Report of Feasibility Survey
(Second Survey)
For Afforestation Cooperation in New Hebrides

August 1978

Japan International Cooperation Agency

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FOREWORD

New Hebrides and Japan maintain close relations, especially in the fields of trade, fisheries and tourism.

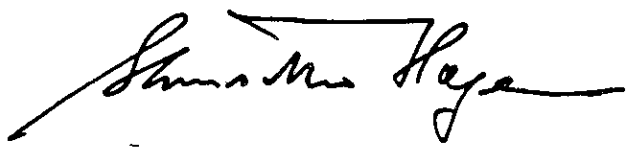
New Hebrides is endowed with abundant forest resources covering more than two-thirds of its land area, and their efficient utilization is essential for the development and stabilization of its economy. For this reason, a series of forest surveys have been conducted in New Hebrides on a private basis.

A forest survey was conducted recently in New Hebrides by a Japanese survey team as part of overseas development cooperation services of the Japan International Cooperation Agency with a view to formulating a detailed plan for afforestation and exploitation of forests on a private basis.

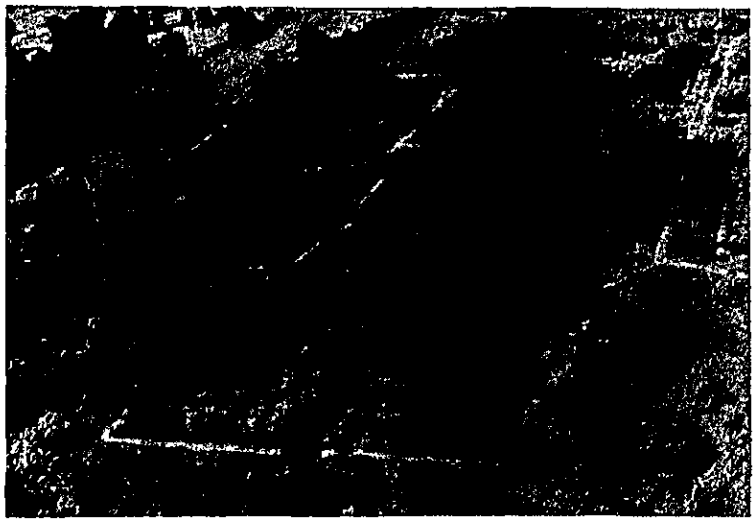
It is my sincere hope that this report, which presents the findings of the above survey team, will be found useful as offering a model of forest-building and exploitation in New Hebrides and at the same time serve for economic development of the country as well as for the furtherance of friendly relations between our two countries.

I avail myself of this opportunity to express my deep appreciation to the government authorities and officials concerned of New Hebrides, United Kingdom and France for their valuable cooperation extended to the survey team.

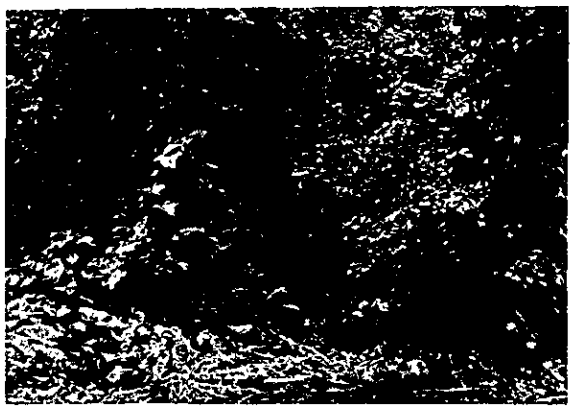
August 1978



Shinsaku Hogen
President
Japan International Cooperation Agency

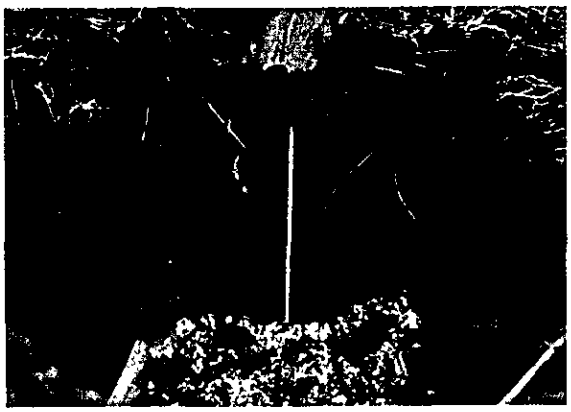


Eastern flat land on the Santo Island.



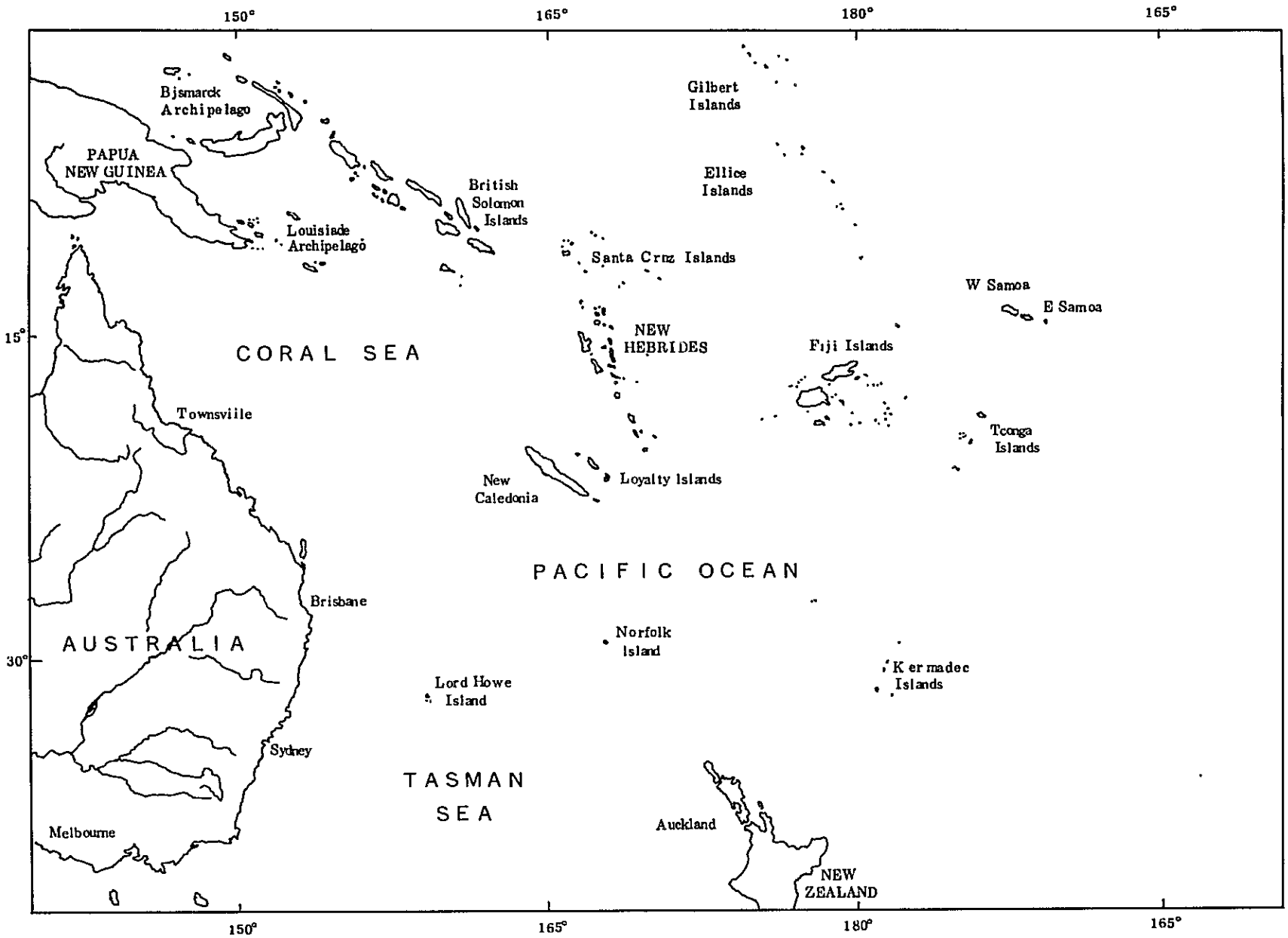
Vines in Santo Island

Soil Profile in Shark Bay



Soil Profile in Vanafo

Soil Profile in Tembotalo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British Solomon Islands
Gilbert Islands
Ellice Islands
Santa Cruz Islands
W Samoa
E Samoa
NEW HEBRIDES
Fiji Islands
CORAL SEA
Townsville
Tonga Islands
New Caledonia
Loyalty Islands
PACIFIC OCEAN
Brisbane
AUSTRALIA
Norfolk Island
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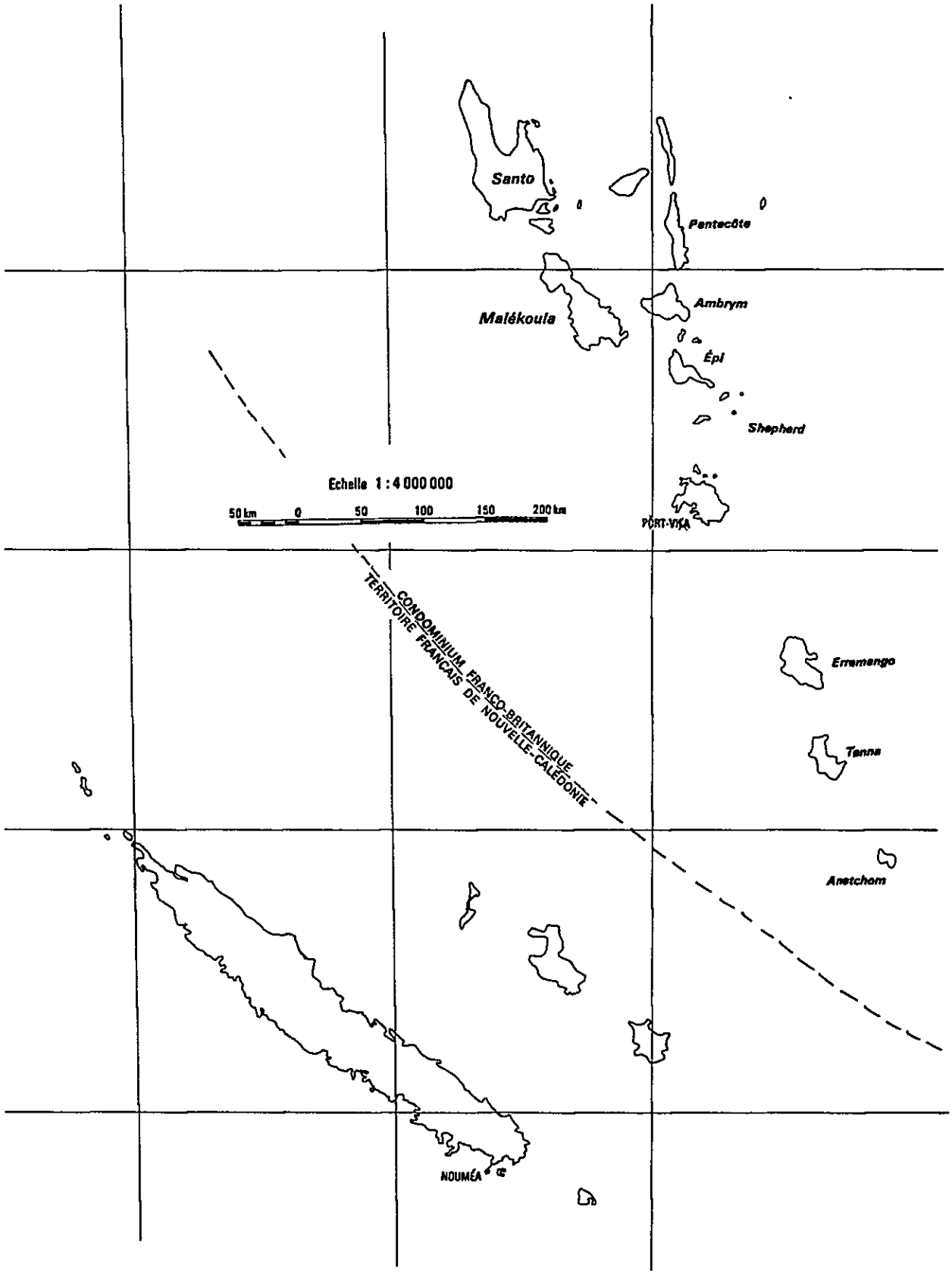
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PORT-VILA
CONDOMINIUM FRANCO-BRITANNIQUE
TERRITOIRE FRANÇAIS DE NOUVELLE-CALÉDONIE
Erromango
Tanna
Aneityum
NOUMÉA

CONTENTS

INTRODUCTION

1. SUMMARY

(1) This report will describe results of the "Second Feasibility Survey for Afforestation Cooperation in New Hebrides" which was made from February 8th through March 2nd, 1978 to find the most suitable method of afforestation in New Hebrides. This survey was preceded by a similar survey conducted by the Association for International Cooperation of Agriculature and Forestry in November 1970 (which was designated as the first feasibility survey).

(2) The Santo Island is considered best suited for afforestation among the islands of New Hebrides. Although Santo is not blessed with rich forest resources at present, it belongs to the tropical rain forest region and offers rapid forest growth as proven by data from an experimental plantation project implemented by the local government. Since cyclones visit the island at an average frequency of 18 years, it is recommended quick growing species such as pulpwood be planted rather than species which grow to trees of larger stem diameter.

(3) New Hebrides will become independent in 1980. In implementing afforestation projects, it is necessary to work in close coordination with officials of the local, British and French Governments and to take into consideration the local government's development policy and the system to be developed after the independence. For instance, copra and livestock are New Hebrides' two biggest industries. It is believed afforestation projects are unlikely to compete with these key industries for the moment. However, afforestation could be affected by these traditional industries depending on the local government's future development policies.

(4) Infrastructure including roads and harbors which will be required as afforestation projects are implemented is yet to be constructed or improved. Construction of infrastructure and securing of land for afforestation must be carried out by adapting to the local government's construction plan and local land ownership system. For this purpose, it is requested that the local government and agencies concerned extend active cooperation and assistance.

(5) Little data is currently available for selection of species for afforestation, and decision on feasibility of afforestation projects. It is necessary to collect data and information by managing experimental plantations in the future. In the first stage, small-scale experimental forests should be planted to establish afforestation techniques. In the second stage, medium-scale experimental forests should be planted to acquire economic techniques.

It is desirable to start afforestation projects on a commercial scale only after these techniques have been established.

(6) In planting experimental forests, the following steps should be taken: (1) This afforestation should be efficiently conducted in close coordination with experimental afforestation efforts made by the local government. (2) Remaining natural forests should be utilized as windbreak forests against cyclones as much as possible. (3) Five species of vines grow on the Santo Island and measures against these climbing plants should be fully studied.

(7) The local government and agencies concerned were highly cooperative with the current survey. They are placing great hope on the development of the Santo Island based on results of the survey. They also count on appropriate cooperation and guidance by the Japanese Government to the investment by Japanese corporations.

2. BACKGROUND UP TO CURRENT SURVEY

(Seccnd Feasibility Survey)

Association for International Cooperation of Agriculture and Forestry made a field survey of New Hebrides and New Caledonia for 15 days from November 6 through 20, 1977 to investigate and study desirable methods of forestry development in these territories.

Results of this survey are summarized as follows:

(1) New Hebrides offers soil and climatic conditions suitable for forest development with good prospects for successful afforestation projects.

(2) New Hebrides is not blessed with natural resources. Copra, its main traditional crop, is affected by sharp price fluctuation in the international market. Thus its economic foundation is extremely unstable. Local government officials are strongly interested in utilizing unused secondary forests as pastures as well as developing forests of high commercial value to establish a sound economic foundation.

In implementing afforestation projects, they place much hope on Japanese technical and financial cooperation.

(3) For afforestation in New Hebrides, the Santo Island is best suited because its infrastructure is comparatively better than any other islands of the territory including roads, harbors, water supply and power. For the scale of afforestation, the project should be started with a small-scale experimental plantation. As necessary techniques are acquired, the project should be advanced to larger experimental forests and ultimately to full-scale commerical forests.

3. OBJECT AND METHOD OF CURRENT SURVEY

The current survey was directed to the Santo Island which is considered best suited for afforestation in New Hebrides. The object of the survey was to investigate natural and economic conditions on the island, find the present situation of forests and forestry, and select sites and species for afforestation, thereby formultating a basic concept of forest development.

Another object was to define a plan to find the forestry development project that is adapted to local conditions and needs.

To accomplish these survey objects, the interpretation of aerial photographs, and aerial and ground surveys (by defining model areas) were conducted as well as exchanges of views with officials of the local government and agencies and people of local organizations concerned.

4. COMPOSITION OF SURVEY MISSION AND ITINERARY OF SURVEY

4-1 Composition of survey mission

Name	Responsibility	Organization and Position
Hisashi Oya	Leader of mission	Managing director, Japan Greening Center
Masaki Sugihara	Cooperation and planning	Planning officer, Business Section, Forestry Agency
Shigeo Yamada	Forest survey	Senior researcher, Survey Department, Japan Forest Technical Association
Jiro Hayashi	Infrastructure and machinery	Director of 2nd Forest Road Technical Department, Forestry Civil Engineering Consultants
Toshio Takaku	Afforestation	Japan Overseas Afforesting Association
Junzo Honma	Coordination	Financial Cooperation Division, Forestry Development Cooperation Department, Japan International Cooperation Agency

4-2 Itinerary of survey

Day	Date	Itinerary	Activities		Stay
1	1978 Feb 8	Tokyo			
2	9	Sydney	AM	Courtesy call at Consulate-General	
			PM	Discussion on arrangements for survey among mission members	
					Sydney
3	10	Sydney to Noumea	PM	Courtesy call on Honorary Consul Noumea	
4	11	Noumea to Port Vila	PM	Arrangements with Delegate by Minister of Natural Resources and forestry official	
					Port Vila
5	12		Collection of data and materials; discussion on arrangements for survey among mission members		
					"
6	13		AM	Courtesy call on local government officials; exchange of views with Ministers and officials concerned	
			PM	Visit to an agricultural school	
					"
7	14	Port Vila to Santo City	AM	Advance party comprising Sugihara, Yamada, Hayashi and Takaku moved to Santo City and made observation tour of port facilities and copra factory.	
					Santo
			AM	Leader and Honma paid courtesy call on senior planning officer of the Planning Bureau of local government and French Residency then moved to Santo City.	
			PM	Paid courtesy call on British and French district agents and exchanged views with them.	

8	Feb 15	AM	Visted Forestry Training Center Santo
		PM	Surveyed Vanafo experimental plantation
9	16	AM	Surveyed Navota experimental plantation
		PM	Visited South Pacific Fishing Co. (New Hebrides) Pty. Ltd. and gathered information.
			Surveyed Navota experimental plantation (exchanged views with the chief of Navota tribe).
10	17	AM	Inspected proposed site for harbor (Hog Harbor, Shark Bay).
		PM	Made general aerial survey by chartering a plane.
			Visited a local company, Sody Pac, and obtained information.
11	18	AM	Exchanged view with the Land Committee of Nagriamel tribe.
		PM	Revisited South Pacific Fishing Co. and obtained information on management.
12	19	Surveyed forests in Tabwemassana district.	
			"
13	20	AM	Surveyed forest and soils in Big Bay district.
		PM	Surveyed forests and soils in Nagriamel district.
			Paid courtesy call on Santo City Mayor and exchanged views.
14	21	AM	Surveyed forests and soils in Tabwemassana district.
		PM	Surveyed experimental plantation in Navota and inspected proposed site for harbor.

15	Feb 22	Advance party: Santo City to Port Vila	AM	Visited industrial estate. Paid courtesy call on chief of Nagriamel tribe and exchanged views.
				Port Vila (advance party)
				Visited Santo district office of local government and exchanged views with officials.
			PM	Advance party (leader and Sugihara) moved to Port Vila, paid courtesy call on Finance Minister of local government and obtained financial and political information.
16	23	Second party: Santo City to Port Vila	AM	Leader and Sugihara paid courtesy call at a local political party, National Party, and exhanged views.
				Exchanged view with Minister of Natural Resources and his advisers.
				Paid courtesy call on Port Vila Mayor (who concurrently holds post of assistant chief of Geographical Bureau) and exchanged views.
				Second party comprising Yamada, Hayashi, Takaku and Honma arrived in Port Vila.
				Port Vila
			PM	Paid courtesy call on Chief Minister, cabinet ministers and British Residency, exchanged views with them and reported outline of surveys to them.
17	24	Port Vila to Noumea to Koumac		Koumac
18	25			Inspected experimental plantation in Cresson and Meretrice.
19	26			Inspected experimental plantation in Col de Point.
20	27	Koumac to Noumea		Noumea

21	Feb	28	Paid courtesy call at French Government-General and exchanged views.
			Noumea
22	Mar	1	Noumea to Nadi to Honolulu
23		2	Tokyo

The members of the survey mission visited and exchanged views with the following organizations and responsible personnel;

Port Vila

Mr. Georges Kalsakau	Chief Minister
Mr. Pottier	French Resident Commissioner
Mr. Champion	British Resident Commissioner
Mr. Vincent Boulkone	Minister of Interior
Mr. Guy Prevot	Minister of Finance
Mr. Albert Ravutia	Minister of Natural Resources
Mr. H. Briand	Delegate by the Minister of Natural Resources
Mr. J. Negri	French Resiency
Mr. G. Norris	British Residency
Mr. P. Delacroix	Cabinet Minister of Natural Resources
Mr. R. M. Bennett	Forest Officer
Mr. P. Ackroyd	Central Planning Officer
Mr. Tamaguchiku Saburo	Officer of Natural Resources

Santo

Mr. Michel Noel	Maire President, Santo
Mr. Coulon Robert	Maire Adjoint
Mr. Jardin Roiland	Secretariat
Mr. Redstone	British District Agent, Santo
Mr. Roland Veyrent	French District Agent, Santo

South Pacific Fishing Co. (New Hebrides) Pty. Ltd.

Noumea

Mr. Dujardin	Secretaire General Adjoint
Mr. Joji Tsutsui	Honorary Japanese Consul at Noumea

Sydney

Mr. Hiroshi Masuda	Japanese Consul at Sydney

CHAPTER I OUTLINE OF AREA COVERED BY SURVEY (THE SANTO ISLAND)

1. NATURAL CONDITIONS

1-1 Position and geographical features

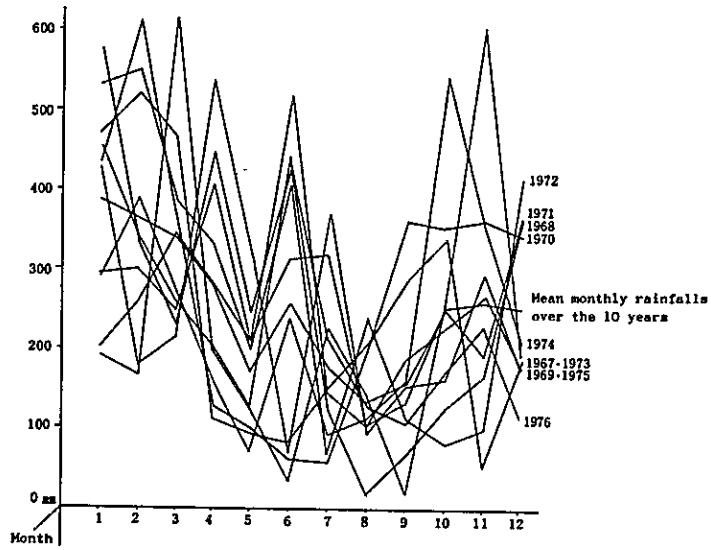
The Santo Island, the largest island in New Hebrides, lies 15°40' to 14°38' south latitude and 166°30' to 167°15' east longitude and has an area of 320,000 hectares. Mountain ranges run from south to north along the west coast with Mount Tawemasana (1,879m), the highest peak in all the New Hebrides Islands. In the north of Santo, peninsulas jut out to the east and west and form Big Bay. The River Jourdain empties into this bay. This river divides the island into the western part with undeveloped mountainous areas and the eastern part which features relatively flat land.

1-2 Climate

An observation station is located at Pekoa (15°31' south latitude and 167°13' east longitude; an altitude of 42m above sea level) and observation data is available from 1951.

(1) Rainfall

The following chart shows mean monthly rainfalls over the past 10 years from 1967 to 1976. The mean annual rainfalls over the 10 years was 3,056mm.

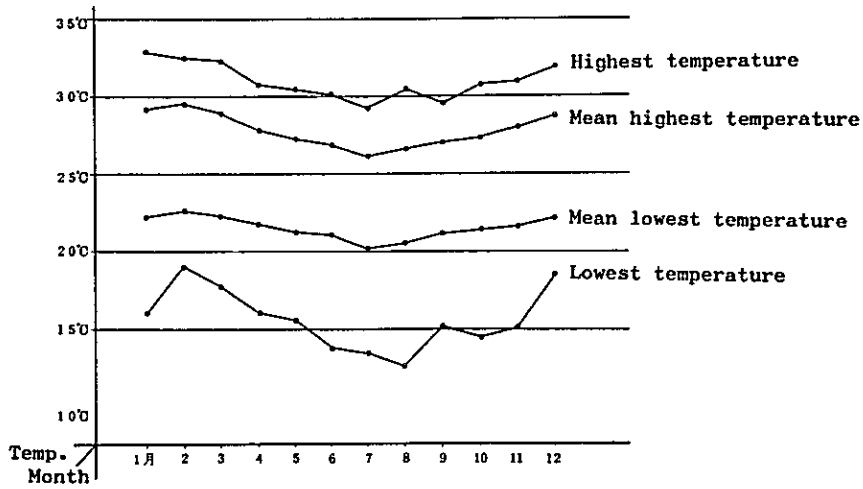


The table below shows the average number of rainy days and average largest daily rainfall by month over the past 10 years.

Month	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
Rainy days	24	21	24	20	19	18	19	16	16	19	18	20	235
Max.daily rainfall	156	203	201	196	114	236	73	80	102	259	214	151	1985

(2) Temperature

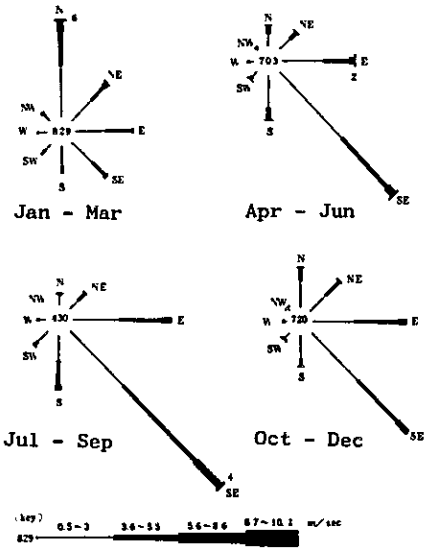
The graph below shows mean monthly temperatures for 20 years from 1951 to 1970.



(3) Force and direction of wind

Both the force and direction of wind are observed 7 times a day (at 5:00, 8:00, 11:00, 14:00, 17:00, 20:00 and 23:00). They were measured a total of 7,672 times over the three years from April 1973 to March 1976. The wind velocity was not recorded when it was less than 0.5m/sec.

The following charts show the force and direction of wind by quarters of the year. Resuts of 10 measurements are represented in 1m/sec.



(total measurement value)

Analysis of these meteorological observation data shows that there is no clearcut distinction between the wet and dry seasons on the Santo Island. A north or northeast trade wind blows from December to March. A southeast trade wind prevails from April to November. In general, there is much rainfall with high temperature and humidity when the prevailing trade wind is from the north. Rainfall is small when the southeast wind prevails.

Most rainfalls are showers of short duration. The mountainous region has much more rainfall than the data given.

(4) Cyclone

Cyclones which visit the Santo Island are spawn in the vicinities of the Solomon Islands and Coral Sea and move southward by gradually increasing their force. The following table shows records of cyclones which struck the Santo Island and its neighboring islands during 37 years from 1941 to 1977.

1941 - 1977

Data	Name	Banks	Santo	Aoba	Pentecost	Ambrym	Malekula
41. 2/3		*					
44. 2/4						*	*
48. 1/24			****			***	****
51. 2/		**	**	**	**	**	**
51. 12/25						****	***
54. 2/15		**	**	**	**	**	**
55. 1/3		*					
60. 1/							***
63. 11/18					***	***	
64. 2/	EPITA	**	**	**	**	**	**
64. 3/31	Henrietta	***	***				
65. 3		*	*				
67. 2		*	*	*	*	*	*
68. 12/14	Becky		***	***	***	***	****
69. 2/1	Collen					*	*
69. 2/18	Irene		*	*	*	*	*
70. 12/30	Rosie						*
71. 12/9	Ursula				**	**	**
72. 1/18	Carlotta		***	***	***	***	***
72. 2/2	Wendy	****	****	****			***
72. 12/13	Diana	*	*	*	*	*	*
75. 3/5	Alison					**	**
75. 3/31	Betty		*	*			*
76. 1/14	David	**	**	**	**	**	**

Note: Wind force 17 2m/sec ~ 24 5 m/sec
** more than 32.7m/sec
*** with record of considerable damage

This observation record shows that the Santo Island was hit by cyclone 14 times. Of these 14 times, extensive damage was inflicted only twice, each at an interval of about 2.6 years and 18.5 years. Moreover, the damage involved the whole area of the Santo Island. Since the wind damage inflicted even by a powerful cyclone is limited to the area within its radius of about 80km, it is believed that any given area on the island will sustain damage much less frequently.

According to local government officials concerned, the frequency of cyclones passing the same area is about once in five years. As is clear from the table, cyclones visit the island only in a period from December to March when north and northeast trade winds prevail.

1-3 Geology and soils

(1) Geology

The Santo Island can be roughly divided into two regions, namely the western mountainous region and the eastern flat land.

The western mountainous region can be subdivided into the steep south part comprising volcanic rocks of the Neocene Miocene aquitanian and the less steep north consisting of rocks of the Miocene langhian.

In the south, precipitous ridges and V-shaped valleys are formed. The watershed in the north is relatively flat.

In contrast, the eastern flat land is relatively new in geological classification. This region is elevated with coral reef limestone belonging to the quatanary period. Igneous bed rock intrudes into the bottoms of the rivers Sarakata and Wambu.

(2) Soils

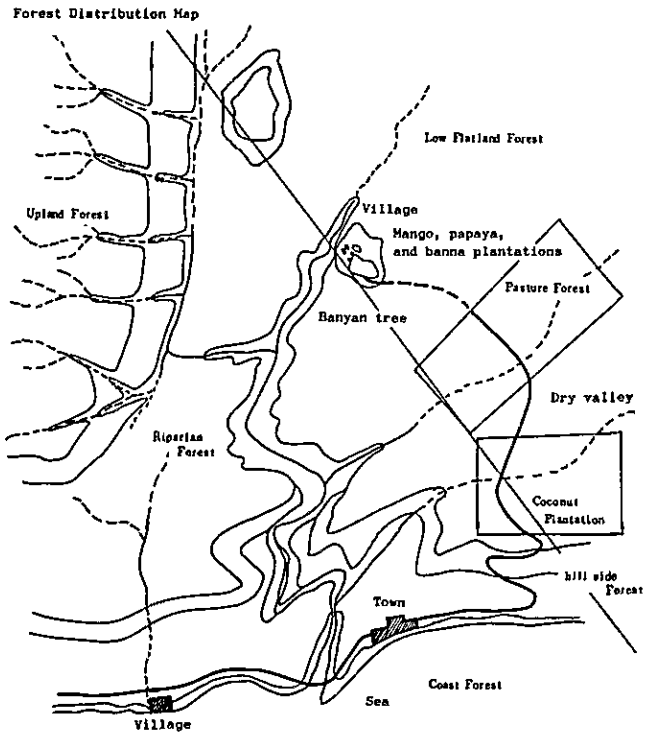
The eastern flat land, the subject of the current survey, is generally fertile, being covered with volcanic ash soil and weathering coral reef soil.

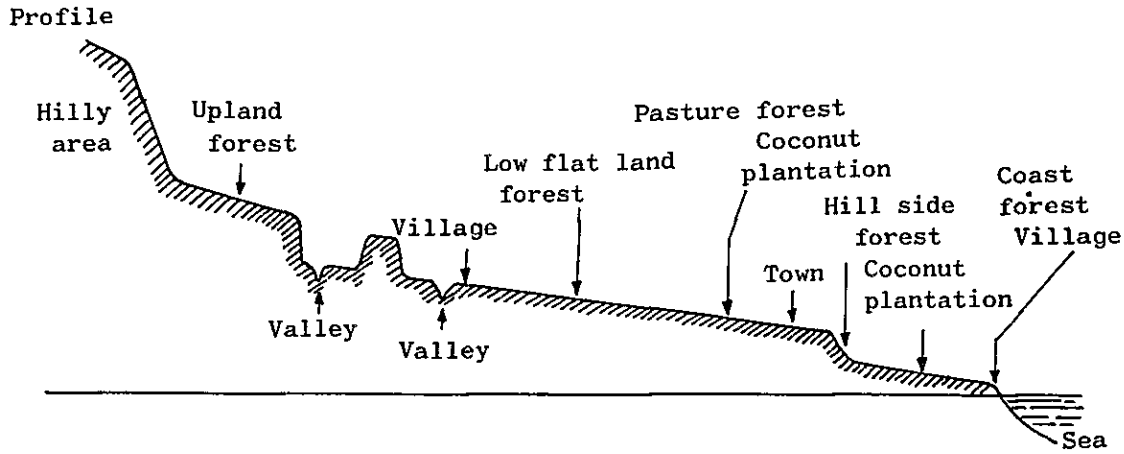
PH value taken at several points ranged from 4.0 to 7.0. In some part of the hilly area in the east, the top soil is shallow so that coral reef rocks are exposed. In the flat area, A-horizon is thick and the soil resembles Japanese Kanto loam.

1-4 Present situation of forests

Since the Santo Island, except its western hilly region, is considered to be the proposed site for afforestation, its topography and approximate distribution of vegetation were surveyed. Based on this survey, the following forest distribution map and profile were produced.

In the northern area, the flat land leading to the coast is actually narrower than represented on the map.





According to the rough demarcation as shown on the map, each area will be described with particular attention to forest vegetation.

(1) Coast forest

Coast forests are distributed along the coast and the mouth of the rivers. There are salt marsh forests at the mouth of the river discharging into Big Bay in the north, near Belmoul Lagoon in the south, and at the base of Palikula peninsula in the southeast. However, the coast forests will be treated without further subdivision.

The following table lists major species of trees. Generally, tree species in this area are as low as 14 to 15m in stem height and the diameter at breast height is up to only 40 to 60cm. The accumulation per hactere remains at 140m^3. Unlike coast forests in Japan, tree stems are not forced to be inclined toward inland by the force of sea wind. Some species grow with some portions dipped in saline water or in land inundated with such water.

As compared with other areas, there are fewer trees with vines climbing over their stems in forests including those bordering on villages and coconut plantations. No thin forests due to windthrow were found, either.

Table Showing Major Coast Forest Species

Scientific Name	Common Name	Characteristics
Casuarina equsetifolia	Oak tree	Abundant along coast and resembles pine trees. With fungus roots, grows in adverse condition of infertile soil. Quickly grows with straight stem. Hardwood difficult to work. Used for handles of implements, storm doors, and firewood as well as material for local wood carving objects.
Barringtonia asiatica	Fish poison tree	A species generally occurring along coasts. Grows to considerably large size and often with small trees. Its crown is irregular and expansive. Wood is used for making forms and floats. Poison to stupefy fish can be produced by compressing seeds and kneading them with water. Hence name of fish poison tree derived.
Acacia simplicifolia	Namariu	Coast vegetation. Usually medium-size trees but sometimes grows large. Many young trees and seedlings grow around the main stem. Crown is slender and branches hang down. Study is yet to be made on wood.
Calophyllum inophyllum	Nabangura	Coast vegetation. Grows to large trees and often has plagiotropic branches close to water surface. Stem is short and crown large and dense, spreading, horizontally. Wood is hard and used for boats, building materials, furniture, musical instruments and golf club heads.
Cerbera odollam		A species of oleander and a small coastal tree. Stem is short and crown is irregular. Soft wood useful only as firewood. Both milk from bark and seed are poisonous and once used as a poison in India.

Cordia sucordata		Most common coast vegetation. Easily distinguished by bright orange, trumpet-shaped flower it bears throughout the year. Seldom grows to a large tree. Crown is round and dense. Hardwood. Of little commercial value because of small or medium size.
Ochrosia oppositifolia		Commonly found along coasts. Like Casuarina above, often occurs on exposed land. Crown is vivid green and dense. Detailed study on wood is yet to be made but wood is used in building rafts and oars.
Terminalia catappa	Napapoa	Distributed near inhabited areas and coasts. Crown is flat and in layers. (Branches are verticil.) Flowers are in spikes and as long as 12cm. (Each flower is white and small.) Durable hardwood used for light building materials, floor boards and furniture.
Pometia pinnata	Natau	Distributed near inhabited areas and coasts. A medium-size tree easily distinguished by its red young leaves. Considerably durable wood used for floor boards, plywood, and other building materials.
Pterocarpus indicus	Nananara	Widely distributed along coasts. Usually a medium-size tree but sometimes grows to a big tree. Crown is bluish green, round and expansive. Wood is hard and durable both in and out of water and is an important material for furniture. Because of quick growth and vigor sucker, used in building fences.

(2) Coconut plantations

Except the western part of the Santo Island, tracts of low flat land of varying width extends for some distance (2 to 3km in the south) from the coast. On these tracts, coconut plantations are widely distributed besides towns and other inhabitated areas, port facilities and roads.

Coconut palm trees grow to a height of 15 to 25m with a diameter of 30 to 60cm. There are many coconut plantations with aged trees or those affected by insect damage because few trees have been planted since the end of World War II. However, no thinned plantations due to windthrow, etc. were observed.

(3) Hill side forests

Coast forests and coconut plantation as described above are distributed in the low flat land along the coast up to an altitude of 20 to 30m above sea level. While some forests further extend toward inland by gradually gaining their altitude, most forests head for inland, increasing the altitude in steps of 20 to 40m.

In the south, the topography presents a hill side slope of 20 to 30°. Forests in the area which lies at this turning point in topography have been defined as hill side forest for this report.

This classification is made on the topographical demarcation, and tree species in hill side forests are not particularly different from those in low flat land forests to be described below. However, according to an interpretation of aerial photographs (and results of some ground survey), sparsely wooded plots are very few in hill side forests in the south and central part, although these regions serve as a turning point in topography and are believed vulnerable to damage from cyclones.

(4) Low flat land forests

When one climbs hills near the coast described above, one can see the land gradually increase in altitude toward inland and lie flat extensively.

Except a limited number of main water systems forming valleys, conspicuous undulations are very few. This area has been defined as a low flat land forest for this report.

Even within this area, coconut plantations are still found near the coast as well as some pasture forests.Note 1

Low flat land forests account for the largest area among the forests taken for study in this report. There is no previous record of forest survey on the Santo Island, but survey results are available on 5,200 ha of Tuku Tuke pasture on the Efate Island. According to the results, there were species with a stem height of 2.5m or more and a diameter at breast height of more than 30cm. Of the 35 species measured, species with a growing stock of more than 5% include the following five:

Antiaris toxicaria (milk tree)	34.2%
Syzygium malaccensis (yellow wood)	13.1%
Elattostachys falcata (Nguli)	10.0%
Castanospermum australe (bean tree)	7.5%
Dysoxylum amoororides (stink wood)	5.7%

Major Low Flat land Forest Species

Scientific Name	Common Name	Characteristics for Identification etc.		Wood Quality	Application
Antiaris toxicaria	Milk tree	Straight stem (bluish white; distinctive stoma) Crown is round on side (thin). Many big trees stand.	buttress Large, thin, and inclined	Bluish white softwood, lacking in durability. Yields large amount of milky juice.	Used for forms, plywood, and interior decoration finish. Locally used as general timber materials. For straight and big wood, development for further utilization is recommended.
Dracontomelon vitiense	Nakatambol	Medium and large size trees. Crowns of big trees are dense and spectacular. Bark in pinkish light blue peels off in large irregular shapes as a distinctive feature of this species.	Particularly big, thin and extensive	Bright gray hardwood	Used for furniture, plywood and rifle butts. Broad roots are used for tables, locally building materials.
Garuga floribunda	Namalans	Medium and large size trees. Crowns expand. Generally, straight stem is short and develops branches from lower portions. Thin, coarse bark is easy to peel off.	Not uniform. If exist, not big.	Hard and durable. When dried, difficult to be worked.	Used as general building materials and mould, locally building materials.

Kleinhovia hospita	Namatal	Easily distinguished by pink flowers blooming all over crown in all seasons. Crown is round and dense.	None	Soft light wood lacking in durability. Prone to insect damage.	Knots are used as ornaments in Malaya, wooden shoes, household woodworking material, and floats of fishing nets in New Guinea. Young trees are used for thatching roofs. Leaves and bark are used as parasiticides.
Endospermum medullosum	White wood	Branches are verticillated and form flat layers at top of stem. For this arrangement, easily distinguished from a distance.	Small and flat	White softwood. Not durable and easy to work.	Important wood on Fiji. Suited for coating, and used for furniture, coffins, art objects, interior decoration finish, and match.
Castanospermum australe	Bean tree	Crown is dense and slender with dark green shining leaves. Stem is not so long but round, straight wood can be obtained.	None	There is much soft sapwood. Vivid yellow. Vulnerable to insect damage.	Used for plywood, wood carving material, furniture, inlaying material, potter's wheels, and rifle butts.
Dysoxylum amooroides	Stinkwood	Crown is dense and round. Bark is coarse and brown with cracks. On aged trees, it peels off in thin flakes.	None or small if any. Sometimes grows large and expands.	Wood is attractive but difcult to be worked. Takes time to dry. Considerably durable.	General building materials. Suited for furniture.

The Santo Island is located 280km to the north of the Efate Island with a higher temperature and more rainfall. Like the Efate Island, milk tree accounts for the largest number. However, other species are slightly different in percentage composition. There are seven major species for low flat land forest trees as shown in the following table.

The best forest is found near Pekoa where the airport is located, although its area has been reduced recently because of road construction and other development. In this forest, there are many trees with a stem height of more than 30m and a diameter at breast height of more than 60cm.

Species in other low flat land forests are not uniform in composition and are difficult to explain collectively. Common to these forests, vines (Note 2) are rampant and most standing trees are covered with these climbing plants. Only a few trees free of these plants prominently rise sporadically. In some places, straight medium and large size trees grow in crowds.

Utilization of tree species given in the table mainly refer to those in other than the Santo Island. Utilization of milk tree and other species should be studied in the future.

Note 1. Pasture forests

Composition of species in pasture forests are the same as those in surrounding low flat land forests. In many areas, a few valuable trees such as Castanosperum australe (bean tree) were cut and Antiaris toxicaria (milk tree) which is of little value at present is left purposely. In some areas, trees were extensively felled to develop pasture land. However, in many parts, livestock animals are allowed to graze in natural forests. In such areas, vines are eaten by livestock and tree stands are much more vigorous than those in other areas.

Except for plots where no stands exist over an extensive area, pasture forests are generally not substantially different from surrounding low flat land forests in the growing stock of stands. In some parts, the stands have more growing stock than areas with a conspicuous growth of vines.

Note 2. Vines

Vines grow thick over an extensive area on the Santo Island, particularly in low flat land forest zones. In the worst case, standing trees of 15 to 16m in height are entirely covered with these plants. Becuase the sunlight is completely screened in this manner, trees are dead. Trees are also said to be fallen under the heavy load of waterlogged vines as well as the increased resistance to wind.

The following were five common species of vine:

Dabele: A domestic with large, thick and shining leaves.

Futoni: A domestic with leaves resembling those of arrowroot.

Ichinol: A domestic with leaves resembling those of a morning-glory. Stalk have thorns. Many plants bear fruit the size of a small plum.

Bikon: An exotic with thin leaves. Said to have been introduced as pasture by the French.

Bonbale: An exotic with thin leaves. Said to have been introduced for camouflage by the U.S. force during World War II.

Together with cyclones, the extent of vine growth will affect plantation. These plants will quickly cross forest roads and intrude into newly planted plots.

Particularly, Bonbale (Mikania micrantha) is a vigorous perennial vine characterized by many heart-shaped leaves and small white or cream color flowers. It yields a large number of seeds.

This species was discovered on Fiji in 1907 and named M. scadens. The present name was given by A. C. Smith in 1942. Leaves develop symmetrically. They are pointed at the tip, have no hair, and measure 5 to 7.5 cm long and 37 to 35 mm wide. When this plant occurs exposed plots, it will show particularly rapid growth. It is widely distributed in areas with much rainfall in South Pacific regions.

Note. Vegetation around inhabited areas

The mountainous region is also dotted with small villages. More villages and towns are located in each part of the low flat land forests.
Around these villages and towns, breadfruit trees (Artocarpus incisus), bannas, pineaple, papaya and mango are grown besides coconut plantations.
Banyan (a large evergreen tree of which aerial roots climb stands and then descend to the ground and become support trees) is distributed throughout the island. Particularly, large banyan trees grow at appropriate places in the center of villages and serve as meeting places.

(5) Riparian forests

Riparian forests are found along main water systems other than dry valleys. (Many water systems penetrate through the soil shortly after they enter low flat land forests from high land forests, or disappear after they flow through side hill forests from low flat land forests.)

Riparian forests comprise a mixture of species given under coast forests and low flat land forests except Casuarina equsetifolia and Acacia simplicifolia. Coast

forest species in (1) will decrease as the distance from the coast increases.

Riparian forests are caracterized by the absence of bare land. As for riparian forests within a low flat land forest, Endospermum medullsum (white wood) distributed in large numbers along their borders.

There are tracts with many small undulations in low flat land forests near these riparian forests.

(6) Upland forests

Although not defined on a topographical map on a 1-100,000 scale, there is a zone which gains altitude in steps near contour lines of about 200 m as a transitional area from low flat land forests to upland forests. Its increments are greater than those on hill side forests along the coast, namely about 50 to 100 m. On the land further upward, a gently inclined tract lies as viewed horizontally.

However, as shown in the "Forest Distribution Map", most of these tracts are dry valleys. Anyway, dissection is substantial in this area including hill sides. Therefore, when one traverses this area in the north-south direction, one will encounter a topography with intensive undulations.

We have designated forests in this area as upland forests. As compared with low flat land forests, upland forests have less distribution of medium and large diameter trees and growing stock is lower.

Although the current survey was not so intensive, it indicated no substantial difference in composition of tree species between low flat land forests and upland forests.

1-5 Estimation of forest growing stock

As a supplementary item of the survey, forest growing stock was roughly estimated based on interpretation of aerial photography compiled in 1972 (Interpretation was made for 140 plots in one hactere. Interpretation key was obtained from field survey on groups of species.)

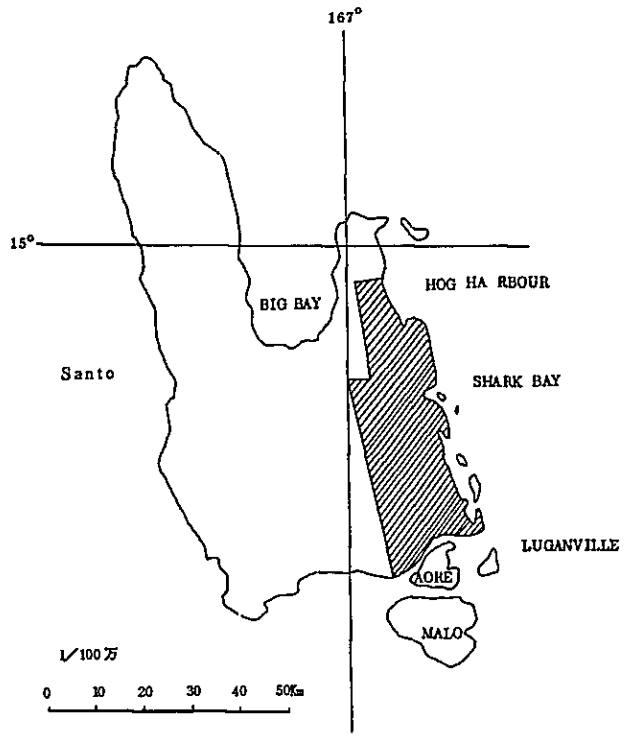
The average of the areas covered by forest composition maps was 44 m^3 per hactere. If this is considered a random sample plot, the confidence interval at 95% reliability is 38 to 49 m^3/Ha.

Estimated Growing Stock by Area

Area		Coverage	Average	Remarks
Coast forest		43 ~ 94	73 m^3/Ha	
Hill side forest		8 ~ 116	43	
Riparian forest		49 ~ 100	60	Average became
Pasture forest		18 ~ 142	51	small due to
Low flat land forest	South	21 ~ 147	72	small value
	Mid-west	2 ~ 95	30	for the north.
	North	4 ~ 47	20	
Upland forest		0 ~ 31	12	

1-6 Preparation of forest composition maps

Three sheets of simplified forest composition map (1-26,000 scale) were produced as attached at the end of this report. They were prepared based on aerial photographs taken in 1972 and a 1-100,000 scale topographical map. These maps cover the area marked with oblique lines in the following map:



The following items were presented on these forest composition maps:

(1) Forest composition classification (0 - 5: 0 represents an area with only a few scattered trees. 1 to 5: high growing stock, high crown density wooded forests)

(2) coconut plantation, (3) pasture forest,

(4) town and village, airfield, etc.,

(5) main road, and (6) water system

These maps are intended for use in grasping general forest situation, and selecting and studying sites for afforestation and road allocation. In particular, these maps clarified areas whose topography is in advanced stages of dissection due to water systems. Such areas are not shown on available topographical maps. However, as far as measurement of distance on the map is converned, the accuracy is nearly in the same order as that with topographical maps.

Type / Forest composition	Coast forest	Hill side forest	Riparian forest	Pasture forest	Low flat land forest	Upland forest	Total forest area
0	-	3	-	1,614	826	19	2,462
1	10	14	15	2,931	10,441	9,455	22,866
2	78	667	197	2,153	20,156	124	23,375
3	535	1,469	2,063	1,564	8,208	158	13,997
4	575	491	156	341	1,784	10	3,357
5	-	77	-	-	264	-	341
Total	1,198	2,721	2,431	8,603	41,679	9,766	66,398

Total forest area	Coconut plantation	Inhabited area and facilities	Swamp land	Roads	Rivers	Total
66,398	5,689	492	149	150	174	73,052

Note: Approximately 900 additional hacteres of coconut plantations exist on the Santo Island, making the total about 6,600 hacteres.

Note: Classification of forest composition (0 to 5)

0: Area where growing stock of standing trees is almost 0 with only very few scattered trees.

5: Forest with high growing stock which lies beside the airfield.

4: Forest with next higher density of stands

3: Dense forest tract which is aboundant in coast and riparian forests

2: Forest area where groups of trees corresponding to class 4 or 5 above sporadically exist but wood is thin as a whole. Vines increase.

1: Forest tract where small groups of trees sporadically exist but wood is thin as a whole. Generally, climbing plants grow thick. This type of area is distributed

in the center of low flat land forests. In upland forests, this type of vegetation is dotted with medium size trees.

CHAPTER II BASIC CONCEPT OF FORESTRY DEVELOPMENT

1. POSSIBILITY OF DEVELOPMENT COOPERATION

1-1 Technical study of afforestation

(1) Recommended species for afforestation

The Santo Island is situated in the tropical high rainfall region and has fertile soils. Thus trees grow extremely fast in experimental forest tracts of the local government. However, the Santo Island is located in the path of cyclones (which leave extensive damage on average once in 18 years). To avert this damage, quick-grow species such as pulpwood should be planted rather than large-diameter trees. In this survey, main emphasis was therefore placed on selection of species suited for production of chip logs. Species particularly suited for pulp production in high volume weight of wood were selected from among those which show favorable growth in natural conditions similar to those on the Santo Island. As a result, the following nine broad-leaf species are recommended:

Species	Origin	Characteristics
Gmelina arborea Verbenaceal	Widely occurs in Southeast Asia	Baars fruit in 3 to 4 years. Fallen fruit is gathered to obtain seeds. The Santo Island is self-sufficient in supply, of seeds. Seed is as large as about 1,400 grainsper/kg. Difficult to store them for long period. Both sprouting and cutting are easy and good growth can be obtained.

Leucaena leucocephala Leguminosae	Central America	Seed has not yet been produced on the Santo Island. It is in about same size as water melon seeds, or 18,000 to 27,000 grains per kg. Possible to store for a long period. For sowing pretreatment is required, involving immersing seeds in hot water after cutting its surface.
Albizzia falcata Leguminosae Mimosoidae	Solomon	Quick growth. Used as a shade plant for tea in Java. Bears fruit in several years. Seed is in size of 30,000 to 42,000 grains per kg. Since outer covering is poor in water permeability, seed is required to be dipped in hot water of 80° to 100°C for about 2 minutes as pretreatment. Growth is extremely rapid.
Caia siamea Leguminosae	Asian Continent	A typical leguminosae seed. Can be stored for a long period. 34,000 grains per kg.
Eucalyptus deglupta Myrtaceae	Papua New Guinea	An eucalyptus which does not grow wild in Australia. Bears fruit in 2 to 3 years. Seeds are gathered in clusters, completely dried and then dropped on a sheet to collect seed grains. Seeds are very fine, being about 1,000 grain per kg. For planting, mixed with sand and sown in sandy soil with good drainage.

Terminalia calamansanai Combretaceae	Solomon	This species has affinity for slightly dry soil, although Terminalia genus is generally adapted to relatively low wetland ground. Easily distinguished by verticillated branches. Seed has a large wing and is in size of 70,000 grains per kg.
Anthocephalus cadamba Rubiaceae	Widely occurring in Asia	A typical light demanding tree Generally flowers and bears fruit in 5 years. Seed is fine, being 17,000 grains per kg. Handled in the same way as Eucalyptus. Big leaves.
Cordia alliodora Boraginaceae	Central and South America	Bears fruit in 4 to 5 years. Seed is a small grain with 3 to 4 small wing. Overall size is about 5mm. On the Santo Island, stump planting was practiced in which the upper portion of the planted seedlings are cut for taking advantage of sprouting.
Eucalyptus urophylla		Details unknown. A French research institute (TFT: Centre Technique Forestier Tropical, based in Paris) planted this species with favorable results and recommended it for afforestation.

Note: For reference, characteristics and other details of these species have been given at the end of this report.

(2) Methods of afforestation

Although the eastern flat land on the Santo Island belongs to the tropical high rainfall region, it is an unusual area with only a few tall trees but rampant vines.

Thin forests of which large area is covered with climbing plants are conspicuous at various spots.

These thin forests have resulted from wind damage due to cyclones and rampant growth of vines. Therefore, it is necessary to take measures against cyclone and vine damage when afforestation is practiced.

1) Measures against cyclones

What occurs first as a measure against cyclone is a windbreak forest. Its effect varies depending on its height and the distance from its location. The following table shows how much the wind velocity is reduced as the distance from a windbreak forest varies:

Distance from windbreak forest (leeward)	Reduction in wind velocity (%)
H	90
2H	75
5H	50
10H	20

Note: H stands for the height of the windbreak forest.

Values in the table will slightly vary according to the width of the windbreak forest, and density, pattern, angle, position, etc. of crowns. Hoewver, the table indicates that it is more effective to plant several forests at an interval five to six times the

tree height that to establish a single large forest.

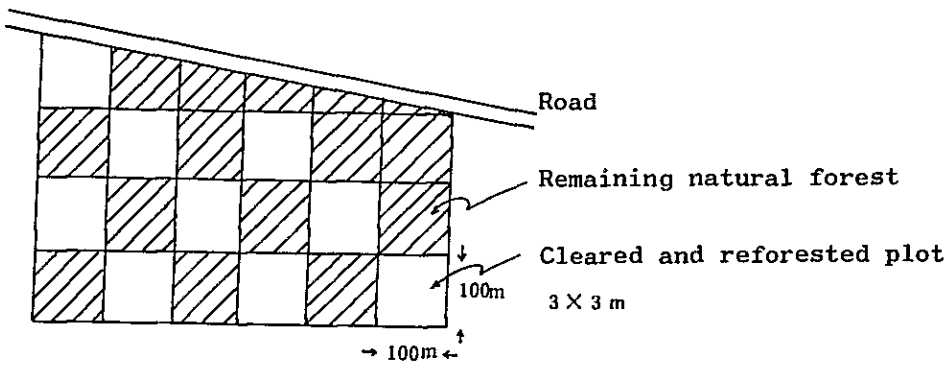
The optimum width is about 10 to 20m, and the maximum windbreaking effect can be obtained when rows of forest belts are arranged at a right angle to the prevailing wind. For winds such as cyclones which blow in varying directions as their centers change, the second forest belt should be arranged at a right angle to the first one. In this manner, several forest belts should be planted in a 90° alternate pattern to break winds blowing in various directions.

On the Santo Island, natural forests that can be utilized as windbreaker are only thin forests. In such a case, special consideration should be made to the width, composition and arrangement of windbreak forests.

The following paragraphs will describe some models of windbreak forest against cyclones:

a. Checkerboard planting method

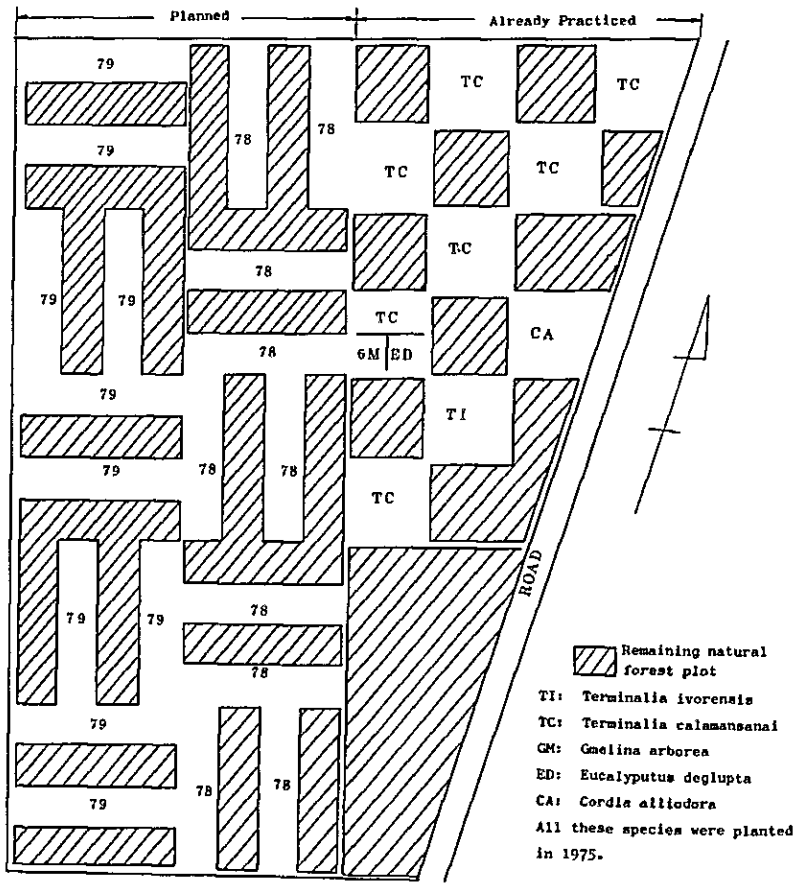
This method was developed by forest officer Bennett on the New Hebrides and has been practiced on a 20ha experimental plot in the Vanfo Experimental Station since 1975.



As shown in the above sketch, this method consists of checkerboarding the proposed afforestation site with 100m x 100m squares. With each square as the unit plot, each cleared and reforested plot is surrounded by remaining natural forest plots. For clearing, a bulldozer is used to upset remaining stands and push toward each side of the square plot with particular care not to remove the topsoil by the bulldozer blade.

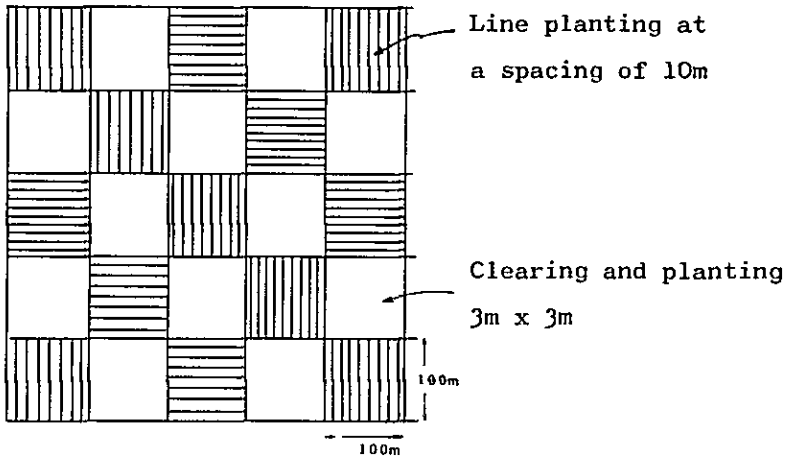
Cleared plots were planted with Terminalia calamansanai, Gmelina arborea and Eucalyptus deglupta at an interval of 3 x 3m.

From this year, the planting pattern has been slighly modified as shown in the following sketch. However, the ratio of the planted area and remaining natural forest area remains the same at 50%.



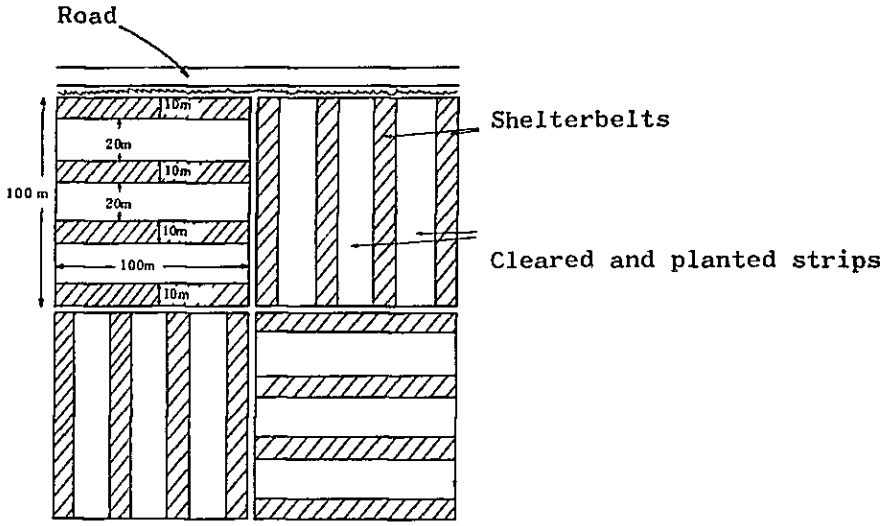
b. Checkerboard planting method by line planting method

This is a combination of clearing and planting with line planting. As shown below, line planting is practiced within remaining natural forest plots. At a spacing of 10, 2m-wide lines are cleared through a natural forest plot. Only trees standing on these lines are either cleared or killed with chemicals. All other stands are left as they are and used as windbreak forests.



c. Belt pattern planting method

As shown below, planting plots in long strip are arranged so that strips in one plot will lie at a right angle with strips in the adjacent plots. Each plot measures 100m by 100m. Shelterbelt of natural forest trees, 10m in width, are left both along the road and inside each plot. Between these natural barriers, 20m x 100m strips of planted trees are established.



In the foregoing paragraphs, the three afforestation models against cyclones have been described. The proposed afforestation sites on the Santo Island are generally poor in trees and comprise a combination of forest land with relatively large growing stock including some tall trees and scarce forests with rampant climbing plants.

Therefore, the former forests have high windbreak effect so that planting method (c) should be used in these forests. For the latter, planting methods (a) and (b) should be practiced as more effective measures against wind.

In practicing afforestation, windbreak belts should be established by taking into account all these models so that remaining natural stands will be effectively utilized.

2) Measures against vines

As mentioned earlier, five species of vine found on the Santo Island show remarkably rapid growth under favorable conditions of sufficient rainfall and sunlight.

These plants propagate by root stock, runner or seedling. Some species also multiply by budding from a cut section.

As viewed from the standpoint of afforestation and tending, these vines have the following ecological features:

a. It is difficult to eradicate highly prolific vines unless afforestation is carried out as soon as forests are cleared.

b. Since they cannot grow in the shade, they will quickly wither and disappear once they are enclosed by crown.

The proposed afforestation sites are flat and are believed to be not so difficult to make the round of by car. Therefore, in the early stages, it is necessary to patrol service roads, which will become borders, by car once or twice a month and to cut off runners found trying to creep into planted sites. A vine cutting machine called "beater" is commercially available.

Cattle feed on all species of vines. Therefore, it is recommended that cattle be left to graze these plants in two or three years after afforestation when planted trees grow to some height. Since cattle also graze grass in planted forests, they can serve as effective weeding at the same time.

The Solomon Islands have obtained favorable results by sowing Koronivia genus grass (a cattle pasture) as a cover plant when land is cleared for line planting. Although this method entails considerable cost in sowing the cover plant, subsequent savings on vines and weed control costs can be achieved once the cover plant is established.

1-2 Sites suited for afforestation

With respect to the eastern flat land on the Santo Island, analysis of aerial photographs and both aerial and ground surveys were conducted to assess its afforestation feasibility based on the topography, present land use, etc. As a result, 41,679 ha of low flat land forests was found suitable for afforestation as described in Chapter I Section 1-6 dealing with the preparation of forest composition maps. However, this total area also includes small tracts of land. Therefore, the potential area for commercial forest operation is only about 30,000 ha.

2. CONCEPTION OF AFFORESTATION PROJECT

2-1 How to implement afforestation project

As described in Chapter II, it is only a short time since afforestation on the Santo Island was started. Its scale is also limited. The planted species mainly consist of those for ordinary timber production.

Experimental data obtained from these operations are valuable. However, it is still too early to determine the feasibility of full-scale afforestation or optimum species based on these limited operations.

In case pulpwood species are to be planted, it is necessary to practice small-scale experimental afforestations as the first step. Through this operation, best suited species should be selected along with the establishment of afforestation techniques adapted to natural conditions encountered on the Santo Island. As the second stage, a medium-scale experimental afforestation project should be undertaken to assess the afforestation techniques acquired from the management standpoint. The object of this assessment is to determine whether the techniques are workable on a commercial base, thereby establishing management techniques.

Commercial afforestation projects should be undertaken only after all these techniques have been established and proven to be workable. It is desirable to follow this process in order to reduce the risk involved as well as to provide forest workers with opportunities of sufficient education and training..

2-2 Conception of experimental afforestation project

(1) Proposed afforestation sites

The eastern flat land is considered a future commercial afforestation site. To practice more extensive experimental afforestation inside this proposed site, it is desirable to divide the land into three equal parts lying in the north-south direction and establish a test plot in each part.

Of the three experimental plots, one will be located relatively close to the coast. The other two will be established inland in areas which should be different in natural conditions from each other. Plant growth will be compared among the three experimental sites.

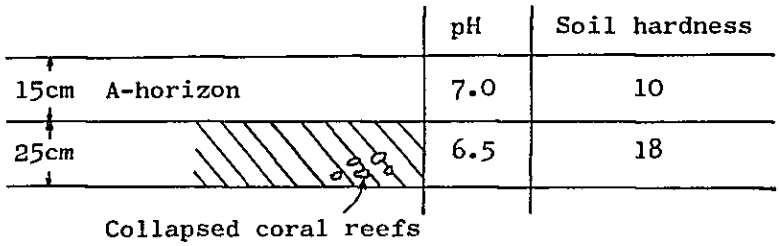
These experimental sites will be established by using tracts of land owned by each of three groups: Na-griamel, Vanuaak-Party and Tabwemassana, respectively. Use of their land will help inhabitants in each group deepen their understanding of forestry and also contribute to provide necessary labor in future full-scale forest operation.

1) Shark Bay site

This site is located on the flat land near the coast to the north of Shark Bay and classified as a low flat land forest.

The proposed experimental site is an undeveloped forest, although it is surrounded by many coconut plantations. It is not in the state of jungle with a density of about 50m^3/ha. Milk trees are most conspicuous, and vines grow thick where no stands exist.

The soil is relatively soft and ideal for planting. However, coral reefs will be exposed if the ground is dug only about 30cm. The following sketch shows the profile of the soil.



2) Vanafo site

This site is located about 2km to the north of the Government's Vanafo experimental station. The area belongs to a low flat land forest and has extremely few standing trees because of extensive cyclone damage and artificial destruction. On completely exposed tracts, vines were not so conspicuous but weed of reed species grew thick instead.

This area has very few bushes which can serve as a windbreak belt when practicing Checkerboard planting. Moreover, the soil is shallow and the coral rock bed is reached at a depth of only 40cm. Both A- and B-horizons are hard.

3) Tembotalo site

This site is located slightly inland about 15 km to the northeast of Santo City. It is adjacent to pasture grounds. The forest in the site is relatively dense with remaining natural stands of milk trees and Kleinhovea.

The soil profile is given below. It is believed this soil will present no problem for afforestation.

		pH	Soil Hardness
3cm	A-horizon	6.5	14
60cm	B-horizon	5.5	20

(SUPPLEMENTS)

Characteristics of Recommended Species of Trees for Afforestation

With respect to recommended species of trees for afforestation, given below are their original habitat, characteristics, growth, planting techniques to be used and other data on afforestation.

1. GMELINA ARBOREA

(1) Original habitat

This species occurs wild widely in Pakistan, Bangla Desh, the south, southeast of India, and Assam, Sikkim, Burma, Thailand, Laos, Cambodia, Vietnam, and southern China. In areas where it quickly grows, the temperature ranges 18.3°C to 35°C, the humidity never drops below 40% although a clearcut dry season exists, and the annual rainfall is more than 1,500 mm. For the amount of rain in particular, an annual rain fall of 1,800 to 2,300 mm is optimum for growth of this tree.

(2) Characteristics

Wood is light yellow or cream in color, and there is no clear distincition between sapwood and heartwood. The surface is medium in fexture and the grain is slightly crossed. The specific gravity in dry air is 0.40 to 0.54. The heartwood has moderate durability. Lumbering and veneer cutting are easy, and the finished surface has luster. In production areas, the wood is used for pillars of houses, wooden shoes, boat deck, and canoes. The wood is also suited for pulp, furniture, lining, boxes and matches (both match boxes and sticks).

(3) Growth

This is a species of extremely quick growth and grows to a diameter of 60 to 80 cm under favorable conditions. Particularly, the growth in the early stages (7 to 8 years) is extremely virogous.

According to a report obtained in the Philippines, trees in the age class of four years had an average annual growth of 4.6 m in height and 42.4 m^3/ha in wood volume. In the age class of six years, they were 3.37 m and 29.73 m^3/ha, respectively. An African report predicted an average annual growth of 25.2 m^3/ha in the age class of eight years.

However, this species generally has a short life. Except for growth under favorable conditions, it tends to end its life in a relatively small size. It is reported that the amount of growth will rapidly decrease from about the 7th year.

(4) Afforestation techniques

As a quick growth species in tropical low land, artificial forests with this species or its experimental planting is practiced in many countries in the Southeast Asia, Africa and Latin America. Optimum conditions for the growth of this species are said to include fertile, deep and humid soil in addition to the climatic conditions similar to those under which it occurs naturally. It also shows rapid growth in tropical rain forests with an annual rainfall of nearly 4,000 mm. If it is left to grow as an isolated stand, it will develop a very large number of branches and the stem will not grow straight. However, if it is planted relatively thick on suitable soil and adequate thinnig is performed, it will form a nearly straight stem with less crowded branches.

2. LEUCAENA LEUCOCEPHALA (PHILIPPINE NAME: GIANT IPIL-IPIL)

Its scientific name is Leycaena puloerulenta benth according to the "Philippines Recommends for the Production of Fast Growing Hardwoods, 1975." However, Mr. James L. Brewbaker at Hawaii University classified it as a species of the genus of Leucaena leucocephala Lam. de Wit. (L. glauca). Originally, species of the genus Leucaena are mostly shrubs. Since their leaves serve as a fodder for cattle, these plants have been introduced for this purpose in Hawaii, etc.

(1) Original habitat

Leycaena puloerulenta is distributed in the northern part of Mexico and the southwest of Texas, North America. It is reported that native trees sometimes grow to a height of 20 m and a diameter of 50 cm. Leucaena leucocephala occurs wild more extensively in Central and South America.

(2) Characteristics

The wood is light yellowish brown in color and is heavy with a specific gravity of about 0.7. An pulpifying experiment conducted at Forpridecom UPLB College, Laguna, indicated that this wood is suitable for pulp production.

(3) Growth

Giant Ipil-ipil in the Philippines was introduced from Hawaii. Its growth is favorable, although it does not grow large enough to be utilized for lumber production. A logging and lumbering mill in the Agusan area on the Mindanao Island is conducting a small-scale afforestation experiment with this species in order to supply their own needs of fuel for industrial energy. This wood is also used as supports for the banana plant.

Seeds obtained from the Philippines were experimentally planted on New Caledonia. However, it was reported that favorable results were not obtained from this experiment due to lack of rainfall and poor soil condition.

Only limited data is available on afforestation experiments. According to experimental data from the eastern Mindoro Island, 6-year old trees attained a height of 17 m and a diameter at breast height of 32 cm. However, it is yet to be clarified how much further this species will grow.

3. ALBIZZIA FALCATA, (L) BACK

(1) Original habitat

Wild trees are found in the northern Indonesia, the Malk islands, West Irian, and the whole of the Solomon Islands. Particularly, on the Santa Cruz Islands of the Solomon Islands which are very close to New Hebrides, this species accounts for the greater portion of forest wood together with Agathis macrophella and is felled as commercial lumber.

(2) Characteristics

It is a tall tree, reaching as high as 45 m. As a young tree, it rapidly develops the stem. When the tree grows to a sufficient height, the stem growth is slowed down and taken over by the rapid growth of branches. Ultimately, the crown spreads in a flat unbrella shape. Both the sapwood and heartwood are white or light yellowish white and thus difficult to distinguish them. The wood is a light, softwood with the specific gravity in dry air widely ranging from 0.24 to 0.49, or an average of 0.37. The grain is light and crossed, and the texture is slightly coarse.

The wood offers extremely poor resistance to wood-destroying fungi and is vulnerable to borers and termites. It is easy to dry and work. Veneers can be easily cut. In producing countries (the Philippines and Indonesia), the wood is used for pulp and packing materials. It use for matches (both match boxes and sticks) is also being studied. In Japan, it is used as for furniture lining.

In Indonesia, this species was first introduced into Java in 1871 and used as a shade tree for tea plantations in western Java. This tree grows fast and the wood is light and easy to handle. For these advantages, farmers in this region plant the tree and produce the wood for local demand.

For its quick growth, it is also considered the most promising species for afforestation in the Philippines. PICOP, the country's only paper mill (located on the east coast of Mindanao), encourages neiboring farmers to grow this tree besides planting its own forest to secure future supply of raw material.

(3) Afforestation technique

This species does not demand fertile soil. It is said that it can grow in dry or wet soil, and even in slightly salty soil. Since its resistance against wind is weak, it should be planted in an area sheltered from wind.

The following nursing and tending methods are used in the Philippines:

(1) Seeds

a. In several years after planting, the tree bears fruit in pods as a feature peculiar to bean trees and produces a large quantity of beans every year.

b. Beans are collected when the pods turn brown from green as they begin to ripen.

c. Seeds are in the size of about 30,000 to 42,000 grains per kg. Fresh seeds will give a budding rate of 90%. When seeds are put into an airtight container and kept in cold storage at 15.5°C, their vitality can be retained for two years.

(2) Sowing

a. Since the seed has a covering which is poor in water permeability, pretreatment is required. Seeds are dipped in hot water of 80° to 100°C for about two minutes. Then they are immersed in water for one day. Furthermore, prior to sowing, they are kept in wet jute sacks overnight.

b. The nursery bed should be established in an area exposed to the sun. Seeds are sown at an appropriate spacing

(5 x 10 cm). Although no sun shade is needed, a shelter against rain should be provided and a proper amount of water sprinkled.

c. Seedlings are transplanted in pots when they grow to a few centimeters. In case seeds are planted directly in pots, they are sown one by one. Sandy soils are most suited and seeds are covered with a mixture of sawdust and sandy soil in equal proportion. Seeds begin to germinate in 5 to 7 days.

Implanting is possible when seedlings grow to 15 to 30 cm.

(3) Planting

The planting space varies depending on production target at main harvesting. No sufficient data is available on the number of trees to be planted in a given area as well as periodic thinning. In the Philippines, trees are planted at a spacing of 2 x 2 m to 4 x 4 m.

(4) Growth and yield

Under favorable soil conditions with sufficient amount of rain, young trees grow to 15 m in three years, 21 m in four years and 30 m in nine to 10 years. According to a Philippine report, there was a total yield of 235 m^3 per hectare in eight years under average soil and other conditions.

4. CASIA SIAMEA LAM, POPULARLY KNOWN AS TAGAYASAN

(1) Original habitat

This species grows wild in India, Burma, Thailand, Cambodia and Vietnam. It is mostly found at an altitude of 0 to 800 m with an annual rainfall of 1,000 to 1,500 mm. The habitats also have a dry season lasting about six months. The species lives and grows in various types of soil except extremely infertile sandy soils.

(2) Characteristics

Because of its quick-growing characteristics, it is planted in various tropical regions for production of pillar and firewood materials. It is also widely grown as roadside trees and garden trees.

It is generally a medium-size tree of about 20 m in height and 50 to 60 cm in diameter at breast height. It is semi-light demanding and develops strong root systems. For these features, it grows strong and overwhelms adjacent trees. However, when kept in the shade by a bigger tree or planted in infertile soil, its growth is hampered.

There is a clear distinction between the heartwood and sapwood. However, the sapwood accounts for the greater portion even on a matured tree. The heartwood is also formed in much latter stages of growth.

According to afforestation experience in Malaysia, this species is very quick in growth but generally short-lived, and many trees end their lives even before the heartwood is formed.

The heartwood is dark brown or almost black, and is very beautiful with stripe-pattern in light color. The specific gravity in dry air is about 0.80 to 0.96, hard or very hard, and duarable. It is used for outdoor structural timbers and cabinetwork. However, its small size imposes restriction on the use. The sapwood is white and less hard than the heartwood, and is suited for firewood. In fact, this species is widely planted in tropical and subtropical regions as an excellent quick-growing species for firewood. The Tokyo University's experimental plantation in Taiwan used to grow this species and produced high-quality hard charcoal from the wood. In this artificial forest, stands were regenerated by sprout.

No data is available on its suitability as a quick-grow pulpwood species. However, it is considered a promising pulpwood species because the wood is white and the specific gravity in

dry air is higher than that of many other quick-grow species.

(3) Afforestation technique

(1) For afforestation, both the direct seeding and seedling planting methods are used.

(2) Seeds are in the size of about 34,000 grains per kg and retain their ability to germinate for a considerable period.

(3) In case of direct planting, holes for planting seeds are thoroughly tilled to soften the soil. Five to six grains are sown in each hole. Seeds are sowing at a spacing of 3 m x 3 m and the quantity is adjusted later by culling.

(4) When seedlings are planted in poor soil, their upper portion is cut off before planting. It is recommended that one-year old young trees of about 1.0 to 1.5 cm in diameter be planted.

Other than general climatic conditions in the original habitat, this species is found to give fairly good growth both in regions with small rainfall of about 500 mm a year and in high-rain regions such as the Santo Island with an annual rainfall of approximately 3,000 mm.

5. EUCALYPTUS DEGLUPTA. BL, POPULARLY KNOWN AS KAMARERE

(1) Original habitat

It occurs wild in Papua New Guinea, south Mindanao, Philippines, west Sulawesi, Indonesia, Seram Island and West Irian. In Papua New Guinea it seems that natural forests of this species are grown only in bare land or the land left by shifting cultivation. This species exists in a regio with an annual rainfall of 2,500 to 5,000 mm, or an average of about 3,000 mm, with no long dry season.

(2) Characteristics

It is a giant tree reaching 73 m in height and 2.4 m in diameter. The sapwood is white or pinkish while the heartwood is reddish brown or light pinkish brown. The grain is usually straight but may be crossed. Sawed wood surface may sometimes

show a ribbon stripe. The texture is slightly coarse but uniform with some luster. When the wood is left in contact with earth, it will lose its durability. However, it is considerably durable even if exposed outdoor, and is suited for interior finish materials. It is easy to work and can possibly be applied to furniture, interior structural members and flooring. It is also suited as pulpwood.

(3) Afforestation technique

In Papua New Guinea, afforestation was started in 1951. By 1973, 736 ha of forest land (mostly the Keravat district on the New Britain Island) has been planted. In the Philippines, a major lumbering enterprise began to plant this species. However, it is still a short time since afforestation was started.

This species prefers land where there is an annual rainfall of about 3,000 m with deep rich soil and good drainage. Artificial forests of this species are yet to be technically clarified. Nursing and tending methods practiced in New Hebrides are as follows:

(1) Seeds

a. This species generally flowers before the rainy season and bears many small pieces of fruit. Seeds are gathered in November and December. They can be obtained from even young trees of two to three years of age. In the Philippines, Papua New Guinea, etc., it is reported that trees bear blossoms and fruit throughout the year. This has not been confirmed in New Hebrides.

b. When the fruit ripens, it turns brown and opens to expose seeds. Seeds are gathered in clusters, spread on a sheet and dried in the sun. A large quantity of very fine seeds are obtained. After chaffs are removed, seeds are separated by fanning. Seeds are in the size of about 1,000 grains per gram.

c. Seeds can be preserved for about four years if they are placed in a sealed container and kept in cold storage.

(2) Sowing

a. Seeds are made to germinate in a sowing box in a germination hut. The sowing box is made in a size convenient to carry. Holes, each about 2 cm across, are made on the bottom to facilitate drainage. The box is filled with sandy soil. In the Philippines, seeds seem to be sterilized by heat.

b. Since seeds are very fine, they are mixed with fine sand to ensure uniform sowing. Water is given by sprayer about twice a day (in the morning and in the afternoon). If the sowing box is covered with a sheet of glass, seeds will germinate in three to eight days. Germinated seeds are implanted in pots.
Before transplanting, make holes in the soil of pots with a stick. Pick up seedlings by small leaf, plant them in the holes and secure roots by slightly pressing soil around the roots. (Do not hold the stem or seedling will be damaged.) It is better to increase the proportion of sand for the soil to be introduced into the pots.

c. In case seeds are directly sown in pots, cull seedlings in a few days after germination, leaving only two or three. Further, one month later, excellent saplings were selected.

d. In three to four months after sowing, saplings grow to 20 to 30 cm and are ready for transplanting.

(3) Planting

In New Hebrides, seedlings were planted at a spacing of 3 x 3 m. In Papua New Guinea, the distance was set at 4.5 x 4.5 m or 3.7 x 3.7 m for production of lumbering logs while the distance of 2.4 to 2.7 m was said to be suited for production of small-diameter trees.

(4) Yield

The yield is yet to be confirmed in New Hebrides. According to data obtained from an existing artificial forest in Keravat, New Guinea, upper layer trees at the age of 6.5 years attained an average height of 30.5 to 29.6m (an average annual growth of 4 to 5m) and produced wood of 198.2 to 262.5m^3 per hactere (an average annual wood growth of 40.4 to 30.5m^3). It is presumed that all these outstanding results were obtained because Keravat is the optimum site for this species.

6. TERMINALIA CALAMANSANAI

(1) Original habitat

This species grows naturally in the Solomon Islands, New Guinea, Indonesia and the Philippines.

(2) Characteristics

This species prefers low land with good drainage, particularly on ridgelines. The crown is not so expansive and the tree grows to a stem height of about 40m and a diameter at breast height of 80cm. It spreads branches in verticils with small leaves. Since branches are arranged in a pagoda-like shape, this tree can be easily identified from a distance. The wood is yellow or purplish. The specific gravity is 0.46 for 30 years old trees grown on the Solomon Islands, and about 0.3 for planted trees of 5.5 years of age. The texture is slightly coarse and has generally low resistance to cracks. Therefore, the wood is liable to crack and is used for packing materials and box-type furniture.

The seed has two paper-thin wings of about 1cm and is in the size of approximately 17,000 grains per kg. When kept in cold storage, the seeds can retain their germination ability for a considerable period. Nursing is also easy.

A similar species, Terminalia ivorensis, is experimentally grown on the Santo Island. This species is naturally distributed in Guinea and Cameroon on Africa. It is successfully planted as a large-scale forest in Libya, Ghana and Nigeria. Both species show favorable results on the Santo Island.

7. ANTHOCEPHALUS CADAMBA

(1) Original habitat

This species grows wild at an altitude of 0 to 900m on the Asian Continent from India to China and down south to Papua New Guinea.

(2) Characteristics

This is an extremely species of light demanding tree has strong resistance to weed and occurs as a pioneer for secondary forests. For these characteristics, a pure species is found along forest roads, tracks of land once used for shifting cultivation, areas of degrated soil and river banks damaged by flooding.

This species also offers an advantage of regeneration by sprout.

Generally, the stem height is 25 to 30m, and the diameter is about 40 to 60cm, but grows to 1m under an optimum soil condition. The stem is straight and the height under branches is substantial. Large branches horizontally extend and slightly hangs down at their tips.
Buttress are almost none.

The wood is light yellowish white and turns cream color later. There is no distinction between the heartwood and sapwood. The grain is straight, and the texture is moderately fine or slightly finer, and is uniform.

The specific gravity in dry air widely ranges from 0.3 to 0.6, but is generally low. Although it is easy to work, no high-quality finish can be obtained. Veneer cutting is said to be easy.

If the wood is exposed to elements or used in applications involving contact with earth, the wood is liable to be rotten. It is suited for low-grade materials, tea boxes, shipping boxes, toys and wooden sandals. It can also be used as pulpwood.

(3) Afforestation technique

In Indonesia and the Philippines, this species is valued as a good artificial forest species. Many farmers grow this tree. Since the woods is suited as match sticks, this species is included in Indonesia's forest industry development plan as one of the most important species for afforestation. In the Philippines, this species is planted by major lumber producers, together with Albizzia falcata, etc.

In 1940, Japan experimentally planted this species in Tawau Borneo with favorable results.

This species generally prefers soils with good drainage. According to reports, it grows well in humid climate as well as a climate characterized by the dry season with an annual rainfall of 1,500 to 5,000mm.

The following nursing and tending methods are practiced in the Philippines:

a. Seeds

This species beins to flower and bear fruit at the age of about five years. Fruits are gathered around

October or November. Immediately after they are gathered, pulpy meat is softened by wire net, immersed in water, made to pass through a fine net three or four times to remove pulpy substances and foreign matter to separate seeds.

The seeds can retain their germination ability for about one year if they are air-dried for two days before they are put into a sealed container and kept in cold storage. The seeds are very fine, being in the size of about 17,000 grains per gram.

b. Sowing

Because of the fine size, the seeds are sown in the same manner as Eucalyptus delupta. They begin to germinate in two to three weeks.

c. Transplanting

When seedlings develop four leaves, they are transplanted into pots. As the soil, a mixture in equal proportions of humus soil and sandy soil is used.

After transplanting in pots, seedlings are partially shaded from the sun for about two weeks until they restore vigour.

d. Planting

Seedlings grow to about 15cm in height in 2.5 to 3 months after germination. Although they are ready for planting, it is said for better results young trees should be allowed to grow to 20 to 30cm before planting.

e. Yield

According to reports, young trees will grow rapidly for several years after planting, but their growth will become slow thereafter. In Indonesia, a provisional yield table has been prepared without sufficient data. This table shows values obtained when the so-called standard type operation involving moderate periodical thinning is performed.

In sites of medium rich soil, trees will grow to an average stem height of 11m and an average diameter at breast height of 11.8cm in three years after planing. During the subsequent five years, the annual stem growth is 1.7m. Thereafter, the growth is slowed down to 0.2m in the 25th year.

Consequently, the peak in the annual growth comes in a short time, or nine to 12 years. At this peak, the yield per hactere (total major thinning yield) becomes 145 to 191m^3. The average height of principal forest species is estimated at 19.1 to 21.2m with the average diameter at breast height of 23.6 to 27.1cm.

In the Philippines, caterpillars of a certain species of moth east leaves of this tree.The damage from these worms can be controlled by spraying chemicals according to reports.

8. CORDIA ALLIODORA

(1) Original habitat

This species belongs to the Boraginaceae genus (the gromwell genus) and occurs naturally in the West Indies, Mexico and the Whole South America.

(2) Characteristics

The heartwood is golden brown or greenish brown with generally dark stripe. However, the color and specific gravity vary greatly depending on the manner in which trees are grown as well as their age. The specific gravity in dry air is said to be 0.4 to 0.7. The texture is slightly coarse, and the grain is straight or crossed.
It is easy to work with excellent finish.

Its applications include building materials, furniture, cabinetwork and plywood.

(3) Afforestation technique

This species has experimentally grown in New Hebrides and adjacent Solomon Islands and Fiji. All the trees in these plantations are intended for timber production. In afforestation experiments on New Hebrides, the initial growth is fast and trees have grown to about 16m in height in five years. However, according to literature, their growth greatly varies according to the origin. It is therefore necessary to attach importance to the origin of the species. Since no trees have been planted for production of pulpwood, full study is required to determine the suitability of this species for pulp production.