishment of seedlings, and to control luminosity for the healthy growth of the settled seedlings. Although we initially planned to carry out such preparation and a survey on seed scattering, the study progressed in an unexpected direction due to chance.

In 1981, at the beginning of the study we had a rich yield of Cedrelinga catenaeformis (one of the main species) and plenty of seedlings resulted. Mid-layer small diameter trees which reduced ground luminosity were removed so that the seedlings could grow well, and as a result, ground luminosity was gradually raised, and the seedlings grew vigorously. Since we could not find seedlings of this species in the forest survey it is presumably difficult for the numerous seedlings to grow at the normal ground luminosity.

The hypothesis resulting from the survey is that in tropical rain forests, it is easy for seedlings to grow if many seeds fall onto the ground, because the ground vegetation is poor due to deficient luminosity. What inhibits the growth of seedlings is not ground vegetation but the mid-layer small diameter trees which absorb most of the sunlight. It is therefore essential for natural regeneration to extract many of those obstacle trees just after the establishment of enough seedings on the ground so that the seedlings may thrive. If luminosity was increased prior to the falling of seeds as it is generally done in temperate zone forest, the result would be rampant ground vegetation either preventing or inhibiting seedlings from growing, thus halting natural regeneration.

In order to verify this hypothesis, we extracted mid-layer small diameter trees just after confirming the presence of seedlings, to ensure a relative luminosity of 50 % in the next rich year, and consequently succeeded in the natural regeneration of Cedrelinga.

This hypothesis proven, similar attempts have been made for some of the other main species.

Hence, it can be said that we have had success with one potential method of natural regeneration in tropical rain forests formerly regarded as being difficult. This provides support for the idea that development can be compatible with the conservation of tropical rain forests.

(3) Others

1) Although it is generally said that the soil in tropical rain forest zone is more clayey, strongly acidic, and fairly infertile, the results of the soil survey in this region show that neutral or slightly alkali CV soil, sandy soil, and soil containing more humus are also present to a considerable extent. This is probably a reflection of differences in the

parent material based on the geology of the area. This is a good example of a soil survey providing important information to assist in the selection of suitable species on suitable sites also in the tropical zone.

2) This study showed that enrichment was an effective methods for both the development and conservation of tropical rain forests from an economical point of view.

5. Remaining Problems

(1) This study has led to feasible proposals being made relatively quickly, on the basis of its short-term results. If long-run forestry is taken into consideration, following up the development of regenerated forests is required at a certain intervals. This is especially important in Amazon for which very little data is available.

(2) What is thought to be good for the regeneration of tropical forests has not always been implemented in previous studies or local efforts, the major reason being the absence of simple and clear manuals. In this study, we thus attempted to employ the simplest and clearest principles and methods. It is very important, however, for these to be improved further to develop simpler and clearer operational guidelines by making good use of the local ecological conditions.

(3) The study on Hypsipyla is incomplete:

Many of the Meliaceae species are extremely valuable in terms of forestry, being extensively distributed. They are also frequently subject to severe damage by Hypsipyla. If this pest could be more effectively controlled, the economical benefits would be substantial. It is recommended that the study of Hypsipyla should be continued.

(4) We could not develop a seed orchard. Many tropical countries have relatively poor scientific knowledge about their indigenous tree species, though they have their respective desirable species. In the future, they may be faced with difficulty in securing seeds when cultivating such species. It is recommended that a study on the development of seed orchards of these desirable species should be carried out in addition to further studying flowering and fruiting cycles. The asexual reproduction method will also be probably required.

Finally, many experts from Japan and Peru have participated in this project. We have respect for their efforts, and pray for the repose of the souls of Messrs. Kenjiro Morita and Toshio Takaku who passed away during the course of the project.

(M. Matsui)

II. Particulars

1. Natural Conditions in Amazonia and Social Conditions in Peru

(1) Natural Conditions in Amazonia

Peru-Amazonia occupies an area of about 60 million ha, and accounts for 60% of the total area of Peru. Accordingly, the ecology of Amazonia varies markedly.

Topographically, the area can be classified into four regions: 1) the Andes, 2) the Andes vanguard, 3) the hilly district, and 4) the flood plain. The Andes district, situated at or above an altitude of 2,000 m, consists almost entirely of extremely steep slopes, while the Andes vanguard district is relatively low in altitude compared to this, and the slopes are not so steep. Coffee and tea have been cultivated there since early days.

The hilly district consists of a plateau composed of ancient alluvial deposits in the basin of the Amazon and its tributaries, and this project was undertaken on a plot in this area, which occupies the largest part of Amazonia.

The flood plain is the area flooded by the Amazon and its tributaries during the rainy season, and occupies a relatively large area.

The climate can be broadly classified into four zones: 1) cold humid, 2) temperate humid, 3) hot humid and 4) hot and wet. The cold zone has a minimum temperature of around 5°C, while that of the temperate zone is around 10°C. The hot zone is obviously warmer than these former two.

In the humid zone, there is a maximum of 2-3 months when the average monthly rainfall reaches 100 mm, while in the wet zone, there are only around four months when the average monthly rainfall is less than 100 mm. Both the cold and temperate wet zones occur in the Andes, and so are not strictly part of Amazonia.

The cold humid zone is situated on the western side of the Andes at an altitude of 1,500 m or more, while the temperate humid zone is found in the Andes vanguard district between 800 and 1,500 m above sea level.

The hot humid zone exists in areas relatively close to the Andes, its expected border line connect Atalaya, Humboldt and Taraporto; the project site is situated in this zone.

The hot and wet zone includes Iquitos and Pucallpa, being largely confined to western Amazon. In this zone, the total annual rainfall exceeds 2,000 mm.

The geological conditions can also be classified into four basic categories: 1) sedimentary rocks in the Andes, 2) sedimentary rocks

in the Andes vanguard district, and 3) deposits in the hilly district, and 4) alluvial deposits. Both the Andes and their vanguard districts are mountains consisting mainly of calcareous sedimentary rocks. Regarding the nature of the hilly district, calcareous deposits are extensively distributed in areas near the Andes, while acid deposits are widespread along the Brazilian border and the hills around Iquitos. Alluvial deposits are composed of acid clay and small particles such as silt.

In terms of vegetation, the Andes largely provide a habitat for relatively hardy plants; the so-called tropical rain forest plants are few. These species only begin to appear in the relatively low areas of the Andes vanguard district. The main rainforest species such as Caoba, Tornillo, Ishpingo, and Copaiba only grow in the places below the Andes vanguard district.

A simple soil map (Fig. II-1-1) is attached to show local soils. Reflecting the parent material and topography, the dominant soils of the Andes and their vanguard districts are Nitoso and Cambisol, being mainly neutral except for Regosol, Lithosol, and Ranker which are found on steep slopes. Soils in the hilly district are largely classified into two types. In areas near the Andes where there is relatively new parent material, calcareous and almost neutral Cambisol and Nitosol are extensively distributed, while the acidic Acrisol and Ferralsol cover most of the plateau on the right side of Rio Ucayali and the northern part of Iquitos. Since the material is relatively new, there is little of the Oxisol commonly found in Brazil-Amazonia. The flood plain is almost entirely Gleysol, while there is little Histosol as peat.

(2) Social Conditions in Peru

For the details of social conditions including Peruvian law, see the section " Analysis of Socio-economic Conditions Associated with Forestry in Peru ".

1) Land Use:

a) Forest and forestry policies are included in the agricultural policies. Accordingly, priority is often given to agriculture. For example, 1 km to each side of the highways and main rivers is primarily for agricultural uses. Recently, agricultural development alongside highways has extended some 2 km.

b) In terms of forestry usage, forests are largely classified into three categories: national forest, free operation forest, and protected forest. Timber production is permitted except in the protected forests. Concessions for logging national forests are open to bid, and of 20 years duration. The scale of operation is between 2,000 and 200,000 ha.

Free operation forests produce timber, and while a scale of up to 100,000 ha. is possible under the 2-10 year contracts, a size of 1,000 ha or less is common. In any case, zoning

is not managed in a proper manner.

c) In connection with the treatment of aboriginal Indians settled throughout the Amazonian lowlands, priority is given to them for land use around their villages.

d) Although the Forest Law was enacted in 1975, and the Regulations on Forest Resources Utilization in 1977, that they have not been properly enforced.

e) Illegal shifting cultivation is frequently carried out along roads. However, because of the high rainfall, the probability of the spread of a fire is very low. There are also many tree thefts. The policing that should enforce the laws on them is ineffective. Forest police exists overall as a sector of the national police.

f) One of the recent problems concerning land use is cocaine cultivation. Coca is a plant of the wet Andes, and has provided Indians with a medicine since ancient times. While the government permits restricted Coca cultivation in a limited area, mainly highland, in recent years, cultivation has spread to the hilly district, and in combination with communist guerrilla activity has led to much social upheaval in Amazonia.

2) Labor Environment:

a) In 1985, the potential labor force was estimated at 6.5 million people, more than half of which are unemployed. Although the people engaged in forestry account for 4 % of this potential working population, most of them live in urban areas, with relatively few of them living in Amazonian villages.

b) The following jobs prove difficult to fill using the local workforce employment: site superintendents, drivers, automobile and electrical mechanics, tree observers, operators on the tree, loggers, heavy machine operators, and nursery managers.

c) Relating to labor, there are several levels of law: the constitution, civil law, and commercial law, under which there are three types of labor laws. Besides these, there are the labor union law, the labor stabilization law, the minimum wages law, and the law concerning retirement allowance and insurance systems.

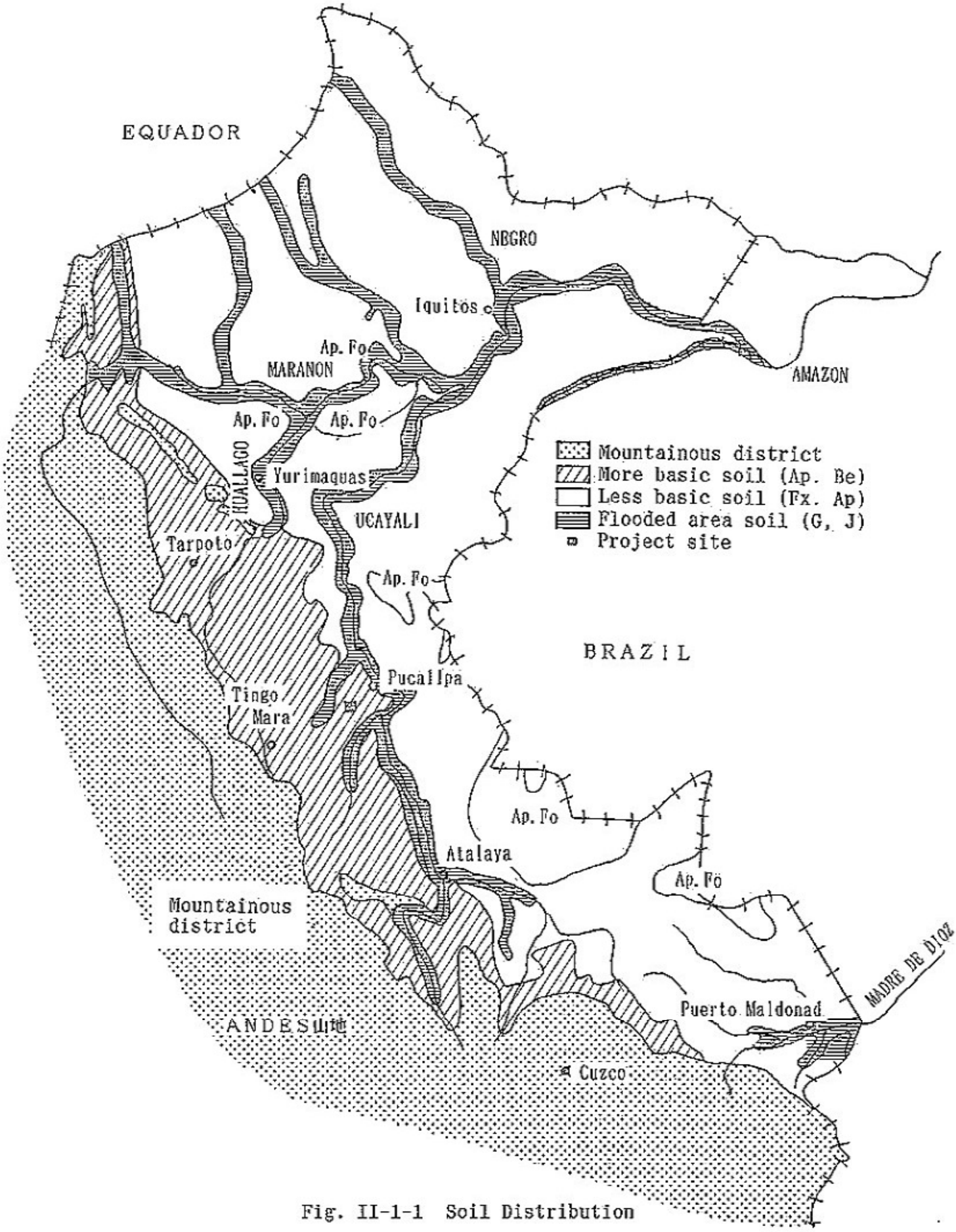


Fig. II-1-1 Soil Distribution

d) Normal hours for general workers are 8 hours a day, 48 hours a week with possible overtime of up to 7 hours a day in the case of men aged 18 or over. Women may work 8 hours a day, 45 hours a week with possible overtime of up to 4 hours a day, and are prohibited from working after 10 o'clock at night. Junior high school students are allowed to reduce the normal hours in order to attend school. The people connected to the project worked between 40 and 42.5 hours a week.

e) Workers who have been employed for one year are given 30 consecutive paid days off a year, plus additional days and sick leave as permitted. Maternity leave of 6 weeks is given both before and after delivery. Although the people connected to the project were otherwise treated, their conditions of work were almost identical.

f) Workers only leave the office as a result of dismissal, midway resignation, or retirement at the age limit. Employers may not dismiss full-time workers who have completed a probationary three months unless they commit gross negligence. Over a fixed period, projects were started under one-year employment contracts. Although the retirement age is not officially set, men aged 60 and women aged 55 retire in many cases because they are eligible for pension.

g) Wages are unstable due to the currently high inflation. Salaries are paid monthly to clerks, while manual workers are paid daily, weekly or monthly, the minimum wage being US$37-58 per month up to April, 1989. The unskilled workers are often employed at this rate. Bonuses are paid twice yearly, the government officially announcing the minimum amount (some 0.5 month).

The legal minimum retirement allowance is determined by multiplying the base salary at the time of retirement by the number of working years, contributions having been made by both the employer and employee to the pension fund at separately fixed rates of base salary. Although there are no laws or regulations concerning other allowances, there are presumably travel and meal allowances, education loans, as well as special technology, transportation and extra work allowances. In this project, each worker was paid some US$ 100 including salary and allowances

h) Labor unions are open shop, and organized within each company, a quorum of 20 proponents being required, plus the signatures of 50 % of all employees. They often go on strike.

i) Skilled workers are not systematically trained, hence employers must train them on their own. The motivation of general workers is not thought to be very high, partially because of the Peruvian Government's policy emphasizing the protection of workers.

(Y. Ohsumi and H. Koike)

2. Forestry Management Model in Peru-Amazonia

(1) Purpose and Plan

The project for joint study on the feasibility of reforestation in Amazon in the Republic of Peru was implemented by the Japanese and Peruvian Governments for the purpose of establishing forestry development in harmony with natural conservation. Since the start of the project in 1981, the key techniques for establishing sustainable forestry in Amazonia have been developed, and the diverse information obtained so far used to construct a viable model of forestry management, which will be made available to the relevant agencies.

Information used in the development of the model is detailed in the attached "Silvicultural Manual" and "Monograph". We hope that you will refer to these whenever necessary.

In developing a model of forestry management, we focused on species for which various types of data were available. It was assumed that emphasis would fall on sawtimber log production in harmony with aims of conservation, and that production of poor quality but fast-growing species would be combined with slow growing highly valuable species in the pursuit of smooth turnover. Moreover, the local conditions were taken into account when selecting species as those resistant to the acid soil prevalent throughout Amazonia are preferable.

The management model developed is a tentative one based on the project results to date. Other models are not excluded by this.

Conditions for promoting this project are as follows:

(2) Selection of Species

We chose a combination of fast growing species, adaptable to a wide range of locations from which an early return can be expected, as well as useful species with a relatively long rotation suitable for typical Amazonian soil. As already mentioned, this is to ensure early capital recovery and lessen the potential risk of the main candidate species not flourishing.

The applications of some useful species, timber are given in Table II-2-1.

Useful species of long rotation period in this region are CAOBA, CEDRO, ISHPINGO and TORNILLO (as shown in the timber price list). Of these, CAOBA (mahogany) is exceptionally valuable followed by CEDRO. Meliaceae species such as these two are susceptible to damage by Hypsipyla which eats the new tops of planted trees. In many cases, infested trees sprout repeatedly before weakening and dying. As indicated in pest control manuals, it is possible to prevent infestation by use of pesticides combined with a special planting method, but these species were excluded from this model

because they require relatively complicated treatment compared to other useful species. Although both ISUPINGO and TORNILLO grow under similar conditions, and information on reforestation of both is available, only the latter was used here as more accurate data was available on it.

With respect to the selection of fast growing species, GOMA HUAYO, TOPA, LUPUNA, and BOLAINA are usually used for sawlog production in Amazonia. However, BOLAINA alone was employed because information on its growth was available, and due to its adaptability to a wide range of locations.

Since the conditions for the adaptation and growth of selected species are detailed in the manual or the attached material, they are just outlined here.

TORNILLO (Cedrelinga catenaeformis) is adaptable to acid soil, especially Acrisol and does not always grow well in basic Cambisol or Gleysol under excessively wet conditions. It is naturally found in acrisol, although judging from its distribution in Brazil and Iquitos, can also grow in Ferralsol, though not so vigorously as in Acrisol. An analysis of its light requirements show that this species grows well under shade and so is unsuitable for mass planting in a large totally cleared area, line planting being a more appropriate method. This provides optimum conditions for the regeneration of this species, which produces first-class timber suitable for beams and other heavy structural members in housing and shipbuilding. These applications both require a certain grade of sawlogs some 30 cm in end diameter, and 30 years cultivation.

BOLAINA BLANCA (Guazuma crinita) is a species expected to grow well in Gleysol, possibly also in Cambisol. Although it tends to grow most vigorously with full light, it grows reasonably well when line planted. Although it is likely that trees of this species will usually be planted in Gleysol, line planting is desirable for reasons of continuous transpiration by the plants, dealing with marshy conditions, and ecological conservation. The timber is used for various purposes such as window frames, ceilings, boxes, posts, and other light structural members. Accordingly, while larger diameters are preferable an end diameter of around 20 cm is useful. Judging from its actual growth, the timber reaches 20 cm in end diameter after 10 years cultivation. Accordingly, the rotation time was set at 10 years.

The model developed using these species will be shown below. See the manual for the selection of suitable sites, seed treatment, seedling production, planting, and nursery operations.

Table II-2-1 Timber Applications
(According to La Molina University)

Species \ Usage	Housing							Shipbuilding			Building			Furniture		Plywood					
	Structural member	Board/fittings	Wooden frame, etc.	Flooring	Deck	Frame	Side plate	Bilge	Heavy structural member	Light structural member	Submersion timber	Truck beds	General furniture	Craft furniture	Box making	Railroad Crossties	Electric pole Poles, posts	Fancy veneer	General veneer	General Carpentry	Tool Handles	Barrels	Match Wood
Caoba	◎	◎		◎	◎	◎	◎						◎				◎	◎	◎				
Cedro	◎	◎			◎		◎			◎			◎				◎	◎	◎		◎		
Ishpingo	◎	◎		◎	◎								◎				◎		◎				
Tornillo	◎	◎				◎				◎	◎	◎					◎		◎				
Copaiba	◎	◎	◎	◎							◎		◎	◎	◎	◎	◎	◎		◎			
Moena negra	◎	◎	◎								◎		◎	◎		◎	◎	◎	◎		◎		
Lagarto caspi	◎	◎	◎	◎	◎	◎	◎		◎		◎		◎		◎	◎	◎	◎			◎		
Yacushapana	◎	◎	◎	◎	◎	◎			◎				◎		◎	◎	◎	◎	◎	◎			
Estraque	◎	◎		◎			◎		◎		◎	◎	◎		◎	◎	◎	◎	◎				
Palo sangre a.	◎			◎											◎	◎							
Palo sangre n.				◎											◎	◎	◎						
Huayruro c.	◎	◎		◎							◎				◎	◎		◎	◎				
Quillobordon				◎	◎	◎	◎		◎				◎		◎	◎	◎	◎	◎	◎			
Pino regional																							
Pumaquiro	◎	◎		◎			◎						◎		◎	◎	◎		◎	◎			
Andiroba	◎	◎		◎				◎			◎		◎			◎	◎	◎			◎		
Mashonaste	◎	◎		◎					◎		◎	◎	◎		◎	◎	◎	◎	◎				
Panguana	◎	◎	◎								◎			◎		◎	◎	◎	◎				
Marupa	◎	◎							◎			◎	◎				◎	◎	◎		◎		◎
Anallo caspi	◎	◎		◎									◎			◎		◎		◎			
Cumala c.	◎				◎	◎			◎		◎	◎	◎		◎		◎		◎	◎			
Bolaina b.		◎												◎		◎		◎	◎			◎	
Bolaina n.																							
Ulos		◎							◎									◎	◎	◎		◎	
Aceite caspi		◎								◎				◎			◎		◎			◎	
Catahua			◎									◎		◎			◎	◎	◎				
Huamanzamana									◎	◎		◎		◎			◎	◎	◎			◎	
Lupuna														◎				◎	◎				
Goma huayo pashaco																							

(3) Managerial Conditions

1) Site area: 1,500 ha

2) Planting area: 1,000 ha

3) Area percentage of planted species:

Conditions of location:

Gleysol	Artificial regeneration	Bolaina blanca	50 %
Acrisol	Artificial regeneration	Tornillo	45 %
Acrisol	Natural regeneration	Tornillo	5 %

4) Annual planting area: 100 ha

5) Planting method: Double line planting 10 m wide 5 m x 2 m zigzag planting

6) Rotation age: Tornillo 30 years
Bolaina Blanca 10 years

(4) Scope

Data used in this management model were obtained from the project conducted in the Humboldt National Forest, hence it is not applicable to regions which differ markedly from the natural conditions of that forest. The scope of this model is explained below.

1) The temperature must show an average minimum of 11°C in the coldest month. There is no problem if it is 15°C or above, as is in the Humboldt National Forest.

2) The Humboldt National Forest has a total annual rainfall of between 4,500 and 5,000 mm, and a monthly average of 100 mm or more even in the dry season (April to October). In the northern and western Amazonian regions, annual rainfall is 2,000 - 2,500 mm, with monthly minimums of 100 mm or less during the longer dry season. In the case of Iquitos where it is relatively dry, the selected species have thrived, and so the model seems to be applicable.

3) Although there are no special topographical problems, the lower temperatures at the higher altitudes of the mountainous district to the west of the Andes are problematical. The model is applicable up to 800 m above sea level, ideally below 500 m. It is impossible to say whether it would work in the flat areas near the Amazon's tributaries, where the ground may flood severely during the rainy season.

4) Regarding soil distribution throughout the project site, Cambisol prevails in the hilly areas, Acrisol on the gentle slopes, and Gleysol over the flat areas. If information from sources other than this project is taken into account, it is

likely that Nitosol, Cambisol, and Vertisol will be found even in steep and well drained regions of Amazonia. However, there is not a large difference between these soils in terms of their fertility. On the gentle slopes, Acrisol or Ferralsol are expected to prevail and although Ferralso may be slightly less fertile than Acrisol, it is unlikely that there is a substantial difference between them. Most of the flat areas consist of Gleysol, which poses no problem. However, in regularly flooded areas, plants are very likely to be submerged even in Gleysol, and so it is difficult to apply this model.

5) The model is applicable to hilly areas, hot and humid zones, and places where Cambisol - Acrisol - Gleysol are found.

6) Although slightly less suitable, the following areas are possible candidates: the Andes vanguard district, the hilly district, the hot humid, and the hot wet zones as well as those areas where Nitosol and Ferralsol are distributed.

(5) Assumptions

1) Social Conditions

a) The government's land use policy will give equal or greater advantages to forestry development compared to the present level. Logging and export of timber will be possible.

b) Government regulations on foreign companies will benefit forestry development, notably they will be permitted to negotiate leaseholds and rents.

c) Political stability and security will be assured.

d) The general demand for timber and its various types will not change.

e) The market prices of useful species will not change markedly either in ranking or share. (See Table II-2-2.)

f) Labor will be available under similar or more favorable conditions than those currently applying.

g) Labor practices will be identical or further rationalized compared to the present.

2) Natural Conditions

a) The existing environment will be disturbed as little as possible. To this end, about 60 % of the whole area will be maintained as a reserve zone or buffer stand.

b) Seeds will be collected in the reserve-seed forests and the buffer stand.

c) Trees of useful species chosen for line planting which have reached a useful diameter, but from which seeds are not collected, will be felled and sold to cover expenses. Other trees will be left. Planted trees of a usable diameter will be selectively felled, while useful species in the reserve zone will be left.

d) On average, there is a useful species stock of about 30 m^3/ha. Approximately two thirds of this will be used as seed trees and bearers.

e) Bolaina will be used for boards when it reaches 20 cm or more in diameter (probably around 10 years), while Tornillo will be used for structural members when it reaches 35 - 40 cm in diameter (around 30 years).

f) In areas where Tornillo trees grow together, natural regeneration is cheaper and more efficient than artificial regeneration, so it will be facilitated in such areas. The range of regeneration will be within a circle of the same radius as the height of a tree.

Table II-2-2 Timber Price List in 1985

Species	Unit Price per m^3 (Inti)	Unit Price per m^3 (Yen)	
Caoba	3,816	48,400	Conversion
Cedro	3,180	40,300	17.35 Inti
Ishpingo	3,180	40,300	= 220 yen
Tornillo	1,866	23,700	
Copaiba	1,272	16,100	
Marupa	678	8,600	

(6) Reforestation Plan

1) Natural and Socio-economic Conditions in the Planned District

a) An annual rainfall of 3,000 mm or more is preferable.

b) Main streams will not back flow and stagnate during the rainy season.

c) Access to the district should be easy, ideally via road, although canals are acceptable in exceptional cases.

d) The district is within 200 km, or half a day's journey from the supply base.

e) There is abundant labor.

f) As shown in the appendix, an area of more alkaline soil is to be favoured as a location for the project. However, Tornillo

and Bolaina spp. are included in this project, areas of more acidic soil may also be suitable, though slightly less likely to be chosen. Thus, planting sites will be selected to include both more and less basic types of soils.

2) Study and Survey of the Selected District

a) The district will be officially demarcated in the presence of the relevant government agency to which application will be made for the use proposed. Simultaneously, a zoning map will be prepared.

b) Since aerial photographs are available in Peru, the location conditions will be assessed by aerial survey. It is recommended that a survey is conducted during the rainy season in order to know the condition of standing water.

c) The district will be divided into three zones. firstly, the zone with frequent undulations of between 20 and 50 m in altitude (C = Cambisol). Secondly, the zone consisting of gentle slopes of about 10 degrees (A = Acrisol), and thirdly, the flat zone (G = Gleysol).

d) Zone C consists of calcareous parent material, the topsoil is black, and the density of useful species is high.

e) Zone A consists of strongly acidic soil, and the topsoil is yellow or orange.

f) Zone G is liable to waterlogging, and the topsoil is white. Areas subject to long term waterlogging are separately classified as Zone G-2.

g) The distribution of Tornillo and Bolaina will be plotted on the map, and this will be used to determine suitable sites for seed collection and natural regeneration.

h) Based on the Tornillo distribution map, sites for natural regeneration will be chosen, then, a forest road network will be planned, and the annual planting of Tornillo and Bolaina will be laid out. (Planning forest roads will be discussed below.)

3) Determining Optimal Sites and Species

a) Zone C will be suitable for Mahogany and Copaiba, but not Tornillo or Bolaina.

b) Zone A is suitable for Tornillo, and an annual growth of about 2 m or more in height is expected in the first ten years. This soil is also suitable for Ishpingo and Cedro species.

c) Zone G is expected to be suitable for Bolaina species to grow well, at a rate of 2.5 m or more in height, and 2 cm or more in diameter per annum.

d) Although Zone G-2 can support Bolaina spp., it will not be used for planting sites, rather, as a buffer stand. Neither vigorous growth or high survival rates can realistically be expected from it.

e) The natural regeneration of Tornillo will be encouraged in places where at least several of these trees grow together.

4) Reforestation Plan

a) Zones A and G will be covered, while Zone C, if used, will be reserved as a buffer stand.

b) In both zones, sites to be used for natural regeneration of Tornillo will be demarcated, and the other sites will be divided using a unit scale of 100 ha taking into account the prospective forest road networks.

c) In each of the lots, 10 m wide planting sites will be mapped-out in an east-west direction. The reserve zone will be 20 m wide.

d) Double line planting will be adopted. The first line of trees will be planted 3 m from the southern edge of the clearing and the second line of trees 2 m away from the first line. The space between trees will be 5 m, and the two lines will zigzag. An average of 133 seedlings will be used per ha.

e) Specific plans for annual seedling production will be made according to the percentages of Zones A and G.

f) In land preparation, branches obstructing the planting will be taken to the reserve zones on both sides after cutting. In doing so, useful volunteer growth will be preserved. There will be no burning.

g) Planting points will be marked with sticks 1.5 m long prior to planting. This is required to improve the efficiency of weeding. There will be no planting underneath any useful species already present.

h) Planting holes will be dug with an iron-headed hoe, and replacement planting will be carried out in the case of less than 80% survival, after confirming the cause of mortality or damage if possible.

i) Regarding planting methods, Tornillo will be planted in pots, while Bolaina will be planted with bare roots.

j) As the trees reach their rotation ages, they will be felled properly, and replacements planted in the same way as originally. Trees will be felled as carefully as possible to minimize soil damage.

5) Tending Plan

a) Two types of weeding will be carried out: total weeding 10 m wide, and removal of climbers around the planted trees.

b) Weeds will be removed using the native hatchet, and weeding will be continued until the trees exceed 3 m in height, as previously planned. The frequency of weeding is not set, and weeds interfering with growth of the trees will be removed at any time.

c) Vines will be cut with a machete sporadically until the trees have grown to about 10 m in height.

d) If planted trees are starved of light as the surrounding preserved trees grow, shading trees or branches will be removed.

e) Tornillo and Bolaina species do not require pruning to improve their quality of growth as they are straight, and their branches naturally fall easily.

f) Although thinning is generally unnecessary due to the large planting space, one improvement cutting will be carried out until the harvesting season.

g) Concerning Tornillo species, weeding and trimming in the reserve zones will be carried out carefully because Tornillo may suffer canker due to Fusarium if its bark is damaged.

6) Managing Natural Regeneration

a) Although Tornillo seeds can naturally scatter further, they will be sown within a radius equal to the tree's height in view of risk rates; i.e., a radius of around 50 m per tree will be covered. For example, in the case of 13 seed trees, about 2 ha of natural regeneration was successful.

b) Surface raking will be carried out before fruiting and seed droppage. The method is to clear all ground plants that can be cut with a machete.

c) Canopy trees will be cut out in order to control light reception when a few main leaves have sprouted.

d) Canopy trees include both trees consisting of a crown, and trees below them. Trees having a crown will be cut to allow over 50% of the total light to reach the forest floor. As a rule, all mid-layer trees will be cleared, but see Item e).

e) Those trees constituting a crown, which are currently regarded as useful will be largely preserved. Among the mid-layer trees, useful species such as Tornillo, Caoba, Cedro, Estoraque, Ishpingo, Huayruro, Pumaquiro, will also be kept.

f) Saplings will be cut out when they have grown about 30 cm. They will be cut out from time to time until they have reached 3 m high.

g) When saplings have grown about 2 m, they will be clipped over their entire height if they are very dense. Extra care must be taken of Tornillo, because excessive density arrests growth in height and diameter.

h) In cleaning-cutting, care must be taken not to damage the remaining small saplings, otherwise they may become infected by Fusarium fungus.

i) After thinning, about 500 trees per ha will remain.

j) Thinned trees will be used as required, even when their diameters are still small.

7) Other Instructions

a) The Cambisol areas will be reserved for planting Caoba trees which are the most valuable in Amazonia. Hypsipyla grandella will inevitably occur and so must be controlled with chemical sprays used according to the manual.

b) Useful species covered by the project which grow en masse especially Tornillo and Bolaina should not be cut because they are required for collecting the seeds used for both natural and artificial regeneration. However, they may be felled and used for raising initial funds, or as construction timber for bridges and project facilities if they obstruct roads or artificial regeneration areas. Otherwise they should be conserved whenever possible.

(7) Seedling Production Plan

1) Seed Collection Plan

a) Since it is extremely difficult to purchase seeds, a plan for our own seed collection scheme should be established.

b) Mother trees for seed collection will be chosen, as many as possible due to possible variations in the fruiting cycles of the various trees.

c) The distribution of the mother trees will be mapped.

d) Mother trees will be regularly checked; for the criteria of seed maturity, see the nursery standards section.

e) Although seeds will generally be collected by climbing the trees, they can also be gathered by shaking the branches using fishing line or rope weighted with ball-bearings. The mature seeds would tend to fall.

f) Since Tornillo seeds cannot be stored, they must be sown immediately after collection, while Balaina seeds can be stored at low temperatures, and seeds selected as required. See the nursery standards for methods of selection.

2) Nursery Development Plan

a) A nursery garden will be established in a well drained place easy to manage, and should be an area large enough for 20,000 seedlings.

b) The nursery beds should be 1 m wide, and must be shaded in some way.

c) To ensure efficient drainage, porous materials such as gravel and charcoal must be used for the foundations.

d) The beds should be raised to a height of 30 cm, an east-west orientation being extremely important.

e) A watering device must be installed, to enable seedlings to be watered once a day, care being taken not to over-water, which results in root rot.

f) Soil for the bed should be an equal mixture of topsoil, sand, and fowl dropping/chaff.

3) Seedling Production Plan

a) Nursery beds composed of germination soil will be used as seedbeds.

b) Seeds will be sown at intervals of about 5 cm, and covered with sand.

c) Watering will be adjusted to prevent the germination bed from drying out.

d) The sprouted seeds will be transplanted into the seedling bed when a few main leaves have emerged. They are planted at a density of 7 x 7 per m^2.

e) The seedlings will be watered to prevent the bed drying out, and weeding will be carried out as required.

f) Tornillo seedlings will be transplanted into 8 cm diameter plastic pots using the same soil, when they have grown to about 20 cm in height.

g) Pesticides or germicides will be sprayed if diseases or insect damage occur. Notably, diseases may be encouraged by excessive watering.

h) The seedlings will be planted out when they have grown to 50 cm in height. Tornillo seedlings generally being planted in

their pots, while Bolaina seedlings generally be planted with bare roots.

i) It is recommended that planting is carried out around four months before or after January to avoid the rainy season.

(8) Road Construction and Management Plan

1) Road Network Plan

a) Areas which flood during the rainy season will be avoided by considering the geology and rainfall of the area.

b) Two types of forest roads will be constructed; main roads and auxiliary access roads. The former will be used all year round, while the latter will be mainly used during the dry season.

c) A network of roads will be established so that forest operations can be carried out within an average distance of 250m from a road. Side paths will also be provided where required.

d) Measures should be taken to prevent trespassing, in compliance with the Peruvian Government.

e) The fragile geological condition of the project site should be taken into consideration when constructing bridges.

2) Road Construction Plan

a) In view of the local conditions, sites will be classified as swamp, plain, or slope. While extra care must be taken of drainage in marshy areas, the other two will also require adequate drainage.

b) Bridge construction should be kept to a minimum due to the fragile geological conditions; instead, Hume concrete pipes, corrugated pipes, and culverts made of local materials should be used in preference.

c) Since gravel is not easily available, and therefore expensive, substitute materials should be considered.

3) Road Maintenance Plan

a) Since rainfall may reach 200 mm a day during the rainy season, it is likely that the ground will be almost entirely waterlogged at this time of the year.

b) Therefore regulations on the use of both main and access roads should be established.

c) Usage will be determined by considering the drainage of the cleared areas on either side of the roads, which aid road

drying, and the dryness of the gravel or gravel substitute foundations of the road.

d) Riverbanks are likely to be eroded as the water level rises during the rainy season. To protect bridges, it is necessary to reinforce them with sheet piles and sandbags.

(9) Facilities Plan

1) Principle

It is unrealistic to find a site 20 km wide in undeveloped Amazonia where administrative, financial and medical facilities are provided, and to which people living in a nearby city (Pucallpa in this project) could commute on a daily basis.

Therefore, we decided to search for a reforestation site within 200 km by car of a regional city, while planning a site office with facilities and machinery. The city office would have the function of negotiation with government agencies and financial institutions, as well as purchasing essential supplies for the site.

2) Field Office

An office will be set up along the road close to the reforestation site.

In the Amazonian region, there are small villages 20 - 30 km apart, linked by small roads. Although they have elementary schools, restaurants, and general shops, an infrastructure including electricity, water supply, communications, regular transportation and medical care is barely present. Therefore, to set up an office, it was necessary to develop our own infrastructure.

Due to the lack of local skilled workers, it was unavoidable that approximately one third of the staff and workers came from regions other than the site. Accordingly, it was important for the site office to provide accommodation and transportation to and from urban areas.

Hence, both vehicle repair facilities and garaging were needed as well as the administrative office and its facilities. A children's nursery was also required. Obviously, efficient electricity and water supplies, plus a communications network were essential.

3) Urban Office

A liaison office was set up in the regional city to provide support for the site office in the following ways: Administration of receipts and expenses in connection with financing; licenses and permission from government agencies; insurance; the treatment of injuries at medical facilities; the

organization of the project; personnel management and welfare; purchasing of supplies; machinery repair, plus contact and coordination with the headquarters.

Facilities relating to the headquarters will not be included in this model.

4) Planning Facilities including Buildings and Machinery

See Tables II-2-3 and II-2-4.

(10) Personnel Plan

In implementing this project, the main operations such as seedling production, planting and forest road construction were generally performed by direct employees, while the construction of facilities, including buildings, was contracted out. Based on this principle, the project was organized as shown in Fig. II-2-1, and the personnel were assigned.

In recruiting personnel, the number of workers required was determined by dividing the number of men by the expected length of each job stage, assuming 221 working days per year (Note 1).*

Note 1: The formula of the assumed annual working days

$$365 \text{ days/year} - \{30 \text{ days} + (52 \text{ days} \times 2 \times \frac{365-30}{365}) +$$

paid holidays; Saturdays/Sundays

$$(12 \times \frac{365-52\times2}{365}) + 10\} = 221 \text{ days/year}$$

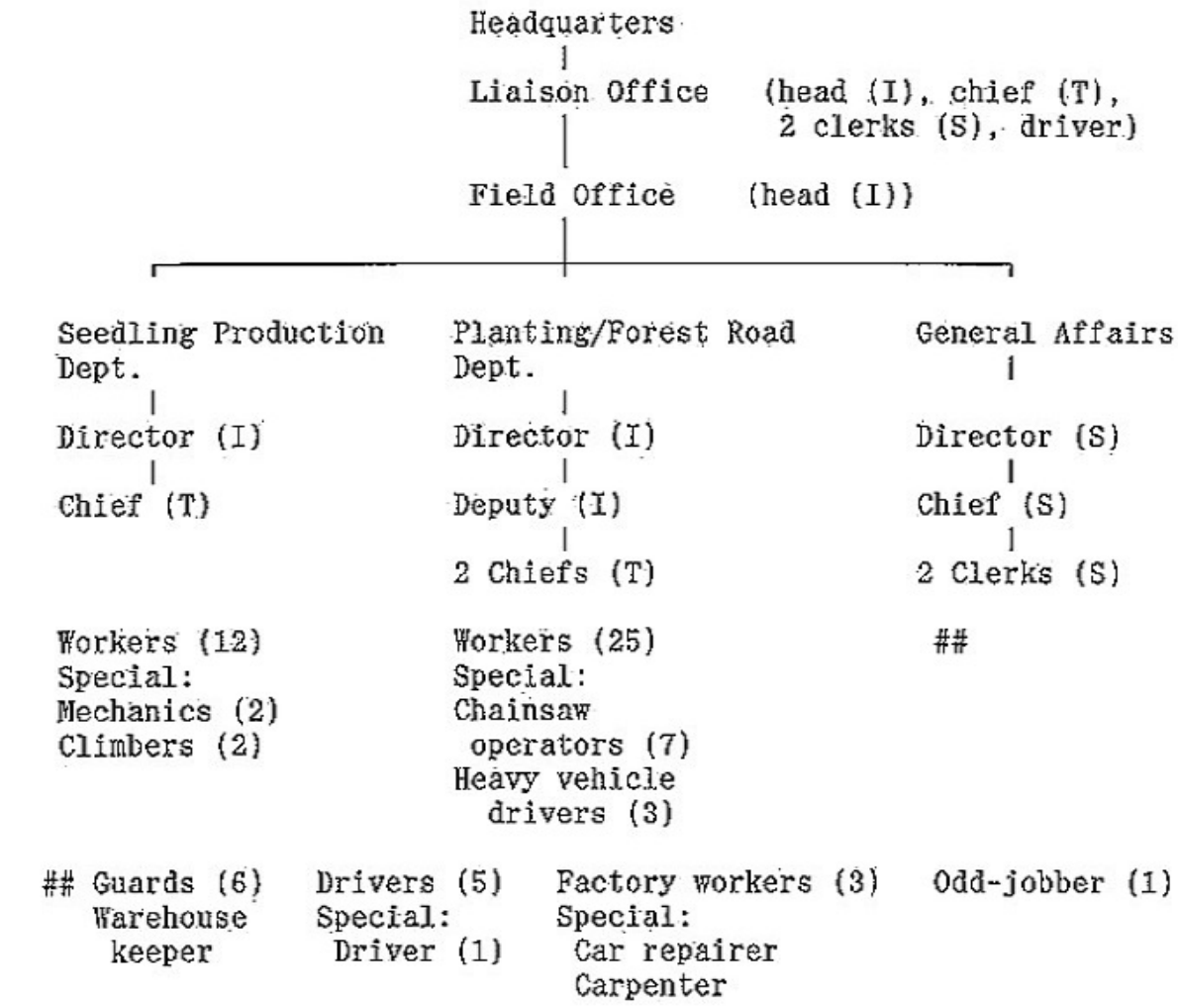
holidays; sick leave, etc.

* The number of administrative personnel was calculated based on the assumption that they would be normally given 30 paid days leave a year plus Saturdays and Sundays off while in Peru.

Annual personnel expenses for each job were determined from a base figure of 100 for general workers' expenses, points being added to this according to additional qualifications, namely 100 points for engineers (I), 50 points for technicians (T), and 20 points for high school graduates (S). In the case of administrative staff, 100 points would be added for the office head, 50 points for directors, and 30 points for deputies and chiefs. In addition, 50 points would be given to Special 1, and 30 points to Special 2.

In compliance with these requirements and the specific annual program shown in Table II - 2 - 5, the number of personnel and their expenses were determined as shown in Table II-2-6.

Fig. II-2-1 Organization Chart



Notes: 1) The figure in brackets is the number of workers.

2) I stands for engineers (university graduates), T for technicians (with professional education), S for clerical workers (high school graduates), and Special for possessing technical skills. Each of these represents standards required for employment.

3) The staff consists of fifteen members i.e., two heads, three directors, one deputy, five chiefs, and five clerks.

4) The line consists of fifty-three members i.e., thirty-seven workers and sixteen other administrative workers.

Table II-2-3 Facilities including Buildings

Category	Subcategory	Name	Q'ty	Unit	Unit Price	Value	Year of Construction	Remarks
Operation	Seedling production	Nursery garden		m^2			1	Permanent
		Seed selection lot	80	m^2			1	3)
		Seed storage	32	m^2			1	1)
		Warehouse	64	m^2			1	2)
		Bed soil yard	80	m^2			1	3)
		Soil preparation yard	75	m^2			1	3)
		Workshop	64	m^2			1	3)
		Office	80	m^2			1	including a seed laboratory 1)
		Water tank	1	unit			1	wooden
		Meteorological observatory	24	m^2			2	Permanent
		Washroom	9	m^2			1	
	Planting	Warehouse	24	m^2			1	administrative building 2)
		Office	45	m^2			1	administrative building 1)
Administration	Main site office	Room (head)	24	m^2			1	1)
		Room (general affairs I)	48	m^2			1	reception, general affairs 1)
		Room (general affairs II)	20	m^2			1	accounting 1)
		Washroom	16	m^2			1	1)
		Document room	15	m^2			1	copier 1)
		Meeting room	40	m^2			1	12 - 13 persons 1)
		Resting room	20	m^2			1	including a clinic 1)
		Dining room	120	m^2			1	including a lounge 1)
		Kitchen	20	m^2			1	1)
		Washroom	20	m^2			1	1)
		Equipment storage	120	m^2			1	2)

Category	Subcategory	Name	Q'ty	Unit	Unit Price	Value	Year of Construction	Remarks
Administration	Main site office	Materials storage	120	m^2			2	timber, etc. 3)
		Workshop	144	m^2			1	repairs, woodworking 3)
		Fuel storage	20	m^2			1	gasoline, light oil 2)
		Power plant	56	m^2			1	1)
		Electric wire		m			1	including ones for lodgings
		Well	1	unit			1	
		Water tank	1	unit			1	concrete, permanent
		Waterworks		m			1	including ones for lodgings
		Sewerage		m			1	including one for lodgings
		Car washing lot	1	unit			1	permanent
		Guard's hut	6	m^2			1	including a gate 2)
		Fence	100	m			1	
		Garage	218	m^2			2	10 cars 3)
	Accommodations on the site	Family lodgings (head)	1	building			2	70 m^2 1)
		Family lodgings (personnel)	4	buildings			2	50 m^2 1)
		Training lodgings (personnel)	1	building			1	1)
		Training lodgings (workers)	1	building			1	1)
		Guest lodgings	1	building			2	including a small meeting room 1)
		Athletic facilities		m^2			2	outdoor cooking facilities volleyball, recreation area

Category	Subcategory	Name	Q'ty	Unit	Unit Price	Value	Year of Construction	Remarks
Administration	City office	Room (head)	24	m^2			1	1)
		Room (clerical work)	30	m^2			1	1)
		Washroom		m^2			1	1)
		Document room	9	m^2			1	1)
		Warehouse	15	m^2			1	2)
	City accommodation	Family (head)	1	building			2	$70m^2$ 1)
		Family (personnel)	1	building			2	$50m^2$ 1)
		Training lodgings (site personnel)	1	building			3	$50m^2$ 1)

Notes 1) Building specifications are graded by unit cost of construction 1), 2), and 3) in descending order.
2) Lifespan is 20 years except if "permanent".

Table II-2-4 Machinery

Category	Subcategory	Name	Q'ty	Unit	Unit Price	Value	Year of installation	Dura-tion	Remarks
Operation	Seedling Production	Small truck	1	unit			1	5	4 WD
		Small jeep	1	unit			2	5	
		Tractor	1	unit			1	10	with a trailer
		Sprinkler	1	set			1	10	
		Meteorological instrument	1	set			1	10	thermometer, hygrometer, udometer
		Refrigerator	2	units			2	20	thermostat
	Planting	Bulldozer 11t	1	unit			1	10	
		Shoveldozer 11t	1	unit			1	10	
		Medium dump car 6t	1	unit			1	5	also used for transporting personnel
		Small dump car 2t	1	unit			2	5	also used for transporting personnel
		Small truck	2	units			1 or 2	5	
Administ-ration	Site office	Jeep	1	unit			1	5	
		Small truck 2t	1	unit			1	5	
		Short-wave radio	1	unit			1	10	including antenna
		Generator 3.40 kw	2	units			1 or 2	10	
		Copier	1	unit			1	5	
		Personal computer	1	set			1	10	with a stabilizer
		Air compressor	1	unit			1	10	
		Oxy-acetylene welder	1	set			2	10	
		Sawbench	1	unit			1	10	round saw
	City office	Van/passenger car	1	unit			1	5	
		Short-wave radio	1	unit			1	10	including antenna

Table II-2-5 Annual Work Schedule

Work Name	Code	Item	Unit	1st Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Work Amount Man/work Personnel Cost Expenses on Goods and Service																
		Total Expenses																
		Work Amount Man/work Personnel Cost Expenses on Goods and Service																
		Total Expenses																
		Work Amount Man/work Personnel Cost Expenses on Goods and Service																
		Total Expenses																
		Work Amount Man/work Personnel Cost Expenses on Goods and Service																
		Total Expenses																

Table II-2-6 Annual Number and Costs of Personnel

		Item	1st Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Head		Number	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		Cost	( )																
Director		Number	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
		Cost	( )																
Deputy		Number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Cost																	
Chief		Number	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
		Cost	( )																
Clerk		Number	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		Cost	( )																
Other Administrative Personnel	Car mechanic Special 1	Number	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
		Cost																	
	Car mechanic Special 2	Number	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
		Cost	( )																
	General	Number	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
		Cost	( )																
Worker	Seedling production	Man/work No. of Personnel Cost																	
	Planting and forest road	Man/work No. of Personnel Cost																	
Total		Personnel																	
		Cost																	

Note: The figures in parentheses show annual personnel costs per person.

(11) Financial Plan

1) Principle

The financial year runs from January to December, budgeting being performed on an annual basis (Table II-2-7).

Due to the instability of the local currency, US dollars will be used as an index.

In budgeting, differences between revenue and expenditure were covered by loans (annual interest %; deferment years; redemption in the year of).

2) Expenditure Plan

Expenses were divided into business and administrative costs, which were then subdivided into the costs of facilities, machinery, personnel, goods, and services.

Facilities were constructed and machinery purchased at a steady pace so that seedling production and land preparation could be carried out in the second year, and planting could be carried out in the third year (Table II-2-8).

3) Revenue Plan

Assuming that trees will be planted in the existing natural forests, profits are expected from felling commercial species in the forests. In the case of artificial regeneration areas, trees standing in the prospective 10 m wide plots at the time of the initial land preparation, and the trees in the reserve zones at the time of the first felling will be cut out. Trees standing along the forest road routes were cut at the time of road construction.

Half the commercial species standing in natural regeneration areas for Tornillo were cut at the time of light reception control, and the second half (except seed trees) will be cut at the time of felling the Tornillo trees.

In the tended tree plots (including natural regeneration areas), wood volume will be determined by setting the rotation ages of Bolaina and Tornillo at 10 years and 30 years respectively, and revenues will be estimated by multiplying the volume by the current stumpage (Table II-2-9). For your reference, estimates based on the current growth will be attached.

(Y. Ohsumi and H. Koike)

Table II-2-7 Annual Financial Schedule

		1st year	2	3	4	5	6	7	8	9	0	Remarks
Expense	A											
Revenue	B											
Profit (A - B)	C											
Loan	C											
Balance (ΣC)	D											
Annual interest (D×0.0x)	E											
Balance of interest (ΣE)	F											
Compound interest (F×0.0x)	G											
Principal and interest (D+E+F+G)	H											
Redemption	C											
Balance of redemption (ΣH+ΣC)	I											

Table II-2-8 Annual Expenditure Schedule

		Item	1st year	2	3	4	5	6	7	8	9	0	Remarks
Operation	Seedling production	[illegible]											
	Planting	Facilities Machinery Personnel Goods/services Subtotal											
	Total	Facilities Machinery Personnel Goods/services Subtotal											
Administration		Facilities Machinery Personnel Goods/services Subtotal											
Total		Facilities Machinery Personnel Goods/services Subtotal											

Table II-2-9 Annual Revenue Schedule

			1st year	2	3	4	5	6	7	8	9	0	Remarks
Natural Forest	Artificial reforestation site	Area ha Volume m^3 Revenue											
	Tornillo natural regeneration site	Area ha Volume m^3 Revenue											
	Forest road routes	Area ha Volume m^3 Revenue											
	Reserve zone	Area ha Volume m^3 Revenue											
Man-made Forest	Bolaina	Area ha Volume m^3 Revenue											
	Tornillo	Area ha Volume m^3 Revenue											
Total		Revenue											

[Appendix I]

Projections of Tornillo Growth Rate and Gross Revenue per Unit Area

Height: 0.5m/y x 2y 2.0m/y x 10y 1.0m/y x 10y 0.5m/y x 8y = 35m
DBH: 0cm x 2y 1.2cm/y x 10y 1.8cm/y x 10y 1.2cm/y x 8y = 39.6cm
Projected volume: = 2.2 m3
No. of trees: 10 wide line planting with a reserved line = 67 pieces/ha
Volume per ha: = 147 m3
Projected sales: ¥23,700/m3 = ¥3.484 mil.

Projections of Bolaina Growth Rate and Gross Revenue per Unit Area

Height: 1.0 m/y x 2y 2.6 m/y x 6y 2.0 m/y x 2y = 22 m
DBH: 0.0cm x 2y 3.0 cm/y x 6y 2.5 cm/y x 2y = 23 cm
Projected volume: = 0.46 m3
No. of trees: 10 wide line planting with one and half lines reserved = 100
Volume per ha: = 46 m3
Projected sales: ¥8,000/m3 = ¥368,000

Basic data for the foregoing calculations will be shown in "Data for the Appendix" and "Growth Data as a Basis for Calculation" below.

[Data for the Appendix]

1) Growth Rate
Tornillo: Data on Blocks 1, 21, 22 and 101
Bolaina: Data on Blocks 3 and 9, and the model forest

2) Projected Volume $r^2 \times 3.14 \times h \times 0.50$

3) No. of Trees just projection

4) Value Koike's data in the interim report

[Growth Data as a Basis for Calculation]

The first year of planting was excluded. Concerning natural regeneration, data on trees one meter or over were used. The informaiton was derived from the 1985 work surveillance report and the reforestation standard drafted by Sato.

Tornillo

<Growth in Height>		Base Year	1 Year After	Differential	
5 m	Block 1	93.7	228	+134 cm	
	Block 1	177	404	+227	
	Block 12	69.3	241	+172	
10 m	Block 21	92	337	+245	2-3 years after (a new system for this block, highly reliable)
	Block 21	337	661	+324	3-4 years after
30 m	Block 2	48.2 (0)	78	+ 30	(0) represents data in the first year.
	Block 9	72 (0)	128	+ 56	
Natural regeneration (C4)		186	341	+155	2-3 years after
"		956	1,250	+294	5-6 years after
"		1,250	1,365	+115	6-7 years after
Natural regeneration (R3)		720	1,092	+372	4-5 years after
"		1,092	1,350	+258	5-6 years after
"		1,350	1,583	+233	6-7 years after

<Growth in Diameter>

Natural regeneration (C4)	6.9	7.9	+1.0
"	7.9	9.4	+1.5
Natural regeneration (R3)	8.6	10.1	+1.5
"	10.1	11.8	+1.7

Bolaina Blanca

<Growth in Height>		(Growth in Diameter: figures in brackets are data on 0.5 year X 2)			
5 m	Block 1	196	404	+208	(2.0 cm)/y
10 m	Block 3	208	436	+228	(3.4 cm)/y
	Block 21	228	488	+260	
		488	732	+244	
30 m	Block 9	274	589	+315	3.0 cm/y
Model forest		185	455	+270	(6.6 cm)/y

3. Silvicultural Manual for Peru-Amazonia

(1) Purpose and Outline

Recent global economic expansion and rapid increase in population have led to forests being used not only for timber production, but also for other purposes such as agriculture. This is mainly in the developing countries. As a result, tropical forests have been severely damaged and their areas reduced extremely rapidly. According to recent FAO statistics, tropical forests are lost at a rate of 11.3 million ha a year. This not only has a strong effect on the local economy and environment but also a direct relationship with environmental fluctuations on a global scale.

In response to this, both the developing and developed countries have made efforts to establish social and technological systems which focus on the sustainable development of tropical rain forests. The reforestation project for which this manual has been prepared is based on the principle of "sustainable timber production in harmony with the natural environment and ecology", and anticipates a global tendency towards this type of forestry. It aims particularly at technological development applicable to the Amazonian forests.

This project was launched by the Japanese (JICA) and Peruvian Governments (Agriculture Ministry, presently INIAA, formerly INFOR). The original plan was to continue it for ten years from 1981 through 1991. Unfortunately, due to local circumstances, data was actually collected after eight years.

Nevertheless, resulting from the efforts of many Japanese and Peruvian experts and technical groups over the eight years, a model for environmentally friendly forestry in Peru-Amazonia has been developed. It includes novel natural regeneration techniques. This has formerly been regarded as being virtually impossible and anyhow inefficient.

In order to promote the development of commercial forestry while maintaining the natural environment, the large-area clear cutting and planting system could not be adopted, although it is used for softwood reforestation in Japan and other advanced countries. Accordingly, a system was needed to make forestry attractive, while simultaneously preserving existing forests to a certain extent. This includes both natural regeneration and line planting. Moreover, in order to strengthen relationships with the local economy, it is appropriate to select useful species not used as fuelwood by local people for sawlog production. Conversely, line planting of local species has not always achieved excellent results, though the FAO and other organizations have attempted it in many regions. There have been few successful attempts of natural regeneration of useful sawtimber species reported.

During this project, we concentrated on both artificial regeneration by line planting, and the natural regeneration of specific species, based on the past experience of FAO and other previous studies. In addition, we also investigated the possibility of simultaneous

artificial regeneration in former area of agroforestry, subsequently abandoned as useless land. As a result, we reached various conclusions relating to reforestation and sylvicultural techniques.

Resulting from our researches, information probably applicable to the whole of Amazonia was obtained, and compiled a starter manual of sustainable forestry. Due to the slow growth of trees, data collected over only eight years is insufficient to provide full and accurate information on them throughout their cultivation. However, we believe that this manual does provide accurate information on general procedures from the early to the mid stage of cultivation. The users of this manual are requested to take that into consideration. For much of the basic data, see various specialists' reports as well as the 1988 interim report.

This manual consists of six sections; Site Selection, Seed Collection, Seed Treatment, Nursery, Planting Standards, and Planting Operations. For your reference, the account books used throughout this project are attached.

Finally, we should like to note that this manual's authors are the last long-term experts specializing in each of the sections except Site Selection. Every section was compiled using the results of studies by various Peruvian and Japanese experts over the entire period of the project.

(Y. Ohsumi)

(2) Site Classification

Introduction

In Peru as well as Japan, the growth of trees varies depending on site conditions. In Japan, where plantations have been widespread for many years, knowledges of soil and environmental conditions can allow accurate predictions of growth rates of trees at a time of harvesting. In Amazonia, where there are few man-made forests, the growth rates cannot be estimated in this way, and this estimations are insufficient to make growth forecasts due to the variety of reforestation species. However, the early growth rates allow some prediction of the size of trees up to the felling year. Judging from the projections based on data by the project so far, there is a very close relationship between local conditions and growth rates. Soil conditions are especially important, and analysis of the natural distributions of useful species showed that specific soil types were preferred by different trees.

In this section, the various soil conditions will be outlined, and the differing species' requirements noted. Concerning the latter, it should be noted that it is based on limited data, and requires further research.

(1) The Soils of Amazonia; a Simple Judging Method

Soils will be classified using FAO's method. According to this, the main types of fertile soil in Amazonia are the following.

Please note that each main category has several sub-categories details of which are omitted here.

Soils were surveyed to a depth of 125 cm. For further details, see the various references.

a) Nitosol

This has less clay in the topsoil than the lower layer within the range of 20%, and appears in well-drained areas near the Andes. It has the following subunits: basic Eutric Nitosol, and less basic Dystric Nitosol.

b) Cambisol

Characterized by the absence of distinctive features, this soil resembles a brown forest soil in Japan, and is most widely distributed in hilly areas with less movement of clay. Most well drained slopes are of this soil, whose colour ranges from red to black. It has the following subunits:

Eutric Cambisol; relatively high base saturation of 50% or more, Dystric Cambisol; having a base saturation less than 50%, Gleyic Cambisol; having a grayish deeper layer affected by water, Calcic Cambisol; having powdery calcium, Chromic Cambisol; relatively common and having a brown and reddish deeper layer, Vertic Cambisol; widely distributed and having a dark grey topsoil prone to make cracking when dry, Ferralic Cambisol; expected to be common in the northern and western regions, having a topsoil with a low base exchange capacity.

c) Vertisol

This soil exists in calcareous areas and has a black and less reddish clayey topsoil, prone to crack as widely as 1 cm or more when dry hence attention should be paid to the shape of wedges appeared in this soil. It occurs in relatively well-drained areas, being distributed near the Andes in Peru. It is fertile for ordinary plants, and has the following subunits: Pellic Vertisol with dark topsoil, and Chromic Vertisol with light topsoil. These are distinguishable by the chroma of wet soil; less than 1.5 for the former, 1.5 or over for the latter.

d) Acrisol

Soil is strongly acidic, with sandy topsoil and a clayey deeper horizon. It is often light red in color and is extensively distributed in well-drained areas, namely gentle slopes. It has the following subunits:

Orthic Acrisol with light red topsoil; Ferric Acrisol with light reddish spots; widely occurring Plinthic Acrisol having a red and white spotted pattern in the deeper layer; and relatively common Gleyic Acrisol having a topsoil whitened by water.

e) Ferralsol

Soil is poor in nutrient owing to extreme weathering, and has a very low base exchangeable capacity. It is not a fertile soil, being extensively distributed throughout the well-drained hilly areas of the northern and western regions. It is slightly less fertile than Acrisol, and has the following subunits.

Xanthic Ferralsol; bright yellow with color value of 4 or more and a chroma of 5 or more when wet, Rhodic Ferralsol being bright red, more so than 5 YR and with value of under 4, Orthic Ferralsol being of other colors, Acric Ferralsol with an extremely low base exchange capacity, and Plinthic Ferralsol with a red and white spotted in the lower layer.

f) Gleysol

This type of soil is affected by water saturation in the topsoil, which is usually grayish, and is otherwise characterized by a white or light blue color resulting from the reduction of iron due to a shortage of oxygen. Orange spots of iron oxides or a mass of black manganese may be present in some cases. It is likely to be waterlogged in the rainy season, and typically appears in poorly-drained concave or flat areas. It has the following subunits.

Eutric Gleysol having high base saturation, Calcic Gleysol containing a powdery calcium, Dystric Gleysol having low base saturation, Mollic Gleysol containing more bases and organic matter in the topsoil, Histic Gleysol with a peat-like organic topsoil, Plinthic Gleysol with a red or orange and white spotted layer within a depth of 1.3 m. This soil is very common in the areas near rivers and flat areas may be expected to consist of it.

g) Fluvisol

Soil originates from recent deposits, having different materials in each of layers. Accordingly, it often appears in frequently flooded areas near rivers and lakes. It has the following subunits:

Eutric Fluvisol having high base saturation, Calcic Fluvisol with soft powdery lime, Dystric Fluvisol having low base saturation, and Thionic Fluvisol containing sulfidic material.

The characteristics of the main soils appearing in the project site are summarized in Table II-3-1.

(2) Relationships between the Initial Growth of Useful Species and Site Conditions

The detailed analysis of these relationships for the artificial regeneration species are summarized in the monograph. Here, the relationships between growth rates of the useful species and the

soil conditions and light intensity of the locations will be described. Caoba and Cedro, the most important species, have been attacked by Hypsipyla, which has made the analysis difficult. In the trial plot where Cedro trees were planted in 1983, Gleysol has proved superior to Acrisol in promoting their growth. Caoba trees have also grown relatively well in their early stages in Cambisol and Gleysol, but not in Acrisol.

a) Tornillo: The initial growth is good in both Acrisol and Chromic Cambisol of similar fertility to Acrisol. Planting in Gleysol cannot be recommended.

b) Ishpingo: This is adaptable to Acrisol and Cambisol, but not to Gleysol. This species is suitable for narrow line planting.

c) Azucar Huayo: This is adaptable to Acrisol, and should be planted with bare roots.

d) Copaiba Negra: This is adaptable to Acrisol; initial growth is poor in Gleysol and Cambisol.

e) Paro Sangre Amarillo: This species prefers Acrisol, Cambisol is also suitable, while Gleysol is unsuitable. This species requires much light.

f) Bolaina Blanca: This requires strong light intensity, and while preferring Cambisol, will adapt to Gleysol. It can be expected to grow 10 m or more in height in five years.

g) Bolaina Negra: Like the previous species, this requires a great deal of light, and grows well in Gleysol. Acrisol and Cambisol are unsuitable.

h) Marupa: This adapts to Acrisol and Gleysol, but not to Cambisol. It should be planted with bare roots.

(3) Natural Distribution of Useful Species Related to Soil Types

The natural distribution of plants obviously reflects their soil requirements, and therefore, data on this is extremely useful for the selection of sites suitable for the useful species where the suitable sites cannot be fully defined. Although confined to the project site, these data will be used to select optimal species related to soil type, in combination with data on early growth in relation to soil and light requirements as shown in 2) above.

a) Vertic Cambisol: This has a high base concentration and rich in nutrient. Caoba and Copaiba grow vigorously, and Yacushapana, Estraque, Huayruro and Lagarto Caspi grow typically.

b) Chromic Cambisol: This has reasonable base levels and high nutrient retention. Although the accuracy of data is low due to its limited distribution, Ishpingo, Tornillo and Cedro species grow relatively well.

c) Gleyic Cambisol: The surface is deoxidized due to periodical water-logging, and its relationships with useful species are unknown because of its limited distribution.

d) Plinthic Acrisol: This is a strongly acidic soil, having a poor retention of nutrients. Tornillo grows very densely, while Ishpingo and Cedro grow relatively densely. Moena and Cumala also grow well.

e) Plinthic Gleysol: This has a relatively high concentration of bases, and retains its bases more than Acrisol. However, it is prone to water saturation in the rainy season and hence oxygen starved. It has few relationships with the main species, of which only a few such as Lupuna are found.

(K. Kawamuro, Y. Ohsumi and A. Castillo)

Table II-3-1 Characteristic Soil Properties in the Project Site

Soil	Horizon	pH	Carbon (%)	Nitrogen (%)	Mn (ppm)	CEC (meq)	Basic Saturation (%)	Texture	Clay Mineral
vertic Cambisol	A	6.4	4.4	0.40	543	43	100 %	Heavy clay soil	Main: smectite Accessory: kaoline mineral
	B	8.1	0.3	0.05	350	29	100 or more	Heavy clay soil	See the above
gleyic Cambisol	Ag	6.1	4.2	0.38	482	nd	nd	Light clay soil	Main: smectite Accessory: kaoline mineral
	B	5.2	0.5	0.07	40	nd	nd	Heavy clay soil	See the above
plinthic Acrisol	A	3.6	1.2	0.12	10	7.1	3.4	Sandy loam	Main: kaoline mineral Accessory: mica
	B	4.3	0.4	0.06	0	11.4	1.2	Light clay soil	See the above
plinthic Gleysol	Ag	5.5	2.7	0.27	230	15.1	79	Sandy clay loam	Main: smectite Accessory: mica
	B	4.8	0.5	0.09	36	19.6	31	Light clay soil	Main: smectite Accessory: kaoline mineral

(3) Artificial Regeneration

(1) Seed

In most cases of present tropical reforestation, fast growing exotic species such as Pinus, Acacia, and Eucalyptus have been introduced. There have been few cases of artificially regenerating indigenous useful hardwoods because of the difficulty in collecting the seeds.

It is due to that the flowering and fruiting habits of the hardwoods have not been sufficiently clarified as well as to the difficulty in finding seed bearing trees in local forests to collect mature seeds from them at the right time. Especially for industrial-scale reforestation, seed supply is the most critical problem; and even in case of natural regeneration, it is essential to forecast the cycles of good harvest and the harvesting time for the mature seeds of the species. To this end, it is necessary to clarify flowering and fruiting habits of every species by observing mother trees. Since observation of mother trees should last long in order to recognize the tendency of flowering and fruiting habits correctly, the continuity of operation is highly important. Therefore, it is vital to determine seed collecting forest, operation area, number of mother trees, frequency of observation, management of mother trees in accordance with personnel, budget and other conditions available.

1) Selection and Management of Mother Trees

i) Selection of Mother Trees

The following points should be taken into consideration on selecting mother trees:

(1) Species to be selected as mother trees should be those which are or would be potentially valuable timber, or which sap and/or fruits (seeds) are useful as raw material for industrial production.

(2) Areas where multiple tree species grow collectively should be designated as seed-collecting forests.

(3) Stands from which mother trees are selected should be close to the base of activities, unlikely to be interfered with (e.g. by shifting cultivation), and accessible by road and foot path throughout the year.

(4) At least five mother trees are required for each species, because flowering and fruiting habits may vary a lot from one tree to another even if they were the same species in the same area. Moreover, in order to avoid low accuracy of data due to the loss of mother trees caused by miscutting or illegal cutting, it is recommendable to determine as many mother trees as are manageable.

(5) Mother trees should meet the following requirements: a DBH of 50 cm or more, a long straight trunk below the branches, a strongly spreading crown, which is entirely in view, a middle-aged and easy access by foot path.

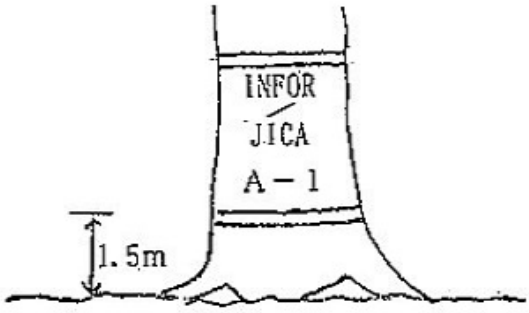
ii) Management of Mother Trees

The following procedures are required for managing mother trees.

(1) It is necessary to make a mother tree register to record tree numbers, species, DBHs, heights, locations, selection dates, and conclusions from observations. Scientific name of the corresponding species should be confirmed and identified.

(2) Surveys will be conducted at the peripheries of the seed collecting forests, and a 50 m wide boundary will be cleared around each area, and signs saying "Seed collecting forests" will be built at several points in order to make clear that it is the operation area.

(3) The selected mother trees will be marked with the name of the agency and tree number with bright color paint at a certain height of the trunk (see the following illustration), and the distribution chart of mother trees within the forests should be made after surveying the position of each mother tree.



(4) The trees will be observed biweekly (at least monthly) because irregular observation will produce less reliable data, and the results will be evaluated according to the "Seasonal Observation of Organisms" system developed by Dr. P.H. Holmes and used in this project.

To summarize results for each species, code numbers representing observed phenomena will be written on the attached form. One tree may show several phenomena at the same time: for example, flowering and fruiting or fruiting and new leaves simultaneously. In that case, the codes will be recorded as fractions, such as 2/4 or 4/9.

The following is the contents of "Seasonal observation of organisms".

<Flower>
1) Buds have come out.
2) Flowering is in process, or in full bloom.
3) Flowering will soon end, or has already ended.

<Fruit>
4) New fruits are developing.
5) Fruits are ripe.
6) Ripe fruits are fallen, or seeds are being scattered.

<Foliage>
7) Trees are bearing few or no leaves.
8) New leaves have come out.
9) Almost all or all leaves are new.
10) The whole of the crown is covered with old foliage.

(5) The trees will be observed using binoculars, but buds and flowers are often very small and require skilled observation. Buds and flowers fallen on the ground also provide important information of the trees.

(6) Patrol and cleaning of the seed collecting forests and its surroundings, maintenance of foot paths in the forests, and cutting out small trees around the mother trees in preparation for forests floor, etc. are required to be done timely as routine work.

iii) The Results of the Survey on Flowering and Fruiting Habits

In this project, twenty-two seed collecting forests were selected from 1979 to 1986 in Von Humboldt National Forest in Peruvian Amazon area to investigate the flowering and fruiting habits of 668 trees (55 species). The results compiled by Ing. Teodoro Trucios et al. are shown in Table II-3-2. However, these results are not to be considered as definitive ones because the flowering and fruiting seasons of the trees from one year to another and from one tree to another.

The climatic conditions of the investigated area are as follows:

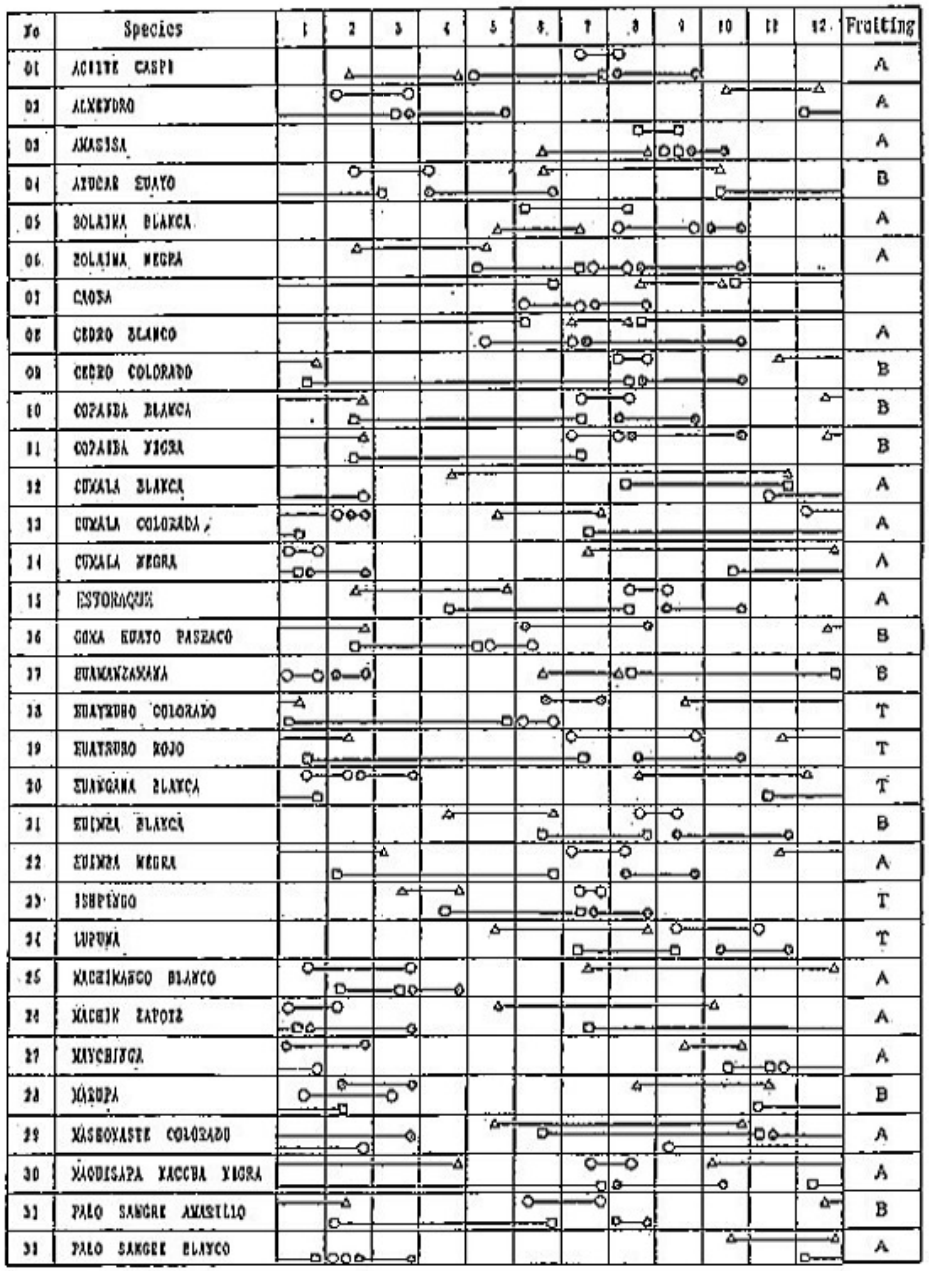
Observation Site: the nursery in the project site (latitude 8° 22' south, longitude 74° 28' west; altitude 200 meters)

Meteorological Observation in Von Humboldt National Forest (Nursery)

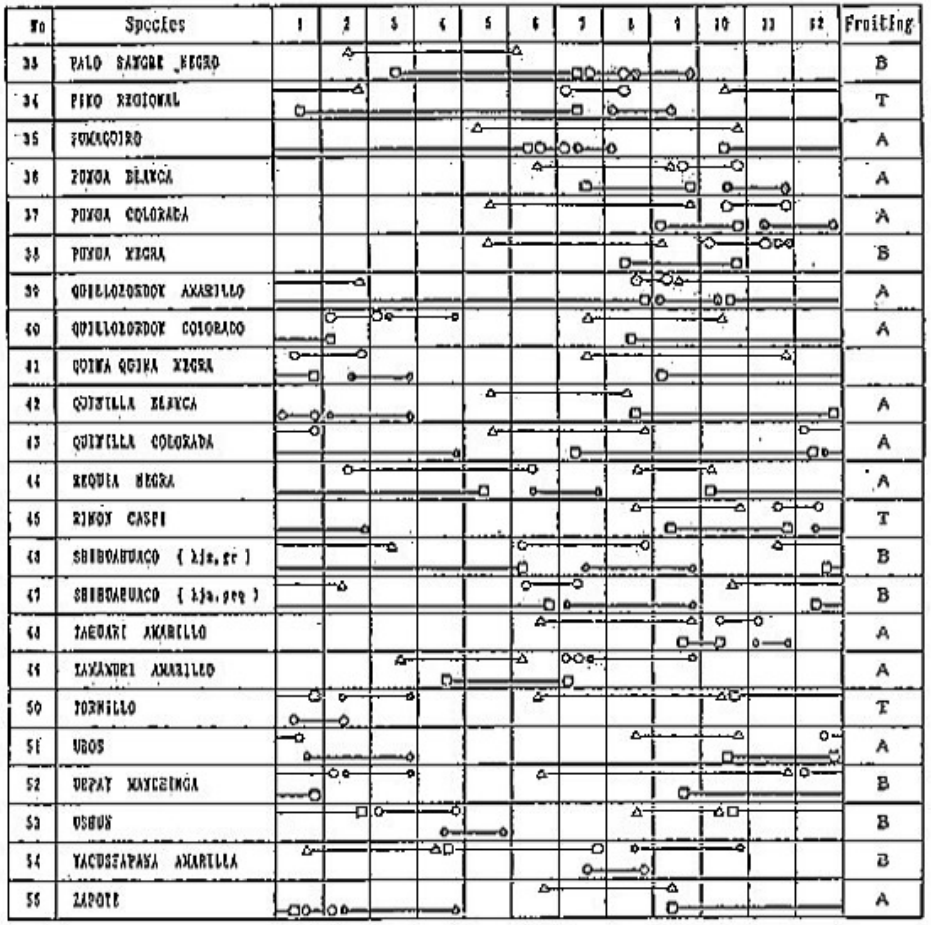
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Average (Total)
Average maximum temp.	29.7° C	29.6	29.6	29.8	30.0	29.1	32.0	32.2	31.9	31.5	31.1	31.0	30.6
Average minimum temp.	21.7° C	21.7	21.8	21.5	20.8	19.5	19.9	20.6	20.5	21.5	22.3	21.9	21.2
Average temperature	25.7° C	25.7	25.7	25.7	25.4	24.3	26.0	26.4	26.3	26.7	26.6	26.4	259
Rainfall	535 mm	489	424	472	218	339	71	195	187	358	637	344	(4,270)
Rainy days	15.8 days	16.7	16.0	13.3	10.5	9.0	4.3	7.5	9.7	15.3	14.2	13.3	(136.8)
Relative humidity	76.5%	76.9	79.8	81.5	81.2	73.5	69.8	69.1	67.0	73.4	77.2	73.3	75.0

Notes: 1) The results of observation from September, 1983 through the end of August, 1987.
2) Rainfall was not recorded between April and June 1985, and between May and July 1986.
3) The relative humidity was recorded at 17:00 in the evening which is approximate to the average of the day.

Table II-3-2 Flowering and Fruiting Calendar for 55 Species in von Humboldt National Forest



No	Species	1	2	3	4	5	6	7	8	9	10	11	12	Fruiting
01	ACEITE CASPI													A
02	ALMENDRO													A
03	AMARISA													A
04	AZUCAR HUAYO													B
05	BOLAINA BLANCA													A
06	BOLAINA NEGRA													A
07	CAOBA													
08	CEDRO BLANCO													A
09	CEDRO COLORADO													B
10	COPAIBA BLANCA													B
11	COPAIBA NEGRA													B
12	CUMALA BLANCA													A
13	CUMALA COLORADA													A
14	CUMALA NEGRA													A
15	ESTORAQUE													A
16	GOMA HUAYO PASZACO													B
17	HUAMANZAMANA													B
18	HUAYRURO COLORADO													T
19	HUAYRURO ROJO													T
20	HUAYRURO BLANCA													T
21	HUIMBA BLANCA													B
22	HUIMBA NEGRA													A
23	ISHPINGO													T
24	LUPUNA													T
25	MACHIMANGO BLANCO													A
26	MACHIN ZAPOTE													A
27	MANCHINGA													A
28	MARUPA													B
29	MASHONASTE COLORADO													A
30	MASHSAPA MACHA NEGRA													A
31	PALO SANGRE AMARILLO													B
32	PALO SANGRE BLANCO													A



No	Species	1	2	3	4	5	6	7	8	9	10	11	12	Fruiting
33	PALO SANGRE NEGRO													B
34	PINO REGIONAL													T
35	PUMAQUIRO													A
36	PUNGA BLANCA													A
37	PUNGA COLORADA													A
38	PUNGA NEGRA													B
39	QUILLOSONOX AMARILLO													A
40	QUILLOSONOX COLORADO													A
41	QUINA QUINA NEGRA													
42	QUINILLA BLANCA													A
43	QUINILLA COLORADA													A
44	REQUIA NEGRA													A
45	RINON CASPI													T
46	SHIHUAHUACO (Aja. ce)													B
47	SHIHUAHUACO (Aja. peq)													B
48	TAHUARI AMARILLO													A
49	TAHUARI AMARILLO													A
50	TORNILLO													T
51	UBOS													A
52	UBPAY MANCHINGA													B
53	USHUS													B
54	YACUSAPANA AMARILLA													B
55	ZAPOTE													A

Titles
- Flowering: △——△
- Fruiting: □——□
- Maturity: ○——○
- Seed: ▫——▫
- Desemination

Fruiting frequency
- A: annual
- B: every two years
- T: every three or more years

2) Collection and Storage of Seeds

The cycles of good crop years of the seeds of the useful tropical species have not yet been completely found out. In order to carry out reforestation over the following years it is required to clarify the methods and conditions that enable long term seed storage without lowering the seeds' germinative capacity by applying low-temperature storage, when a large quantity of seeds are obtained.

Below I'm going to explain the seed storage method we adopted in our project.

i) Seed Collection

Details were given above for selecting, managing and observing mother trees in order to collect seeds, but actually it is almost impossible to collect a large quantity of seeds from one mother tree, so they are collected from several trees other than mother. In this case, it is important to record data on these trees (location, diameter, height, etc.).

The location and species of trees expected to offer good crop in the fiscal year should be included in the observation of mother trees. Simultaneously, information on fruiting (species from which seeds can be collected, their quantity, location, and present state of seeds) should be obtained opportunely in collaboration with local universities and research institutes referring to the "Flowering and Fruiting Calendar".

Seeds of some species may be eaten at an immature stage by birds in years when there is a poor yield, or chance may dictate that few seeds can be collected from one tree which happened to have lots of flowers and fruits. Regular observation is therefore essential.

A seed collection plan will be made based on the operation plan drawn up as early as possible. In this, the species and the quantity of seeds which are available at the sites or are needed to be found elsewhere will be noted. Alternatives to the main desired species will also be considered.

The most important thing in seed collection is to collect mature seeds at the right time. To make this possible, seeds must be frequently observed as they approach maturity in order to determine collection time. This is particularly important in the case of winged or small seeds which are troublesome (difficult in many cases) to collect after scattering, and should be collected before the strobiles split, or the seeds fall.

The maturity of seeds that is the most important point can usually be judged from a change in the color of pericarp, sarcocarp, or strobile (which will take on a particular color when ripe, e.g. light color --> dark color); changes in the water content of seeds (high --> low), and changes in the hardness of seeds (soft --> hard) according to the species.

There are several ways to collect seed: 1) human being climbing up the trees to collect (suitable for winged seeds such as Cedro, Caoba, and Ishpingo, and very small seeds such as Bolaina), and 2) to collect seeds on the ground--(i) to collect seeds which fell naturally (large seeds and heavy seeds such as Copaiba and Palosangre), and (ii) to collect seeds which fell naturally using traps (small seeds such as Aceite caspi). One of these methods will be chosen according to the size of seeds. If method 1) is used, care should be taken not to damage the trunk with iron spikes, which may cause trees to wither. Although method 2)-(i) is not a problem in easily accessible places, it should be performed carefully because the seeds are vulnerable to browsing by animals, as well as insect and fungal damage.

The seeds of isolated trees can be collected by catapulting strings over the seed bearing branches, and changing the strings step by step to ropes. The branches can then be swung to shake the seeds loose.

ii) Preparation of Seeds

The collected seeds will be dried immediately after recording their date and site of collection, identification of the mother tree, their weight and size. The seeds, strobiles, and fruit should also be checked for diseases or infestation, and damaged seeds should be burnt to prevent cross infection of sound seeds.

The collected seeds should be placed on drying shelves and dried naturally in a well-ventilated place. For reference, the drying shelves used in our project were composed of a wooden frame 70 cm wide, 150 cm long, and 10 cm deep, on 50 cm high legs the bottom of which was covered with a fine P.V.C. mesh.

Seed drying procedures are briefly described below.

1) Non-fleshy seeds will be dried naturally on the drying shelves. Due to the risk of damage by insects or fungi during the drying process, insecticides and pesticides will be sprayed on the produced seeds. During drying, the seeds should be protected from rain and night dew.

   Chemicals must be handled with care, using gloves in order not to touch directly and avoiding accidental bodily contact. The workers should be encouraged to wash the face and hands after work.

2) Fleshy seeds must be stripped before drying. Flesh should be totally removed by hand when possible. If not, it can be soaked in water for flesh to rot or removed by rubbing it with a coarse riddle after softening. If any flesh remains, it is likely to go moldy during the drying or storage process.

3) Seeds in pods or soft shells will be dried as they are, and as the pods or shells split, the seeds will be removed for

further drying.

Seeds in hard shells should be softened by soaking in water, then the seeds removed for drying. When they are fully dry minus seeds are to be sorted.

Empty seeds or sterile seeds can be frequently distinguished from sound ones by their appearance: 1) shape (deformed, small, browsed), 2) color (pale, unglossy), 3) Weight (light), and 4) texture (soft). The empty seeds or sterile seeds of every species can be identified by examining a certain number of seeds which seem to be empty or sterile according to the above criteria, and cutting them open to confirm. Alternatively, empty seeds or sterile seeds can also be identified by immersing them in water to see the differences in specific gravity or by wind (medium sized winged seeds can be assessed). An appropriate selecting method should be chosen according to the form of seeds.

Due to limited storage space, winged seeds should have their wings removed.

The wings can be removed from small winged seeds, by rubbing them lightly in a bag, while the wings of larger seeds can be broken off by hand, a little way from the junction with the seed. Particular care must be taken with thin coated seeds as there is a risk of damaging or losing germinative capacity during sorting.

Instructions for Storage

Reconfirm that the seeds are free from disease or insects. Use seeds larger than a certain size. (Do not use small seeds.) Dust the seeds with powder fungicide, and seal them in a double black plastic bag.

On the bag put label with species, date and site of collection, mother tree number, germination rate, storage conditions and chemical treatment.

iii) Storing Seeds

Seeds prepared as above are stored. The results of storage tests on 24 species will be shown below. The tests were conducted to find the safest and most realistic room temperature storage condition bearing in mind the local power supply, and the maintenance and management of warehouses. Storage at room temperature in this project was to place bagged seeds in a glass desiccator (inside diameter 23 cm; depth 15 cm) together with naphthalene and silica gel, keep them in a dark cold place in the laboratory.

According to the results of the tests conducted up to now the following tendency can be observed by the form of seed.

Species for which long storage is difficult:

Flat seeds such as Tornillo and Pumaquiro, and seeds enclosed in high water content flesh such as Palo Sangre Amarillo tend to lose germinative capacity in short time.

Species suitable for long term storage:

Seeds with shell such as Goma huayo pashaco, Copaiba, and seeds wrapped in hard coat such as Palo sangre negro. Also, seeds enclosed in fruits which split after maturation, such as Cedro, Caoba, and Huimba seem to be possible to store for a long time if storing conditions are fulfilled.

Table II-3-3 Storability of Main Tree Species

Species	Storage Life at Room Temperature	Convenient Temperature more than room temperature
1. Aceite caspi	4 months	Storable at other temperatures
2. Achiote	9 (12) months or more	See the above
3. Achiote caspi	12 months or more	25° C to normal
4. Aguano masha	12 months or more	Storable at other temperatures
5. Amasisa	9 (12) months or more	See the above
6. Bolaina blanca	9 months or more	25° C to normal
7. Bolaina negra	12 months or more	
8. Caoba	12 months or more	Storable at other temperatures
9. Cedro blanco	12 months or more	See the above
10. Cedro colorado	12 months or more	See the above
11. Copaiba blanca	4 months	5 to 15° C (8 months or more)
12. Copaiba negra	4 months	5 to 15° C (10 months or more)
13. Estraque	4 months	Around 50° C (10 months)
14. Goma huayo pashaco	9 (12) months or more	Storable at other temperatures
15. Huimba negra	10 (12) months or more	See the above
16. Ishpingo	4 months	15° C (7 months or more)
17. Lupna blanca	10 (12) months or more	15° C to normal
18. Palo sangre negro	12 months or more	
19. Quillosisa pashaco	10 (12) months or more	Storable at other temperatures
20. Tahuari amarillo	0	15° C (4 months)
21. Tornillo	1 month	15° C (2 months)
22. Ucshaquiro colorado	12 months or more	Around 5° C (12 months or more)
23. Vilco pashaco	8 (12) months or more	Storable at other temperatures
24. Yacushapana amarilla	12 months or more	

The figures of "Storage Life at the Room Temperature" represent the period during which the seeds have some germinative capacity (regardless of their germination rate), while the figures in parentheses indicate the expected storage periods according to changes in the germination rate.

The bracketed figures in the "Convenient Temperature" column represent the periods during which the seeds have germinative capacity at the particular temperatures.

(A. Yokota and V. Colan)

(2) Seedlings

1) Introduction

Over the eight years of this project, many experts have worked on the development of a nursing method for commercial hardwood seedlings. Initially, trial and error was used to modify the methods employed previously in FAO projects, Japanese seedling production methods, and techniques employed in other tropical reforestation projects. Fortunately, our Peruvian colleagues had gained experience in FAO projects and this proved invaluable for the current project. They could also improve some of FAO's methods to aid this project. Consequently, suitable techniques for seedling production were developed.

This manual only contains information generally applicable to the whole of Amazonia. For more detailed results, please consult the "Monograph", the section on nursery tests, various post hoc reports written by experts after their return to Japan, and the 1988 interim report as required.

"Developing a Nursery" was based on a preliminary study made on this project and the 1982 interim report while "Managing the Nursery" and "Producing Seedlings" were both based on the 1988 interim report.

[Establishment of Nursery]

Nursery should be situated relatively close to and accessible from the field office, as many routine duties such as watering and frequent observation are required. Steep slopes should be avoided to facilitate operations of nursery, and any such slopes should be levelled. In Amazon, naturally flat areas consisting of Gleysol are poorly drained, and prove to poor aeration. If the site is entirely flat, there will be problems in drainage, so it is therefore better to gently slope the site by taking account of the free drainage available.

The size of the nursery is decided by calculating the required number of seedlings assuming a reasonable yield to be about 30 plants per m^2 of seedbed. The outplanting time for almost all the species is under a year, and in the case of 10 m wide line planting, about 134 seedlings per ha are required. It is recommended that seedbeds are rebuilt every three years in order to maintain efficient drainage. Subsequently, the area of the garden should be around 30% larger than the minimum required area. In this project, a maximum number of 63,000 seedlings a year were produced in a garden slightly under one hectare in area.

Although nurseries need many facilities, the minimum requirements are watering facilities, auxiliary reservoirs, water tanks and pumps, soil mixture preparation lots, and warehouses to store shades and tools.

In Amazonia, there is less rainfall from May to October, although there are marked annual fluctuations owing to the continental climate. Because of high temperature, plants require frequent watering. In the dry season, the many small rivers can dry up and water must be pumped from reservoirs, water tanks and other rivers to the nursery reservoirs and water tanks. The nursery in this project was equipped with the system shown in Fig. II-3-1, which was adequate. For reference, the specifications of the pump used are given.

A workshop for preparing seedbed soil was constructed in a lot adjoining the warehouse where equipment such as tractors was stored. Part of the warehouse could be used as a resting room, an office, and a section for seed preparation. The floors of the warehouse and the seed preparation section were paved with concrete. In addition, garages and soil storage space may be required.

The structure of the seedbed as shown in Fig. II-3-2 is probably generally suitable. Because poor aeration is likely to stunt and damage seedlings, care must be taken with the ratio of soil materials, and the base of the bed must be composed of porous materials such as gravel, sand or charcoal to encourage good drainage. Regarding the light supply, an east-west direction is ideal while a space of around 1 m between seedbeds allows seedlings to be transplanted or weeded easily.

[Managing the Nursery]

The choice of seedbed soil is a key to seedling production. It should preferably have good water and nutrient retaining characteristics, while not holding excessive water. For germination bed, which do not require nutrients, an equal mixture of forest topsoil and sand is appropriate, while for the transplanting beds, a 2:1:0.5 mixture of topsoil, sand, and rice husk/chicken droppings is adequate. if rice husk is unavailable, leaf mold can be used. Since mixing these soils is very time consuming, a simple mixer can improve efficiency.

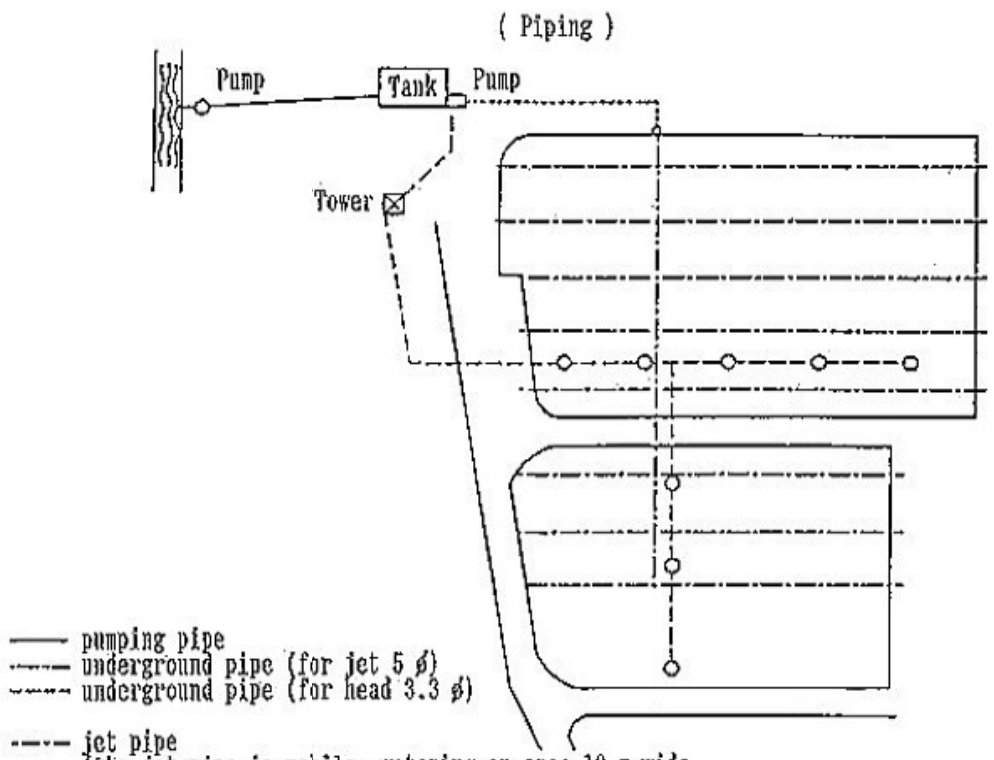
The base of the seedbed should be composed of gravel and sand to ensure good drainage, and the seedbed soil should be turned over every year otherwise the soil itself may become compacted and poorly drained as time passes. The soil should be totally replaced every three years to maintain a certain level of water and nutrient retention as well as drainage.

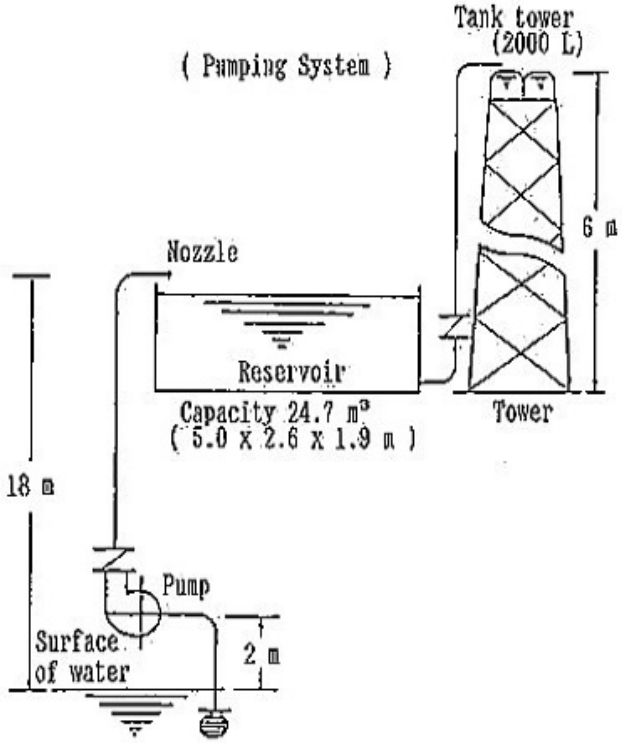
Seedbeds should be facilitated suitable for shading, which is necessary to avoid adverse effects on germination and growth, such as the outflow of the covering soil. However, shading can sometimes reduce germination rate and influence growth after germination. The degree of shading must be adjusted according to the species: for example, both Moena negra and Cumala negra require weak shading, while Bolaina negra requires more shade. Cheesecloth is a suitable shading material, a double structure being used for strong shading. Shading will be continued after

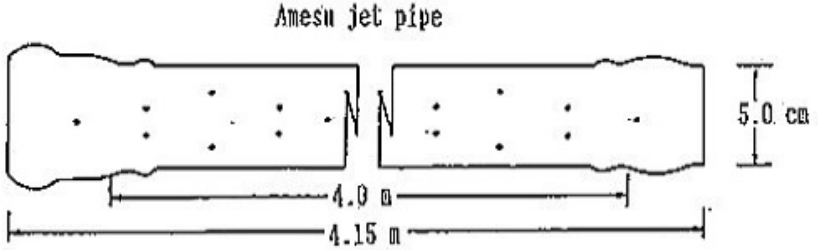
transplanting.

An appropriate watering system pumps water up to the tank, and then supplies the sprinklers by gravity. There are methods of watering from above, and of sprinkling water through a jet pump connected to underground water pipes either of which is applicable. Water pipes were distributed as shown in the illustration of the watering facilities.

Fig. II-3-1 Illustrated Watering Facilities



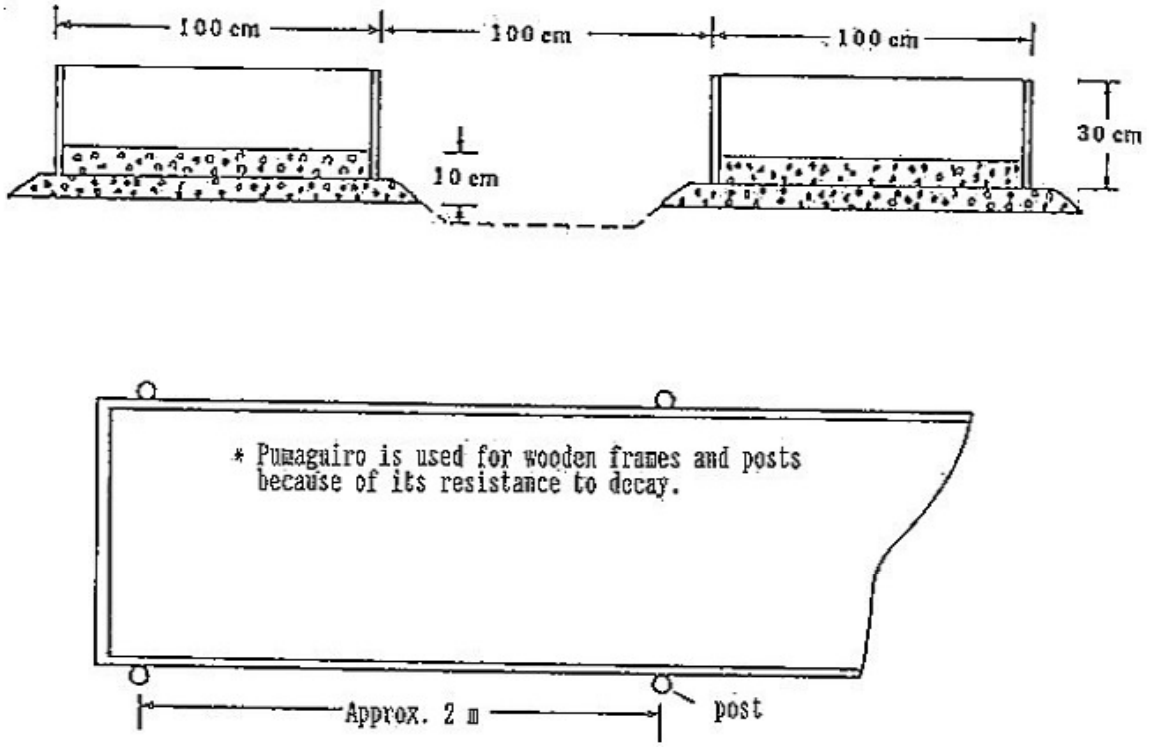




(Specifications)

Pumping-up		Injection	
Engine	Pump	Engine	Pump
Type Suzuki S200	Diameter 80 mm (3 sun)	Type Kubota Diesel ER 700	Type Karui Canal SS50
Horse power 5 ps/4000 r.p.m.	Maximum capacity 980 l/min	Horse power 8 ps/2000 r.p.m.	Maximum capacity 500 l/min
	Pumping height 23 m		Required horse power 5 ps

Fig. II-3-2 Structure of the Seedbed



The fertilizer will initially be used by traditional practice due to the diversity of regions, climates, seedbed soils, and species grown, extra fertilizer being used as required. It is notable that while the use of less fertilizer will not damage seedlings, excessive use will. Although slow-release compound fertilizers are generally used, slow-effective fertilizers such as bone meal and fish meal are preferable if they are available at low costs. For your reference, the method adopted in this project is summarized in Table II-3-4.

Table II-3-4 Design of Fertilization

(1986)

Category	Fertilizer	Component %			Fertilizer	Amount g/m²		
		N	P	K	g/m²	N	P_2O_5	K_2O
Basic fertilizer	Compound Subtotal	12	12	12	30	3.6	3.6	3.6
Additional fertilizer	Compound " Subtotal Total	12 12	12 12	12 12	30 30	3.6 3.6 7.2 10.8	3.6 3.6 7.2 10.8	3.6 3.6 7.2 10.8

* Additional fertilizer will be used according to the growth of seedlings.

[Nersery Procedures (for Gending)]

Although it is not essential, sowing just after collection has achieved the best results in every case. Accordingly, seeds will be sown immediately after their collection, that is, between July and September. To ensure reliable germination, the seeds of Azucar huayo and Goma huayo pashaco should be slightly damaged with sandpaper to break seed coat and to aid water absorption, while Estraque seeds should be soaked in water for 72 hours. These are the only species requiring pre-treatment.

All seeds should be disinfected by immersion in a fungicide solution, as they are vulnerable to fungi both during and after germination. Readily-available fungicides such as Benlate will be used. Quillobordon, Tornillo and Pumaquiro species which are especially vulnerable to mold should be treated as early as possible.

Sowing methods vary according to the size and species of seeds. Some, which are liable to damage by rats, need protecting with nets and small seeds will preferably be scattered, although they must be thinned out if too dense. Large seeds (except winged or long ones) will be sown in lines, while relatively large and long seeds such as Quillobordon, Tornillo and Pumaquiro should be half buried with the rooting part of seeds downwards. The standard sowing rates for main species are shown in Table II-3-5.

Immediately after sowing, seeds should be lightly covered with sand using a sieve of 3 mm mesh to just cover them, and the surface slightly compacted.

The shades over seedbeds should not be removed until transplanting, after which the degree and duration of shading should be adjusted for each species. Generally, two sheets of cheesecloth will be used for about 20 days after transplanting, when seedlings grow rapidly, and then only one sheet will be used. On average, shading will be removed after 45th day, but should be continued for some species such as Tornillo, Requia, and Azucar huayo, which are liable to scorching and subsequent disease. It is fundamental that the more light received, the better developed the root should be. This produces more vigorous seedlings. It is preferable to reduce the shading as soon as possible while watching out for scorching or other problems.

There are two transplanting methods, namely beds and pots. As Requia has a poor survival rate in beds, it is transplanted directly into pots. There are also species which need transplanting twice, first into beds and then into pots. These include Tornillo and Azucar huayo. The pots used are black plastic bags 25 cm x 16 cm or 23 cm x 13 cm with eight holes at the bottom, chosen according to the size of seedlings.

The transplanting times vary from species to species, and for the important species are as follows: For Copaiba, Lagarto caspi, Palo sagre A., and Bolaina B. and N., the size of plantlets is not

related to growth after transplantation.

Table II-3-5 Sowing Rate and Expected Germination

Species	Sowing Rate kg/m²	No. of Seeds piece/kg	Expected Germination %	Remarks
ACEITE CASPI	0.31	25,000		
AZUCAR HUAYO	2.56	340	70	Peeled seed-coat off
BOLAINA B.	0.01	860,000	40	
BOLAINA N.	0.09	165,500	60	
CAOBA	400 pieces	1,242	95	
CEDRO C.	0.08	16,000	70	
COPAIBA	500 pieces	663	80	
CUMALA N.		213	40	
ESTRAQUE	0.70	666	80	Soak
ISHPINGO	0.35	1,540	90	
LAGARTO CASPI	1.22	650	70	
MARUPA		2,500	30	
MASHONASTE	2.70	306	80	
MOENA N.	1.68	338	100	
PALO SANGRE N.	0.84	528	70	
PUMAQUIRO	0.48	636	90	Disinfect, vertical sowing
PALOSANGRE B.	0.33	2,041	70	
QUILLOBORDON	0.52	1,111	90	Disinfect, "
TORNILLO	280 pieces	1,280	70	Disinfect, "
UBOS		345	60	
YACUSHAPANA	0.06	14,300	75	

(Transplanting Time)

1) CAOBA: when a main leaf comes out
2) CEDRO COLORADO: when three main leaves come out
3) ISHPINGO: when 4 or 5 main leaves come out
4) TORNILLO: when two main leaves come out
5) AZUCAR HUAYO: when a main leaf comes out
6) YACUSHAPANA: when 1 to 3 main leaves come out
7) ESTRAQUE: when 1 to 3 main leaves come out
8) MARUPA: when 3 or 4 main leaves come out

Although a density of 4 x 4 plants per m² was favorable in transplanting beds in many cases, a density of 6 x 6 or 7 x 7 plants is more practical to conserve space.

Generally pots will be densely arranged (about 70 pots per m²), and as the seedlings grow, will be spaced out. Soil in the pots will be the same as seedbeds, and pots will be filled so they can stand

upright, the seedlings being transplanted into them 3 to 5 days after filling.

Although watering depends on the species, the size of seedlings, and the type of soil, it is required once or twice a day during the dry season, and may be required once during the rainy season. The soil should be kept moist; if water can be squeezed out from a handful of soil, it is excessively wet and liable to cause root rot. Care must be taken to avoid excessive water.

Since weeds inhibit seedling growth and deprive them of nutrients, they must be controlled as early as possible because they grow very quickly.

The rootcutting used in Japanese nursery is ineffective for the species used in this project.

Seedlings should be planted out in the rainy season from late October onwards to ensure their survival in the planting plots. Potted seedlings should be planted out first, then bare-rooted ones. Supplementary seedlings will be properly planted in the rainy season.

The standard size for outplanting is approximately 50cm in height. 25-50 bare-rooted seedlings will be packed in a jute bag after trimming their leaves and roots in the workshop after digging out, and covering mud over their roots. They will be planted as soon as possible after packing. The leaves should be removed to reduce transpiration.

Prior to sowing, the soil should be disinfected to prevent disease, for example, using Penta or Clornitrobenceno at a rate of 5 g per $0.12m^3$ of soil. Diseases occurring after germination will be treated with chemicals such as Tecto, while Sumithion will be employed as an insecticide. For details, see the disease control section of the monograph.

Nursery procedures are itemized below.

[Nursery Standards]

Standards for the main species are shown in 67-74 p.p.

2) Preparing the Nursery

i) Developing a Nursery Bed

[Principle]

A necessary infrastructure of nursery must be prepared for efficient seedling production.

[Procedures]

. Selecting Land
Select a well-drained gentle slope or flat area considering accessibility to the reforestation site.

. Constructing and Arranging Facilities
Plan watering facilities, a workshop, and a warehouse attached to the main facilities.

. Demarcating the Nursery Bed Compound
Make the lot rectangular or square and divide it into a grid.
Build two drainage systems.
Arrange drainage ditches properly.
The shape of the bed would approximately be adjusted with that of the cheesecloth shades.
Arrange the beds in an east-west direction for optimal light.
Allow approximately 100cm between the beds for maintenance.

ii) Soil Preparation

[Principle]

Nursery bed soil should be prepared carefully and should include organic material to display its nutritional and physical properties.

[Procedures]

. Selecting Soils
Sandy loam, loam, or humusic sandy soil is suitable. The topsoil and sand collected nearby the site would be the materials for soil mixture.

. Storing Soil Material
The nursery bed soil should be stored in a sheltered place.

. Preparing Soil
Collected soil and sand should be sieved to eliminate stones and gravel before use.
An equal ratio of soil and sand should be used for seedbeds.
A mixture of 2:1:1 of soil, sand and humus should be used for transplanting beds.

. Instructions
Fungicides and pesticides should be applied to seedbed during preparation.
Pesticides should be applied to nursery beds during preparation.

3) Seedling Production

i) Sowing

[Principle]

Seeds should be sown in considering their requirements and the environmental conditions to ensure reliable germination.

[Procedures]

. Sowing Methods
  Scattering: small seeds
    The seeds are sown by mixing them with sand, and using a sieve.

  Line sowing: medium seeds
    The seeds are sown in regular lines.

  Piece sowing: large seeds
    This method is suitable for all coated seeds.

. Seed preparation
  Pre-treatment: Thick and hard seed coats should be scratched and broken a part with sandpaper (in the case of seeds showing a low germination rate without this treatment)
  Seed disinfection: Protect seeds from diseases
    Seeds should be sprayed with or immersed in fungicide.
  Soil disinfection: Prevent damping-off of seedlings.

. Watering: Seeds must be given ample water at the time of sowing, but rapid and excessive watering after sowing must be avoided.

. Covering: After sowing, seeds should be lightly covered with sand, to extent some seeds can be seen on the surface.

. Shading: Shade seedbeds with palm leaves to protect them from heavy rain.
  Do not remove shading until the seedlings are ready for transplantation to nursery beds or pots.

ii) Transplanting from seedbeds

(a) Normal Transplantating

[Principle]

The purpose of transplanting is to promote the sound development of seedling roots.

[Procedures]

. Transplanting
Dig seedlings out of the seedbeds carefully after sprinkling them with water.
Place seedlings in the shade or a bucket full of water at all times to avoid root damage.
Carefully trim their roots as straight roots are generally long.
Sprinkle them with water and apply a transpiration retardant after transplanting.
The transplanting time will be decided according to the number of developed main leaves.
Tornillo should be transplanted when 2 or 3 main leaves have come out.

. Shading
Seedling should be shaded with double cheesecloth immediately after transplantation.
One layer can be removed approximately 20 days later, and the second 45 days after transplantation.

. Species Requiring Special Care
Those whose transplanting time is judged by the color of main leaves: Copaiba, Goma huayo pashaco
Species which require weak shading at all times:
Tornillo, Moena

(b) Potting Seedlings

[Principle]

This method is appropriate when it is difficult to produce good seedlings using normal transplantation, or in unsuitable planting seasons when potted seedlings have a higher survival rate than bare-rooted seedlings.

[Procedures]

. Making Pots
Make drainage holes in black plastic bags, fill them with soil and moisten it to prepare for transplanting.

. Transplanting
Transplant seedlings using a guide stick.
Sprinkle water and a transpiration retardant on them after transplantation.

. Management after Transplanting
Regulate the spacing by a small log as the seedlings grow between rows to ensure getting suitable light.

. Shading
See the normal transplanting method above.

. Species which must be Planted in Pots
Azucar huayo, Tornillo, Estoraque

4) Care of Seedlings

i) Watering, weeding, and Rootcutting

[Principle]

These are all required to maintain vigorous seedling growth. Careful watering and weeding are especially important.

Rootcutting should be carried out only for species which require it.

[Procedures]

. Watering during the Nursery Period
Keep the topsoil moist.
Watering will be done intermittently.
Water the seedlings as required, every day in the dry season.
Excessive watering is likely to cause root rot.
Watering should be reduced as the outplanting time approaches.

. Weeding
The beds and pots should be hand-weeded.
Use herbicides for side walks, adjacent areas, and fallow beds.
Early weeding is cost efficient.

. Rootcutting
No specific species require.

ii) Pest and disease Control

[Principle]

Priority should be given to insect pest and disease prevention to ensure efficient seedling production. If the damages occur, the cause should be detected and dealt with as early as possible.

[Procedures]

. Disease Prevention
Soil should be disinfected during preparation.
Chemical sprays should be used to prevent damping off after transplantation.

. Insect Pest Prevention
Spray regularly to prevent Hypsipyla infestation after transplantation. The seedlings should be sprayed with Sumicyzin or Fenvalerate once biweekly or a month.

. Other Pests
Rats may attack seeds and seedlings.

. Species Requiring Special Care
Tornillo and Marupa are vulnerable to excessive watering and damping-off, while Caoba and Cedro are prone to Hypsipyla.

5) Transplanting to the field

[Principle]

Seedlings are usually transplanted during rainy season. The most vigorous seedlings should be selected and supplied on time by keeping in contact with the field preparation.

[Procedures]

. Preparing Seedlings
Bare-rooted seedlings: Select seedlings meeting the standards, dig them out, and ensure that their roots are prevented from drying out and weakening.
Potted seedlings: Select seedlings meeting the standards, and sprinkle them with water prior to transplanting.

. Packaging bare Rooted Seedlings
Pack between 25 and 50 seedlings in each jute bag.

. Instructions
Use potted seedlings for transplanting or supplementary transplanting only when it is difficult to plant out bare-rooted seedlings: early in the rainy season, during the dry spell, and late in the rainy season. In usual rainy season, use bare-rooted seedlings.
Plant seedlings out early in the morning before the temperature rises.
Take care of seedlings in transportation in case they overheat or their roots dry out.

(K. Watanabe and J. Pinedo)

Cedro colorado

Nursery Standards

A class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m²	No. of tended seedlings per m²	Nursery Period	Remarks
Sowing	26 m² (13)	6,393	77 g 500		6	Germination rate 89 % Survival rate 70 %
Transplanting	412 (206)	6,168		30	7 8 9 10	Yield 95 %
Potting	354 177	6,168		35	7 8 9 10 11 12	Yield 95 %
Shipping		5,551			1 2 3 4 5 6 7 8 9 10 11 12	Shipping rate 90 %

Item	
Treatment prior to sowing	unnecessary
Sowing method	line sowing
Transplanting method	Normal transplanting
Nursery control	nothing particular
Pest and Disease	Hypsipyla
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	cm	cm		
Seedlings for shipping	50			

Azucar Huayo

Nursery Standards

B class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m²	No. of tended seedlings per m²	Nursery Period	Remarks
Sowing	0.5 m² (0.3)	112	3,185 g 360		9 10	Germination rate 87 % Survival rate 90 %
Transplanting	8 (4)	106		30	6 7 8 11 12	Yield 95 %
Potting	6 (3)	106		35	6 7 8 11 12	Yield 95 %
Shipping					1 2 3 4 5 6 7 8 9 10 11 12	Shipping rate 60 %

Item	
Treatment prior to sowing	necessary
Sowing method	line sowing
Transplanting method	potted seedling
Nursery control	nothing particular
Pest and Disease	〃
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	cm	cm		
Seedlings for shipping	25	6		

Copaiba

Nursery Standards

B class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per a^2	No. of tended seedlings per a^2	Nursery Period: 1 2 3 4 5 6 7 8 9 10 11 12	Remarks
Sowing	2.8 m^2 (1.4)	455	746 g 340			Germination rate 86 % Survival rate 80 %
Transplanting	24 (12)	432		36		Yield 95 %
Potting	26 (13)	432		35		Yield 95 %
Shipping		259				Shipping rate 60 %

Item	
Treatment prior to sowing	unnecessary
Sowing method	line sowing
Transplanting method	normal transplanting
Nursery control	nothing particular
Pest and Disease	rats
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	cm	mm		
Seedlings for shipping				

Lagarlo Cespi

Nursery Standards

B class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per a^2	No. of tended seedlings per a^2	Nursery Period: 1 2 3 4 5 6 7 8 9 10 11 12	Remarks
Sowing	2 m^2 (1)	384	937 g 360			Germination rate 74 % Survival rate 80 %
Transplanting	24 (12)	364		30		Yield 95 %
Potting	22 (11)	364		35		Yield 95 %
Shipping		218				Shipping rate 60 %

Item	
Treatment prior to sowing	unnecessary
Sowing method	line sowing
Transplanting method	potted seedling
Nursery control	nothing particular
Pest and Disease	"
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	cm	mm		
Seedlings for shipping	50			

Palo Seagre Negro

Nursery Standards

B class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m^2	No. of tended seedlings per m^2	Nursery Period: 1 2 3 4 5 6 7 8 9 10 11 12	Remarks
Sowing	1.8 m^2 (0.9)	304	1,118 g 340			Germination rate 72 % Survival rate 80 %
Transplanting	20 (10)	288		30		Yield 95 %
Potting	18 (9)	288		35		Yield 95 %
Shipping		172				Shipping rate 70 %

Item	
Treatment prior to sowing	unnecessary
Sowing method	line sowing
Transplanting method	normal transplanting
Nursery control	nothing particular
Pest and Disease	〃
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	0	0		
Seedlings for shipping	50			

Bolaina Negra

Nursery Standards

C class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m^2	No. of tended seedlings per m^2	Nursery Period: 1 2 3 4 5 6 7 8 9 10 11 12	Remarks
Sowing	96 m^2 (48)	38,095	21 g 800			Germination rate 45 % Survival rate 50 %
Transplanting	2,010 (1,005)	36,190		36		Yield 95 %
Potting	2,068 (1,034)	36,190		35		Yield 95 %
Shipping		32,571				Shipping rate 90 %

Item	
Treatment prior to sowing	unnecessary
Sowing method	scattering
Transplanting method	potted seedling
Nursery control	nothing particular
Pest and Disease	〃
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	0	0		
Seedlings for shipping	50			

Estoraque

Nursery Standards

C class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m²	No. of tended seedlings per m²	Nursery Period 1	2	3	4	5	6	7	8	9	10	11	12	Remarks
Sowing	2.8 m² (1.4)	473	717 g 340														Germination rate 89 % Survival rate 80 %
Transplanting	30 (15)	449		80													Yield 95 %
Potting	28 (13)	449		35													Yield 95 %
Shipping		314															Shipping rate 70 %

Item	
Treatment prior to sowing	unnecessary
Sowing method	line sowing
Transplanting method	potted seedling
Nursery control	nothing particular
Pest and Disease	〃
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	cm	mm		
Seedlings for shipping	50			

Pomaquiro

Nursery Standards

C クラス

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m²	No. of tended seedlings per m²	Nursery Period 1	2	3	4	5	6	7	8	9	10	11	12	Remarks
Sowing	5.6 m² (2.8)	423	360 g 174														Germination rate 95 % Survival rate 80 %
Transplanting	26 (13)	458		36													Yield 95 %
Potting	26 (13)	458		35													Yield 95 %
Shipping		366															Shipping rate 80 %

Item	
Treatment prior to sowing	Disinfection just after seed collection and conditioning
Sowing method	piece sowing
Transplanting method	normal transplanting
Nursery control	nothing particular
Pest and Disease	〃
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	cm	mm		
Seedlings for shipping	60	8.5	5.0	

Lupuna

Nursery Standards

D class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m^2	No. of tended seedlings per m^2	Nursery Period 1	2	3	4	5	6	7	8	9	10	11	12	Remarks
Sowing	m^2 62 (31)	12,500	32g 400														Germination rate 87 % Survival rate 70 %
Transplanting	792 (396)	11,875		30													Yield 95 %
Potting	680 (340)	11,875		35													Yield 95 %
Shipping		10,687															Shipping rate 90 %

Item	
Treatment prior to sowing	unnecessary
Sowing method	line sowing
Transplanting method	normal transplanting
Nursery control	nothing particular
Pest and Disease	〃
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	cm	cm		
Seedlings for shipping	50			

Gona Kuayo Pashaco

Nursery Standards

D class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m^2	No. of tended seedlings per m^2	Nursery Period 1	2	3	4	5	6	7	8	9	10	11	12	Remarks
Sowing	m^2 4 (2)	1,126	577g 650														Germination rate 90 % Survival rate 88 %
Transplanting	86 (43)	1,070		25													Yield 95 %
Potting	62 (31)	1,070		30													Yield 95 %
Shipping		963															Shipping rate 90 %

Item	
Treatment prior to sowing	necessary
Sowing method	line sowing
Transplanting method	normal transplanting
Nursery control	nothing particular
Pest and Disease	〃
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	cm	cm		
Seedlings for shipping	60	12	7.0	

Marupa

Nursery Standards

C class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m^2	No. of tended seedlings per m^2	Nursery Period: 1 2 3 4 5 6 7 8 9 10 11 12	Remarks
Sowing	m^2 2.4 (1.2)	460	833 g 400			Germination rate 24 % Survival rate 80 %
Transplanting	32 (16)	456		30		Yield 95 %
Potting	26 (13)	456		35		Yield 95 %
Shipping		319				Shipping rate 70 %

Item	
Treatment prior to sowing	unnecessary
Sowing method	line sowing
Transplanting method	potted seedling
Nursery control	nothing particular
Pest and Disease	blight
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	T/R ratio	
Plantlets	cm	cm		
Seedlings for shipping	50	13	3.0	

Caoba

Nursery Standards

A class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m^2	No. of tended seedlings per m^2	Nursery Period: 1 2 3 4 5 6 7 8 9 10 11 12	Remarks
Sowing	m^2 4 (2)	895	480 g 430			Germination rate 90 % Survival rate 80 %
Transplanting	56 (29)	850		80		Yield 95 %
Potting	50 (25)	850		95		Yield 95 %
Shipping		595				Shipping rate 70 %

Item	
Treatment prior to sowing	Unnecessary
Sowing method	line sowing
Transplanting method	normal transplanting
Nursery control	nothing particular
Pest and Disease	Hypsipyla, rat
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	T/R ratio	
Plantlets	cm	cm		
Seedlings for shipping	50			

Bolaina Blanca

Nursery Standards

C class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m²	No. of tended seedlings per m²	Nursery Period 1 2 3 4 5 6 7 8 9 10 11 12	Remarks
Sowing	286 m² (143)	114,285	7g 800			Germination rate 39 % Survival rate 30 %
Transplanting	7,238 (3,619)	108,570		30 本		Yield 95 %
Potting	6,204 (3,102)	108,570		35		Yield 95 %
Shipping		97,713				Shipping rate 90 %

Item	
Treatment prior to sowing	unnecessary
Sowing method	scattering
Transplanting method	normal transplanting
Nursery control	nothing particular
Pest and Disease	〃
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	12 cm	2.5mm		3
Seedlings for shipping	50			

Tornillo

Nursery Standards

A class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m²	No. of tended seedlings per m²	Nursery Period 1 2 3 4 5 6 7 8 9 10 11 12	Remarks
Sowing	7.2 m² (3.6)	932	282g 260			Germination rate 97 % Survival rate 80 %
Transplanting	54 (27)	942		36		Yield 95 %
Potting	54 (27)	942		35		Yield 95 %
Shipping		659				Shipping rate 70 %

Item	
Treatment prior to sowing	Disinfection just after seed collection and conditioning
Sowing method	piece sowing
Transplanting method	potted seedling
Nursery control	Continuous shading
Pest and Disease	blight
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	cm	mm		
Seedlings for shipping	30	6		

Ishpingo

Nursery Standards

A class

Item	per 1 kg of seeds: Required area (Bed area)	per 1 kg of seeds: No. of seedlings	Sowing rate per m^2	No. of tended seedlings per m^2	Nursery Period: 1 2 3 4 5 6 7 8 9 10 11 12	Remarks
Sowing	m^2 6 (3)	1,084	348 g 360			Germination rate 84 % Survival rate 80 %
Transplanting	66 (33)	982		30		Yield 95 %
Potting	58 (29)	982		35		Yield 95 %
Shipping		785				Shipping rate 80 %

Item	
Treatment prior to sowing	unnecessary
Sowing method	Line sowing
Transplanting method	normal transplanting
Nursery control	nothing particular
Pest and Disease	〃
Others	

Seedling Standards

Item	Standards: Length	Basal diameter	TR ratio	
Plantlets	cm	mm		
Seedlings for shipping	50			

(3) Reforestation

1) Introduction

Previous reforestation activities in Peru-Amazonia have been limited in terms of both methods and area as mentioned in Koike's section of the "Monograph" included in this report. Although there are same examples of FAO's experimental reforestation and schemes in Iquitos, these are basically experimental, and the results are fragmentary.

The Japanese and Peruvian Governments co-operated on this project in order to clarify the problems associated with the pursuit of practical, conservative and sustainable forestry, and to develop a method suitable for this region. It was largely successful and a variety of new techniques applicable to the region were developed.

In this section, forestry techniques and operations, and the care of regenerated trees will be summarized. The information was obtained from the artificial regeneration mainly by line planting of 37 species, the experimental natural regeneration of 19 species, and the experimental care of regenerated trees in the seven years from 1982 to 1988. Since this project was limited in time, only insufficient data for assessment of further silviculture works could be obtained. Nor was sufficient data gathered on salvage-cutting, light adjust-cutting, and thinning. Therefore, these are explained to some extent by analogy. Our overall aim was to produce a model generally applicable to the whole of Peru-Amazon by eliminating peculiar aspects in the Humboldt National Forest project site.

The information used here was collected by many Japanese and Peruvian specialists and the technical groups associated with this project. For details, see the reports by the visiting experts after their return to Japan, and the interim report whenever necessary.

The key points are itemized below.

2) Land Preparation and Planting

i) Survey and Site Categorization

[Principle]

A reforestation site will be efficiently planned by carefully reviewing the overall scheme including the requirements for the natural regeneration plots and forest roads.

[Procedures]

A survey should be conducted with reference to the soil and topographical maps with considering forestation plans. If a site liable to flooding is chosen, it is advisable to conduct the survey during the rainy season when the extent of the floods can be seen.

Using a compass, planting lines will be oriented in an east-west direction. Areas of stagnant water or those liable to flooding, swamps, and previously cultivated areas will be treated as non-forest land, and eliminated in advance from the reforestation plan.

ii) Land Preparation

[Principle]

Land preparation includes the clearance of weeds and trees from the site to facilitate the planting and to get good survival and growth of seedlings.

[Procedures]

Land should be prepared for planting as follows:

1. Extract vines and small diameter trees with a machete.
2. Fell medium and large diameter trees with a chainsaw.
3. Remove branches of felled trees with a machete or a chainsaw.

It is recommended that land preparation should begin after the rainy season when the soil is dry for easy operations and safety, and be finished by late November when planting starts.

iii) Planting

[Principle]

Planting places should be marked by wooden posts.

[Procedures]

Plant seedlings in double lines. the first line being 3 m from the south boundary of the clearing. The second line should be 5 m away, and the trees should be planted in zigzag arrangement. The position of the seedlings should be marked with 1.5 m wooden posts to make weeding easier.

Begin planting in late November at the beginning of rainy season, and complete it by early April. Transfer the bagged seedlings for outplanting by truck from the nursery to the planting site, dig planting holes near the marker post using a cavador (a local digging tool) and a mulberry.

Use potted seedlings for planting in the early or late rainy season. Marupa, Yacushapana A, Tornillo, Azucar H., and Estoraque have low survival rates and should also be planted in pots. Use bare-rooted seedlings otherwise. In Gleysol areas, soil mound must be formed for preventing stagnant water.

iv) Supplementary Planting

[Principle]

The results of the survey on survival rates are used to plan supplementary planting. It will be utilized for further improvement of the seedling standards and the planting method.

[Procedures]

Survival rates should be assessed one month after planting. If less than 80% have survived, or if many seedlings have wilted, the cause should be confirmed, and the wilted or dead seedlings replaced with the large potted specimens.

3) Tending

i) Weeding

[Principle]

Weeds and bushes likely to compete with the planted trees should be eliminated.

[Procedures]

Weeds and bushes should be removed manually using a machete when they are likely to interfere the growth of planted trees.

Weeding is no longer required when the planted trees have outgrown the other plants of the area and are no longer at risk from competition with weeds and bushes.

Weeding will probably be required at least twice in the first year after planting, and once or twice in the second year.

ii) Climber Cutting

[Principle]

Climbers will be removed if these affect to the sapling growth.

[Procedures]

Climbers within 1 to 2 m of the planted trees and those winding around the trees should be cut using a machete.

Climbers should be cut out until the planted trees have grown to a height of 5 m or above. While the trees are less than 3 m, they must be very carefully removed.

More attention must be paid to marshy areas where vines are especially common.

iii) Light Reception Control

[Principle]

This is to maintain optimum light conditions when branches in the buffer zone grow over the planting zones and begin to shade the planted trees.

[Procedures]

Branches or trees growing over the planting lines should be removed using chainsaws and machetes; an absolute light intensity of 10,000 lux or more should be present.

iv) Salvage cutting

[Principle]

This is to eliminate weeds which are obstructing the growth of planted trees by surrounding them.

[Procedures]

Excess seedlings should be cut out using a machete. Insect and wind damaged, as well as other poor quality trees, should also be removed to aid the growth of planted trees.

(4) Natural Regeneration

1) Regeneration

i) Plot Selection

[Principle]

A certain area must be maintained for keeping considerable amount of the seedlings to survive.

For species having a known fruiting and germination cycle, the area containing the mother trees will be demarcated, and land clearing will be carried out prior to germination of seedling. Generally the entire area over which seeds are germinating will be designated as a regeneration area.

[Procedures]

The plot should be demarcated within a radius of around 1.5 times of the height of mother trees, at the time when seeding has been confirmed following the flowering and fruiting of several mother trees.

ii) Land Preparation

[Principle]

This is to reduce weed growth in order to facilitate seed germination after they have fallen.

[Procedures]

Weeds and small trees from the defined area should be cut out with a machete after confirming that the regeneration species has seeded.

Trees of other useful species would be preserved.

2) Tending

i) Weeding

[Principle]

This is to remove shrubs and weeds which suppress the seedling growth.

[Procedures]

Weeds should be removed using a machete when they appear to interfere with the intended species' growth. Extra care must be taken while the seedlings are small as they will probably germinate irregularly. If many seedlings are growing together, weeding should be continued until they reach 3 m, while if they are isolated, weeding should continue until they reach 5 m.

ii) Light Control

[Principle]

This is to ensure adequate light to the seedlings by cutting upper-layer trees.

[Procedures]

Chainsaws and machetes should be used to cut trees and branches.

Since frequent cutting is likely to damage the regenerated seedlings, it is suggested that the operation is performed at one time if possible, although the frequency of weeding increased.

Useful species should be conserved and other mid-layer trees cut out until sufficient sunlight reaches to the seedlings (in the case of Tornillo, a relative light intensity of 5%). Canopy trees may also have to be cut if necessary.

iii) Salvage Cutting

[Principle]

This is to stimulate growth of remained seedlings by controlling the number of them.

[Procedures]

Poor quality and damaged seedlings should be removed when they grow too densely to receive adequate light and too much competition for survival. If the seedling have grown to this density when they are 2 m high, they should be removed in every 2m in width.

If overcrowded, girth growth of Tornillo will be strongly retarded as well as height growth.

3) Thinning

[Principle]

This is to stimulate growth in girth by reducing the density of the seedlings from the competition among seedlings.

[Procedures]

Saplings of the target species should be thinned when they begin to compete each other. The inferior trees should be removed. The final density should be 400-500 trees/ha.

Care must be taken not to damage the trunks of the good trees during thinning, otherwise Fusarium is likely to invade.

(5) Common Instructions

1) Protection

i) Chemical Control of Hysipyla which attacks Cedro and Caoba

[Principle]

This will be planned by identifying the afflicted species and considering the climatic conditions which influence the behavior of this moth. So far, the followings have been found: 1) Hypsipyla damage decreases as trees grow above 5 m, 2) the moth lays eggs on shoots and new leaves, hence trees which have just sprouted leaves are more likely to be inflicted by it, 3) caterpillars damage new leaves and shoots, 4) most new leaves are produced in the early and late parts of the rainy season, fewer are sprouted during the dry season, 5) Cedro is affected worse than Caoba. Based on these findings, the beginning (September - October) and end (April - May) of the rainy season will be designated as a danger period, during which the trees will be sprayed over to prevent or reduce Hypsipyla attack. To improve the efficacy of spraying, the Mellaceae site

should be chosen for ease of operations, and a planting method designed to reduce blight will be used.

[Procedures]

1) Chemical treatment method: spray the foliage, paying special attention to shoots
2) Chemicals: Fenvalarate (pyrethrin) emulsion. Sumithion and Mikantop (Fenvalate-dimethote emulsion) are also very effective, but only in the short-term.
3) Concentration: 0.1%, diluted with water
4) Frequency: 5 - 7 times a year for Cedro, 3 or 4 times for Caoba
5) Time: in the early larval stage during the rainy season
6) Method: Spray sprouts, leaves, and shoots from the branches outward to the extent that chemicals drip off them (about 200 cc per tree)
7) Confirming efficacy: Check on third or a half of the sprayed trees 2 or 3 weeks after spraying. If 10% or more of the trees are damaged, spray them again. In the case of mild infestation, pick out the affected parts and burn them.
8) Safety Measures: Care must be taken to prevent chemicals from scattering towards the body (i.e. note wind direction). Raincoats, masks, glasses, and gloves should be used and the workers must take a bath after spraying.

(S. Yamazaki)

2) Road Management

i) Road Network Plan

[Principle]

A standard for the network is to construct about 10m/ha of the trunk forest road and spur road so that all the operations can be carried out within an average distance of 250 m from the roads.

[Procedures]

Peru-Amazon is largely covered with the alluvial deposits of ancient rivers everywhere except near the Andes. Therefore, the ground is composed of fine soil particles and fragile. Since there makes a lot of submerged points during the rainy season, forest roads are easily destroyed.

Areas of Gleysol should be avoided when planning the roads; if this is not possible, areas prone to long term flooding should be avoided to make management easier.

Since illegal felling and shifting cultivation may occur in this region, site access should be limited to one main road branching from the public road, and provision should be made to prevent unauthorized people from entering. In line with this, the Peruvian government has encouraged agricultural development along public

roads. Accordingly, forest roads must comply with the government policy.

ii) Bridge Construction and Maintenance

[Principle]

This should be avoided whenever possible due to the cost. However, if absolutely essential, the following points should be taken into consideration.

[Procedures]

Bridge construction requires a great deal of reinforcement to ensure stability due to the fragile soil. This is another reason for avoiding the use of bridges whenever possible. If wooden bridges are constructed it should pay great care to choose the suitable timber; Shihuahuaco is the most suitable.

Column supported bridges will be mainly used bearing in mind the fragile ground. Small-scale rivers can be dealt with by culvert drainage using Hume concrete pipes, corrugated pipes, or wooden culverts made from local timber.

With regard to bridge maintenance, riverbanks are liable to erosion as the high water level during the rainy season. If this occurs, it will be necessary to reinforce both the riverbank and supports using sheet piles and sandbags.

iii) Standards of Trunk Forest Roads and Spur Forest Roads

[Principle]

Roads can be classified as Trunk and Spur roads. The trunk forest roads should remain open during the rainy season while the use of temporary forest roads should generally be avoided at this time.

[Procedures]

In view of the layout of this region, trunk and temporary roads will be designed as three types; marshy, flat, and slanted. Trunk forest roads should be 4 m wide; temporary roads 3 m, and the former should be sloped to encourage good drainage.

Forest roads in swampy areas are those built on Gleysol prone to long term flooding. These require wide, deep drainage ditches and a layer of logs to be laid over the foundations to ensure a stable roadbed as well as improved drainage.

Flat type of forest roads are suitable for Acrisol areas, and require medium depth drainage and roadbed construction between the required for swamp or slope type roads.

The slope type roads are those built on Cambisol, and require smaller drainage ditches than the former two types, as well as

relatively simple roadbed construction.

Although the spur forest roads will be simplified in terms of drainage and their roadbed engineering compared to the forest roads, they are also required in the three types.

Draft standards are shown in the attached chart.

In terms of subbase materials, although gravel is theoretically required in large quantities and is available from the riverbed, it should be very costly. It can be replaced with relatively cheap and easily obtained sand for road construction in well-drained and Zone C areas.

iv) Forest Paths

[Principle]

These are necessary to reach all the areas where trunk forest and spur forest roads cannot be easily built, so that maintenance, cultivation and protection work may be continued.

[Procedures]

At the start of reforestation, paths should be regularly weeded and the wooden foot-bridges reinforced to make work supervision easier and improve security to prevent theft and shifting cultivation.

Special standards will be set.

v) Management of Trunk Forest and Spur Forest Roads

[Principle]

This should be aimed at allowing continuous use bearing in mind the climate and soil conditions.

[Procedures]

1) Suitable management of roads for the rainy season is most important (because rainfall may sometimes reach 500 - 700 mm a month and 200 mm a day). The soil is often waterlogged, and so more care must be taken of drainage.

2) Although trunk forest roads are designed to be used during the rainy season, extra care must be taken with driving heavy vehicles on them. This is not so during the dry season.

3) The use of spur forest roads will generally be avoided in the rainy season and the vehicle weight limit should be around 2 tons during the dry season.

4) Since the gravels on subbase sink considerably every year because of the fragile ground, supplementary gravel will be required annually.

5) The road verges should be kept cleared so that sunlight can help to dry the road surface. It will also improve the safety of the road.

6) If the road becomes deeply rutted by vehicles and cannot be used, the subbases must be replaced.

(T. Sato and E. Quintana)

[Chart] Construction Specifications of Forest Roads

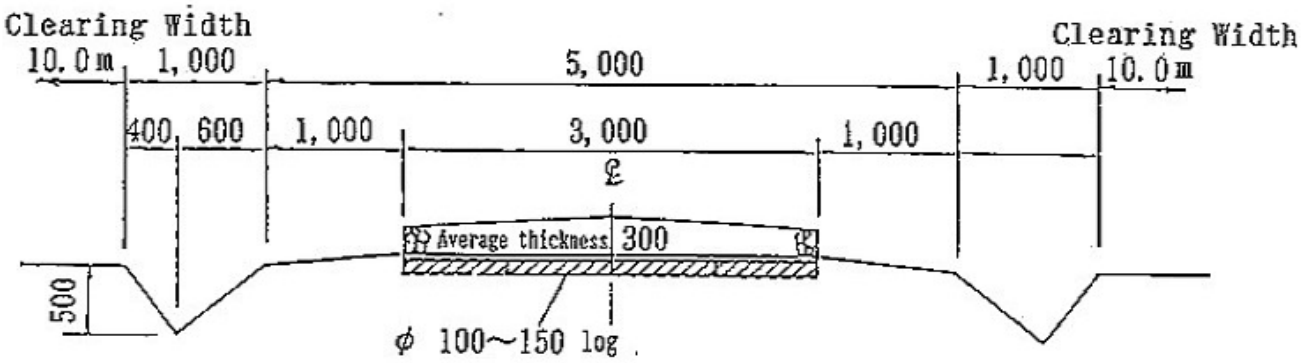
1) Standard Design of Trunk Forest Roads

a. This is outlined in the table below.

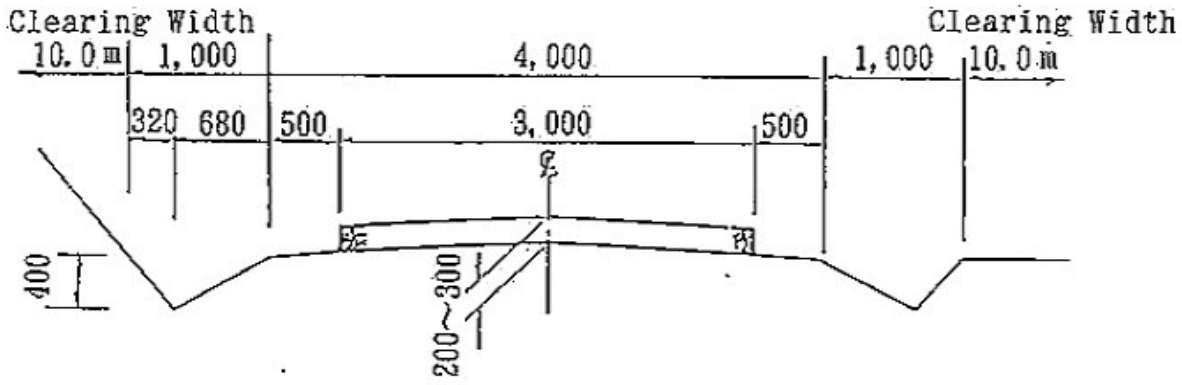
	Swamp	Flat	Slope
Motarable width	3 m	3 m	3 m
Verge	1 m	0.5 m	0.5 m
Side ditch	1 m x 0.5 m	1 m x 0.4 m	0.7 m x 0.3 m
Clearing Width	10 m	10 m	10 m
Roadbed	Corduroy road, gravel 30 cm	gravel 20 - 30 cm	gravel 15 - 20 cm

b. Standard plans in mm:

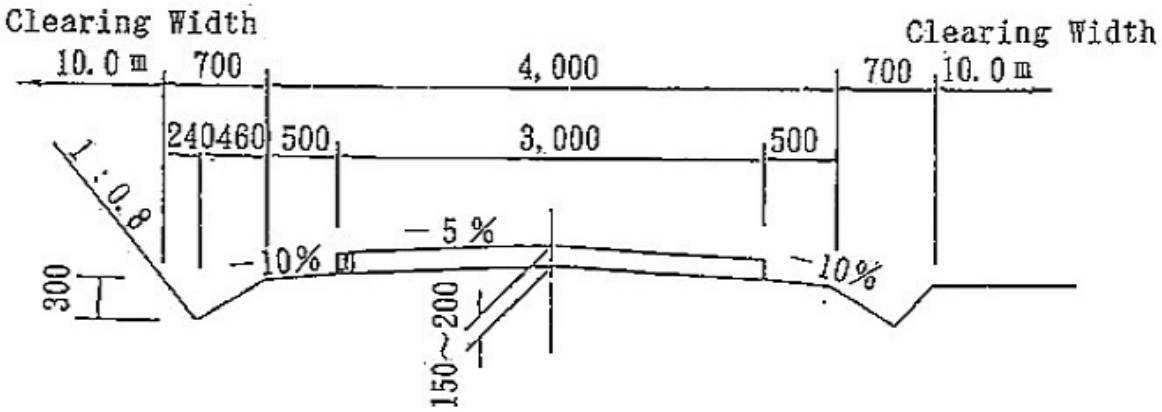
a) Swamp type



b) Flat type



c) Slope type



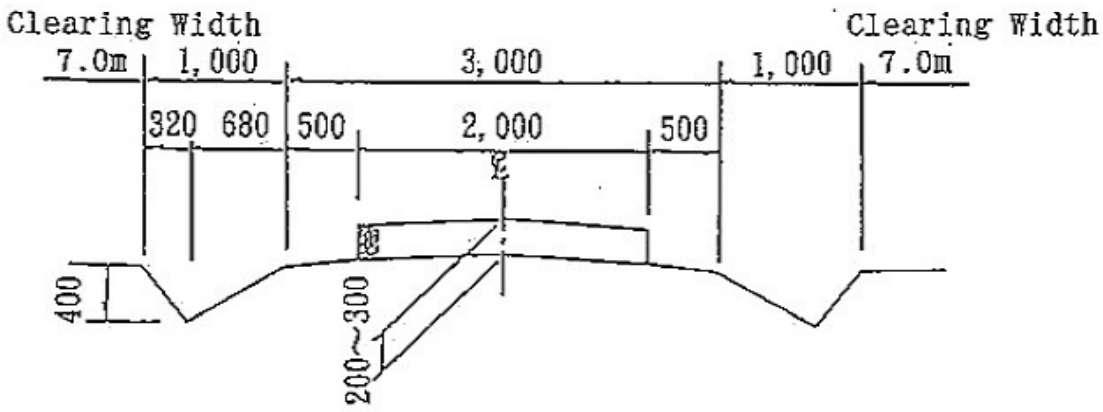
2) Standard Design of Spur Roads

a. This is outlined in the table below.

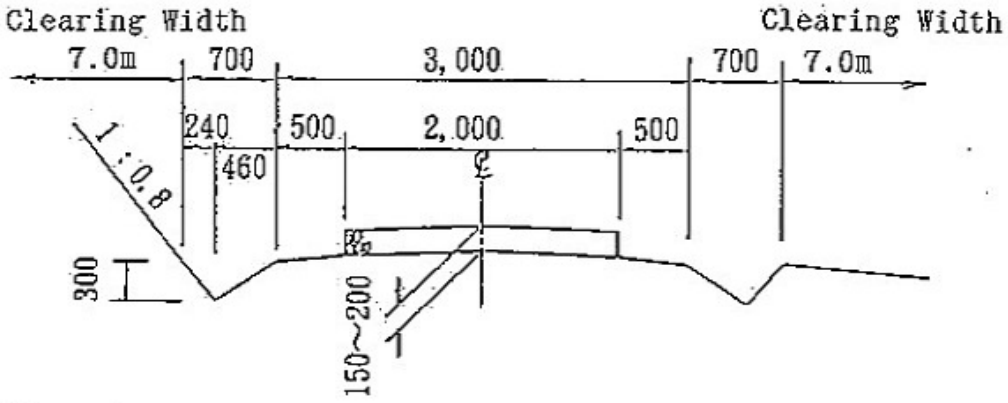
	Swampy	Flat	Slant
Width	2 m	2 m	2 m
Verge	0.5 m	0.5 m	0.5 m
Side ditch	1 m x 0.4 m	0.7 m x 0.3 m	0.7 m x 0.3 m
Clearing Width	7 m	7 m	7 m
Roadbed	Gravel, if required, corduroy road, 20 - 30 cm	Ballast bed 15 - 20 cm	Ballast bed 5 - 10 cm

b) Standard plans:

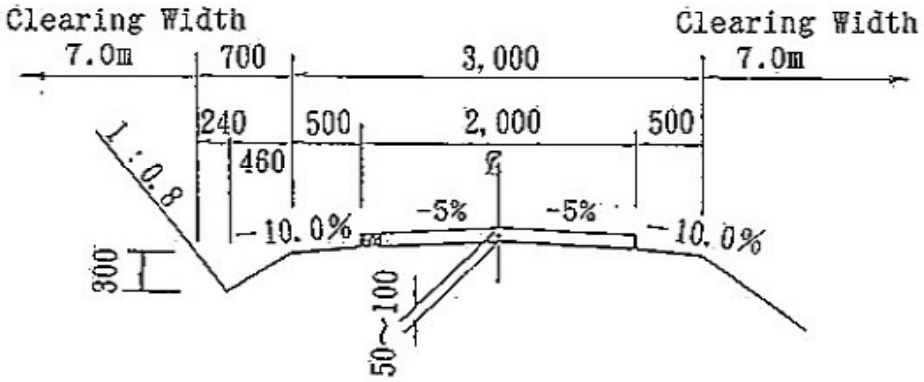
a) Swamp type



b) Flat type



c) Slope type



3) General Matters

i) Site Boundary

[Principle]

This is necessary to prevent trespassing (mainly shifting cultivation) and the theft of valuable properties.

[Procedures]

The boundary should be marked with posts and signs, and an area 3 - 5 m wide cleared on the outside to remind the locals.

Areas near shifting cultivation or where trees have been stolen must be patrolled regularly; normally patrolling can be combined with weeding once a month.

ii) General Reforestation Instructions

[Principle]

All operations not covered elsewhere will be dealt with below.

[Procedures]

a) Surveys on growth, blight, and analysis of findings
b) Equipment maintenance
c) Odd-jobbers (environmental coordination, warehouse arrangement, etc.)
d) Others

It is expected that they will account for 5% of all men/work, and 10% of all expenses on goods and service.

[Tending Standards]

Soil	Tree Type	Weeding						Climber-cutting						Light Control						Salvage-cutting					
		1 times	2	3	4	5	~	1 times	2	3	4	5	~	1 times	2	3	4	5	~	1 times	2	3	4	5	~
Gleysol	fast	○	○	△				○	○	△	△					←	△	→							
	medium	○	○	○	○	○	△	○	○	○	○	○	△			←	△	→							
	slow	○	○	○	○	○	○	○	○	○	○	○	○			←	△	→							
Acrisol	fast	○	○	○	△			△			△	△			←	△	→								
	medium	○	○	○	○	○	△	△					△		←	△	→								
	slow	○	○	○	○	○	○	△					△		←	△	→								
Cambisol	fast	○	○	△				△		△	△				←	△	→								
	medium	○	○	○	○	△		△					△		←	△	→								
	slow	○	○	○	○	○	○	△					△		←	△	→								

(2) Natural Regeneration

Tree Type	Weeding						Light Control						Salvage-cutting					
	1	2	3	4	5	~	1	2	3	4	5	~	1	2	3	4	5	~
Especially fast	○	○	△				△	○						△	○			
Medium	○	○	○	△				△	○						△	○		

Notes: Circles represent the usual standards expected while triangles represent those standards less frequently applied.
Arrows indicate the extent of operations at the current time.
Light reception was not normally controlled in artificial regeneration plots once the trees reached 10 m in height.
Cleaning-cutting has not been carried out in the 10 m line planted plots.

4) Record books

These were found to be very helpful during this project, and were modelled on Japanese ledgers. Over the course of the project they were modified and improved, and although not perfect, are still useful references for launching similar projects. They are attached to this report.

Field Survey of Experimental Natural Regeneration Plots

No. Date of Survey:

Block		Operating Method		Expected Species		
		Weeding/Control				
Plot	No.	Species	Height	Basal Diameter*1	Remarks (damage)	Light intensity*2

*1: Write only the number of trees as far as their average height is 50 cm or less.
*2: Measured at a height of 1.5 m.

Field Survey of Artificial Regeneration and Model Plots *1

Man-made Forest/Model Forest

Block	Line No.	Date of Survey:			No.
No.	Species	Height	D.B.H.*2	Remarks (damage)	Light intensity*2

*1: Attach a distribution map.
*2: Two meters or more above sea level.

Survey Sheet to Record Nursery Standards (seed)

Species					
Origin	*1	Growth of Mother Tree	*2		
Date of Collection		Fruiting	*3		
Collection Method					
Extraction Method					
Weight	g/l	Browsing Rate		Insect	
Moisture Content	%	Storage *4			
Sowing Date		Germination Rate		Germination Acceleration	
Germicide		Pesticide			
Remarks	*5				

*1: Write numbers in the case of observed trees.
*2: Record the existence of other mother trees of the same species and whether they have fruited.
*3: Write full, many or few.
*4: From collection to sowing.
*5: Write the blossoming time if possible, and the shape of seeds (deformation, empty seed ratio)

Survey Sheet to Record Nursery Standards (seedling)

Species					
Tending Period	*1 x x	Planting Density	*2 x	Shading Period	*1 x x
Use of Fertilizer *3	day g/m^2	Frequency of Watering	times/day	Rooting	*4
Planting Site	Subblock	Planting Method	*5		
Date of Outplanting	Survival Percent	(Survival) / (Planted trees) = %			

Diameter Class			Diameter Class			Remarks *6
No.	Height	Basal Diameter	No.	Height	Basal Diameter	
1			. . . . . 20 or 10			

*1: germination bed x seedbed x pot
*2: pieces x, pieces/m2, length x width
*3: time, type, amount
*4: Record whether the seedling has only a tap root, or many fibrous roots, and note their size and amount.
*5: Record whether the seedling was potted or bare-rooted, and whether truncation or undercutting was carried out or not prior to planting.
*6: Attach a photograph of the measured seedling here, and record whether blight occurs, if so, its time of occurrence, symptoms, and control methods used.

Classification of Operations

Item	Type		Category		Subcategory		Type		Category		Subcategory	
Reforestation	A	Natural regeneration	1	Regional survey			C	Model Forest	1	Land preparation	1	Measurement
			2	Land preparation							2	Felling small trees
			3	Light control							3	Felling medium and large trees
			4	Nursery	1	Weeding					4	Burning
					2	Salvage cutting					5	Planting plan
	B	Artificial regeneration	1	Land preparation	1	Measurement			2	Planting post	1	Marker post
					2	Felling small trees					2	Planting
					3	Felling medium and large trees						
					4	Burning			3	Supplementary planting	1	Survival survey
					5	Planting Plan					2	Planting
			2	Planting	1	Marker Posts			4	Nursery	1	Weeding
					2	Digging					2	Cleaning-cutting
					3	Planting						
							D	Others	1	Construction of new forest paths		
			3	Supplementary planting	1	Survival survey			2	Repairing forest paths		
					2	Supplementary planting			3	Blight control		
									4	Survey		
			4	Nursery	1	Weeding & climber-cutting			5	Mechanical treatment		
					2	Cleaning-cutting			6	Odd-jobber		
					3	Girdling			7	Others		

Classification of Nursery Operations

No.	Category	Subcategory	
1	Observation of mother trees		
2	Seed	Collection	
		Selection	
		Germination test	
3	Sowing	Seedbed preparation	
		Soil transfer	
		Sowing, etc.	
4	Transplanting		
5	Chemical treatment		
6	Normal nursery	Bed preparation	
		Soil transfer	
		Transplanting	
7	Potting nursery	Pot preparation	
		Soil transfer	
		Transplanting	
8	Installation		
9	Shipping		
10	Watering		
11	Soil preparation	Collecting soil	
		Fertilizer	
		Mixing	
12	Test		

Daily / Monthly Report on Reforestation
Daily / Monthly Report on Nursery

Month, Year

Type of Operation					
Block					
Day / Item	Man/work	Remarks	Man/work	Remarks	
1					
2					
3					
4					
5					
6					
Man/work/month					

Summary of Reforestation and Nursery Procedures (annual report)

Year _____

No.	Type	Category	Subcategory	Work Amount	No. of Steps	Man/work	Remarks

Daily Shipping Report

Date	Species	Type of Seedling *	Block No.	Remarks

* Write the time in seedbeds - the time in nursery beds - the time in pots on a monthly basis.
For example, 1 - 6, or 1 - 5 - (2). Circle the period of potting.

Record of Natural Regeneration Plots *1, *6

Block _____

Area	Topography	Slanting Direction	Soil	Cover degree *2	Situation Prior to Felling	*3	Existence of Saplings in the Previous Year	*3
	Flat, gentle, steep							

Species		A			B			C	D
Month Year	Book No.	Height	Basal *4 Diameter	No. of Trees	Height	Basal Diameter	No. of Trees		

*1: Attach a 1/5000 map showing the plot location.
*2: Light conditions is optional.
*3: For example, write the conditions of upper-, mid-, and lower-layer trees.
*4: For trees with an average height of 50 cm or less, write only the number and height.
*5: Write the code number of the book.
*6: Attach a distribution map of mother trees including their height, D.B.H., and crown area.

Record of Artificial Regeneration & Model Forest *1

Block *2

Area	Length of Line Cleared	Height of Reserved Tree	Soil	No. of Planting Lines	Survival Percent	Planting Space

Month Year	Species	Type of Seedling	Average Height	Average D.B.H.	No. of Trees	Light conditions	Damage	Book No.	Remarks

*1: Attach a 1/5000 map showing line locations.
*2: Include the code numbers of the lines. If there are different clearing widths in the same block, comply with the other ledgers. Include daily outplanting reports.

Progress of Operations

Block

Month, Year	Category	Subcategory	Amount	Man/work	Remarks

Record of Trunk Forest and Temporary Forest Roads

Name	
Type	
Standards	

Extension (m)	1982	1983	1984	1985	1986

Progress of Operations

Month, Year	Category	Amount	Man/work	Remarks