FEASIBILITY SURVEY FOR FORESTRY DEVELOPMENT IN FIJI

Mach, 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

FOREWORD

In recent years, imported timbers which fill about 65% of Japan's timber demand have shown a notable increase with the growing diversity in both species and countries of origin.

Specifically, the advent of new timber exporting countries such as Indonesia, Papua-New Guinea, New Zealand and Australia in the last ten odd years has immensely augmented the supply of timbers to Japan which she used to obtain from the United States, Soviet Union and the Philippines. With the increasing import of timbers from the Oceanian countries, saw-logs of lauan or Dipterocarpus species which accounted for the greater part of imported tropical wood are now giving place to logs and wood chips of versatile other species including eucalyptus and mangrove.

Under such a background the present survey was realized in Fiji, an Oceanian country known for its noteworthy wealth in silviculture and timber production. Although the relationship between Fiji and Japan in the field of forestry was not very close in the past, today, the Japanese forestry circles are interested by the high potentials of forestry productivity in Fiji due, in particular, to the diversification of sources of timber supply to the Japanese market. In the last several years, a number of Japanese forestry survey missions visited to Fiji either with the government support or on private basis.

The present survey was conducted by a mission dispatched by the Japan International Cooperation Agency in compliance with the request of the Fijian government for Japan's cooperation in the development of afforestation and utilization of hardwoods and in the more effective use of coconut palm stems. It was the first government - to - government basis survey between Japan and Fiji and it was a preliminary forestry survey to be followed shortly by a full-scale feasibility study.

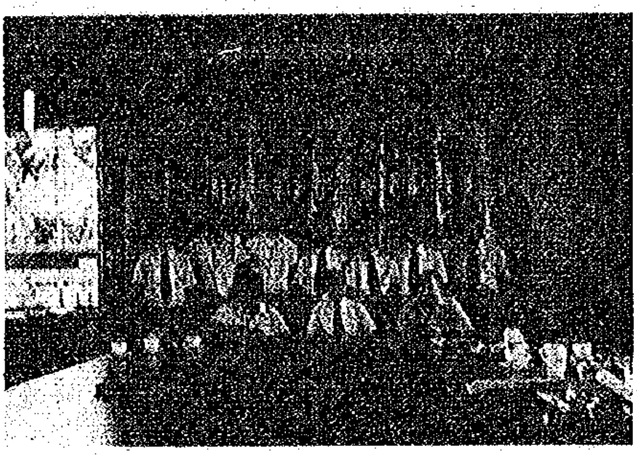
While anticipating that the execution of the survey will open up the way for a closer linkage and all-out cooperation in the field of forestry development between Japan and Fiji, I sincerely hope that the findings of the survey presented in this report will be found useful for that purpose by all parties concerned.

Availing myself of this opportunity, I wish to express my deep gratitude to the competent Fijian authorities including the Forest Department for the helpful assistance offered to the mission throughout the survey period.

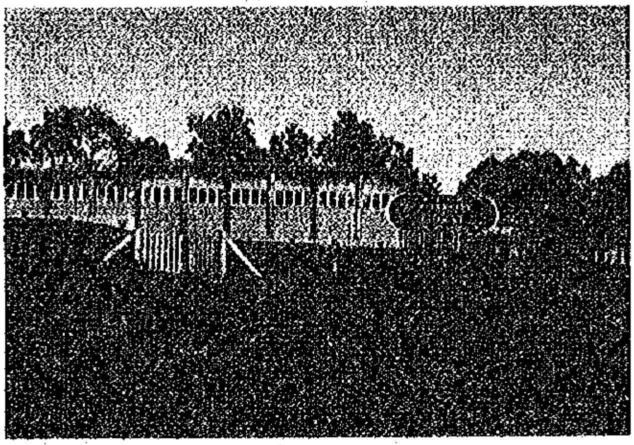
The elaborate effort exerted by all members of the mission and the kind cooperation extended by the Japanese Ministry of Foreign Affairs, Ministry of Agriculture and Forestry, and the Japanese Embassy in Canberra are also gratefully acknowledged.

March 1977

Shinsaku Hogen
President
Japan International Cooperation Agency

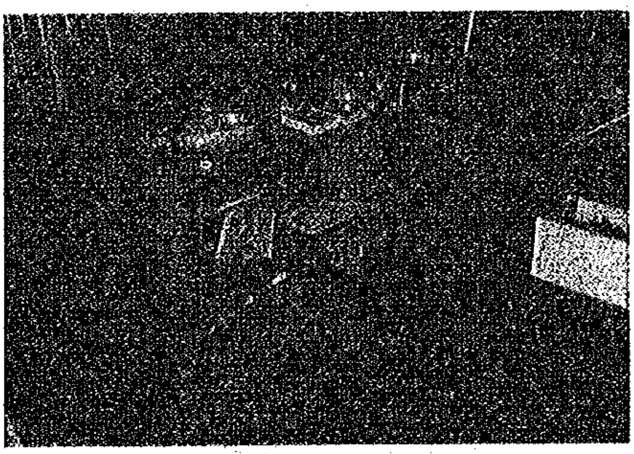


With the staff of Forestry Department

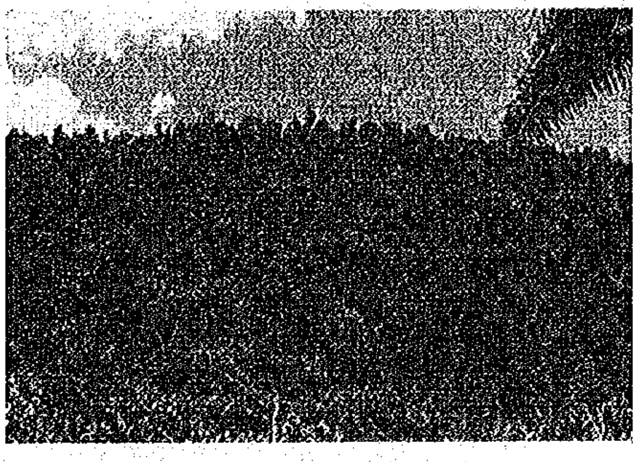


Institute of the Timber Utilisation Research

Logging operation at the GALOA area



Furniture and wood works made of coconut palm stem

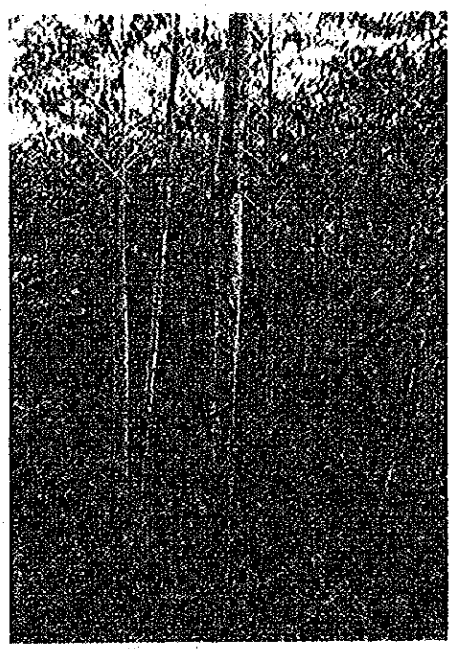


Man-made forest of Mahogany (Swietenia macrophylla) reforested by line planting method at the GALOA area 14 years old

Seedlings of Mahogany: ordinary size for out-planting

Eucalyptus deglupta

12 years old DBH=58 cm
200m^3/ha



Man-made forest of Anthocephalus chinensis

5.5 years old 140m^3/ha

Man-made forest of Mahogany
(Swietenia macrophylla)

14 years old

Terminalia ivorensis

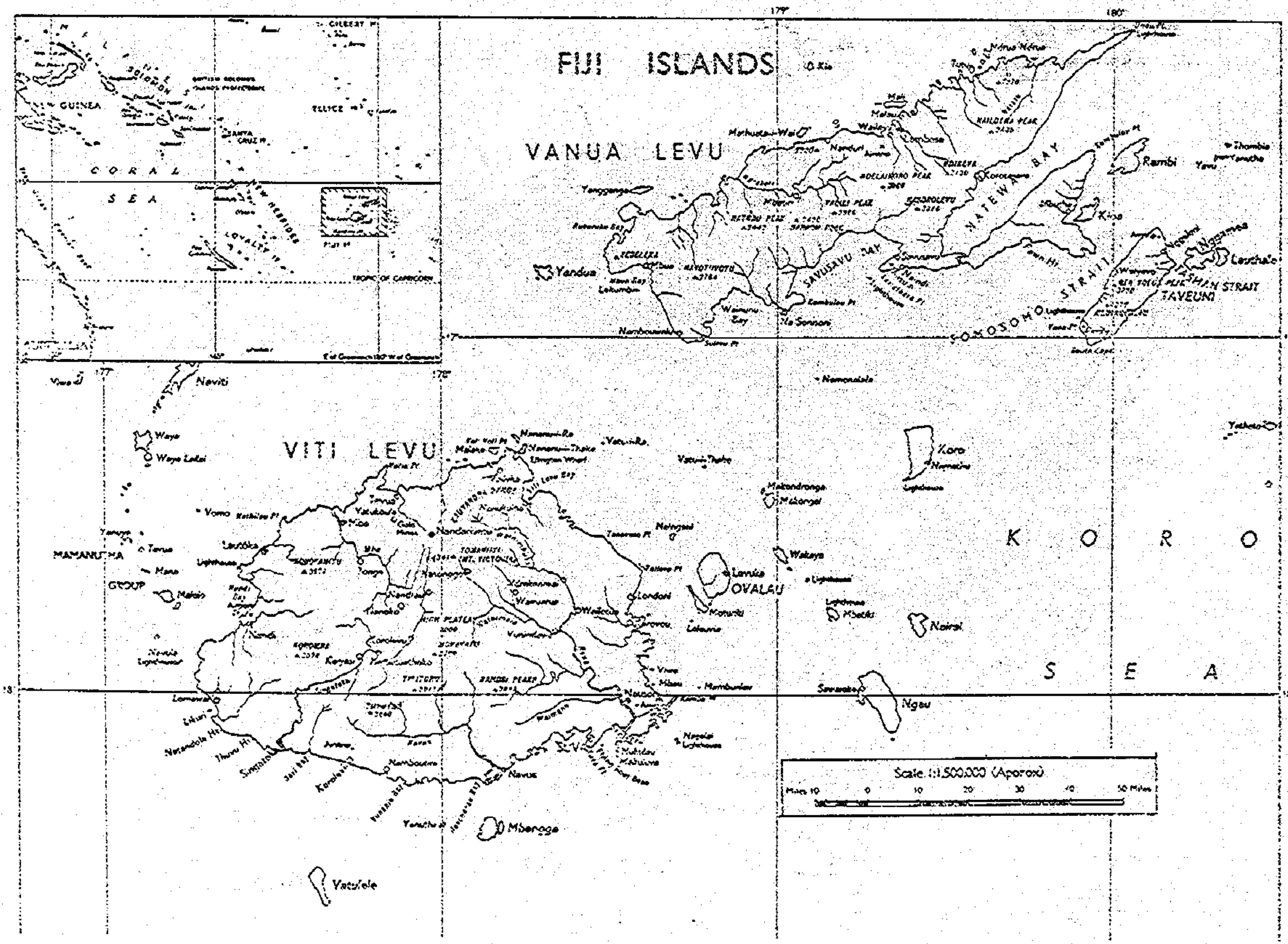
5 years old

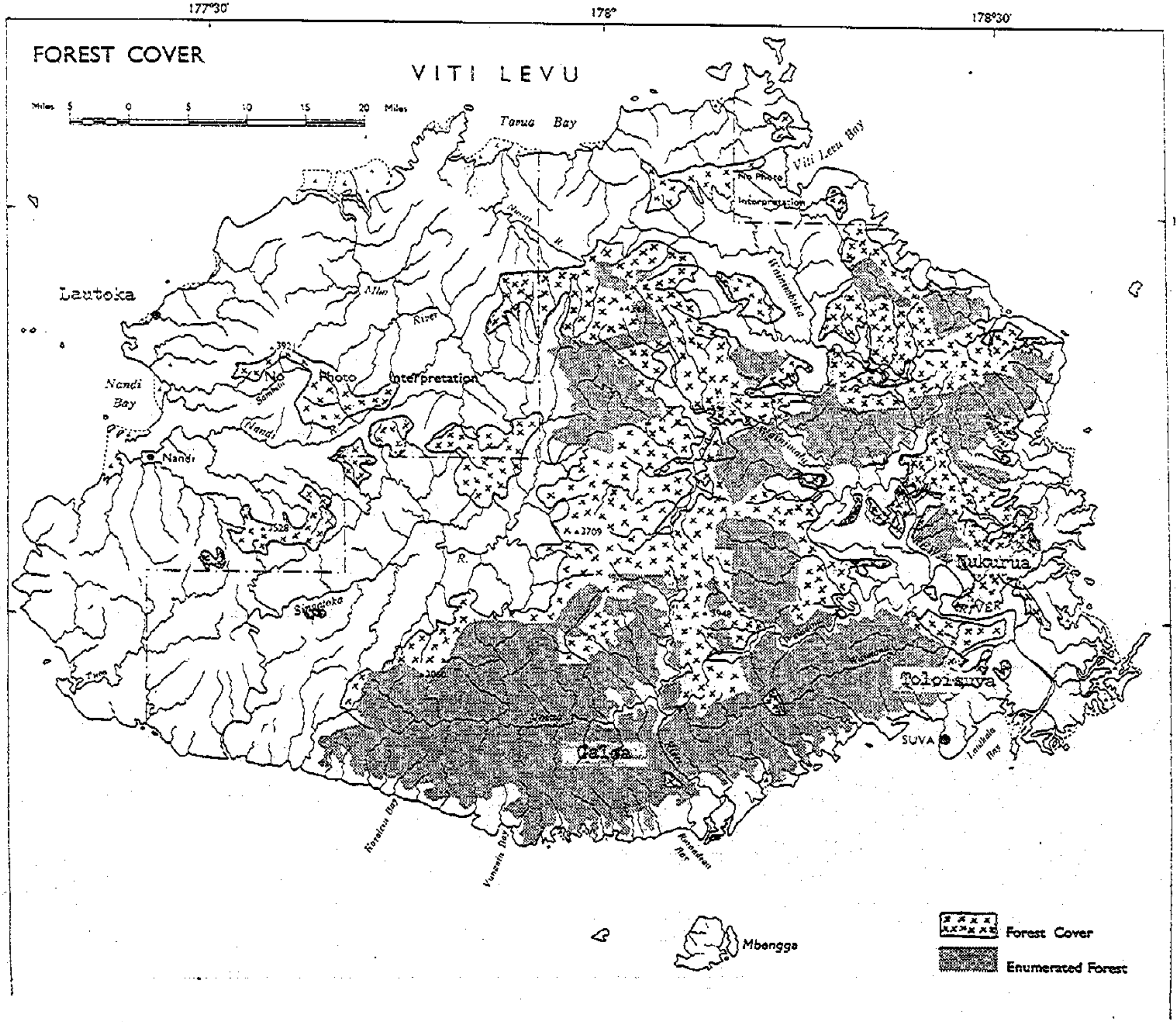
Man-made forest of Maesopsis eminii
(white trunks)

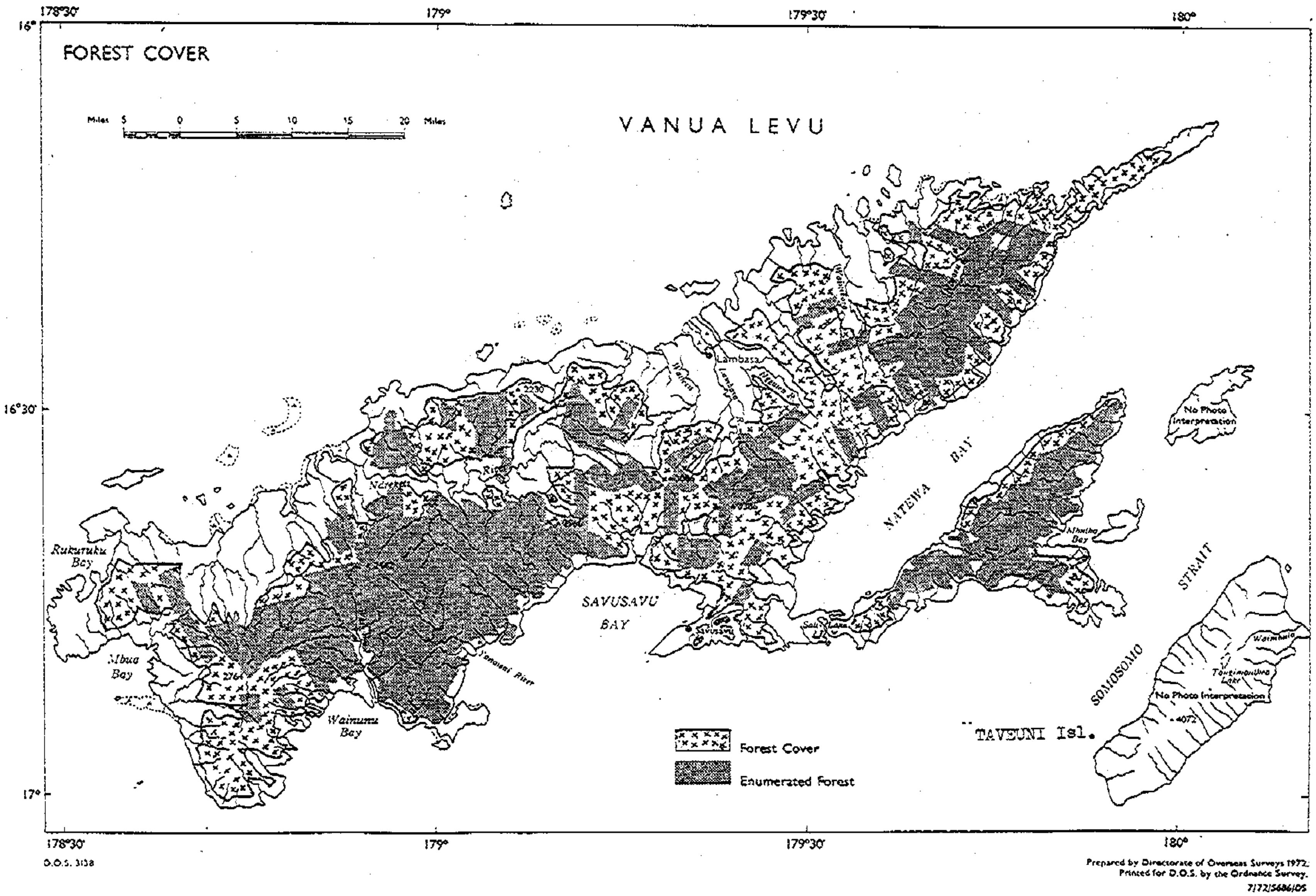
9 years old $\overline{H}$=22m $\overline{DBH}$=28cm

Cordia alliodora

5 years old


FIJI ISLANDS
VANUA LEVU
VITI LEVU
KORO SEA
NATEWA BAY
SAVUSAVU BAY
SOMOSOMO STRAIT
TASMAN STRAIT
TAVEUNI
OVALAU
MAMANUTHA GROUP
CORAL SEA
NEW GUINEA
SOLOMON IS
NEW HEBRIDES
LOYALTY IS
TROPIC OF CAPRICORN
Rambi
Kioa
Koro
Nairai
Ngau
Mbenga
Vatulele
Yandua
Naviti
Waya
Waya Lailai
Vomo
Malolo
Lautoka
Nandi
Navua
Lomaloma
Wakaya
Makongai
Levuka
Scale 1:1,500,000 (Approx)


FOREST COVER
VITI LEVU
Miles 5 0 5 10 15 20 Miles
177°30'
178°
178°30'
17°30'
18°
Tavua Bay
Viti Levu Bay
No Photo Interpretation
Lautoka
Nandi Bay
Nandi
No Photo Interpretation
Sigatoka
Wainimbuka
Nukurua
RIVER
Tolotuva
SUVA
Galoa
Mbengga
Forest Cover
Enumerated Forest



FOREST COVER
Miles 5 0 5 10 15 20 Miles
VANUA LEVU
Lambasa
NATEWA BAY
SAVUSAVU BAY
Savusavu
Rukuruku Bay
Mbua Bay
Wainunu Bay
Ndreketi
Yanawai River
2764
2230
No Photo Interpretation
SOMOSOMO STRAIT
TAVEUNI Isl.
Waimbula
Tagimaucia Lake
No Photo Interpretation
4072
Forest Cover
Enumerated Forest
178°30'
179°
179°30'
180°
16°
16°30'
17°
D.O.S. 3138
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7/72/5686/OS

CONTENTS

1. PURPOSE OF SURVEY

This survey was made as a preliminary study at the request of the Government of Fiji for the following purpose.

a. To evaluate the result of the hardwood reforestation project which has been carried out by the Government of Fiji and to study the feasibility of farther development of reforestation in the future.
b. To study the feasibility of producing wood chip from hardwoods from the industrial view.
c. To consult with the officials of the Fiji Government on the matter related to the experiment on pulping from coconut stems.
d. To exchange views with the related agencies of the Fiji Government for cooperative works in each of the above-mentioned fields.

The Fiji Government has been carrying out a hardwood reforestation project for a cut-over areas of tropical rain forests in the wet zone expanding in the southeast half of Viti Levu, the main island of Fiji, and has also been promoting trial planting to select appropriate species for reforestation from among approximately 200 species of hardwoods. In the former hardwood planting project, mainly Mahogany (Swietenia macrophylla) has been planted using the line planting method since around 1960 and the man-made forests of hardwoods now cover an area of nearly 10,000 ha. The latter trial planting is designed to select appropriate tree species other than Mahogany (Swietenia macrophylla) because the attack of Ambrosia beetles to Mahogany has been marked since about 1870.

In this feasibility study, therefore, evaluation was made of the result of the reforestation project and trial planting with the cooperation of the Fiji counterparts.

As for the feasibility of producing wood chip from hardwoods, a request was made by the Fiji government for a study to determine the possibility of developing a wood chip industry using hardwoods in view of the fact that in Fiji some specific commercial trees are felled, while other non-commercial trees are left without felling, which is not only a major obstruction to planting but also a big waste of valuable forest resources.

The feasibility study also included a study on the prospects for chip production from fast growing hardwood species which may be planted in the future in addition to these unused hardwoods in natural forests.

With regard to the experiments on pulping using the stem of coconut palm, experiments on a laboratory basis have already been conducted in various countries including Japan and a request was made by the Fiji government for experiments on a production basis. To study the possibility of chipping and pulping from the stem of coconut palm on an industrial basis, it was necessary to obtain accurate data on the availability of coconut palm resources or location conditions of the industry. Consultation was made with the Fiji counterparts on these points in the study.

2. COMPOSITION AND ITINERARY OF SURVEY TEAM SCHEDULE

(1) Composition of Survey Team

Assignment	Name	Organization
Leader	Tomohisa Fukumori	President, Japan Forest Technical Association.
Coordinator	Niro Namura	Director, Forestry Development Cooperation Department JICA.
Wood processing	Dr. Shoji Sudo	Head, Tissue Research Laboratory, Lumber Department, Forest Experiement Station, Ministry of Agriculture & Forestry.
Timber production and marketing	Kiyoshi Fujii	Manager, Wood Division, Oji Paper Co., Ltd.
Silviculture	Dr. Yoshinari Tadaki	Head, Second Afforestation Research Laboratory, Silviculture Department, Forest Experiment Station, Ministry of Agriculture & Forestry.

(2) Itinerary of Survey Team

Date	Activities
November 10 (Wed)	Departed from Japan.
11 (Thu)	Paid a courtesy call on the Japanese Embassy in Canberra and held consultations with the Embassy Staff.
12 (Fri)	Moved to Sidney
13 (Sat)	Moved to Nadi, Fiji Islands
14 (Sun)	Observed facilities of Lautoka port and then moved to Suva city.
15 (Mon)	Reviewed and discussed the survey schedule prepared by the Fiji side. Observed facilities of Suva port and others.
16 (Tue)	Paid a courtesy call on the Director of Forestry Department, the Vice-Minister of Agriculture & Forestry and the Deputy Vice Minister of Agriculture & Forestry. Held a conference with the Director of Forestry Department and other high-ranking officials in the afternoon.
17 (Wed)	Held a conference at the Forest Products Research Institute on the subject of pulping from coconut palm and other subjects in the morning. Held a conference at the Tholoisuva Reforestation Experiment Station on the subject of planting of hardwood species in the afternoon.
18 (Thu)	Made a field survey of logging in natural forests and hardwood plantation at the Nukurua area.

Date	Activities
19 (Fri)	Made a field survey of logging in natural forests and the hardwood plantation at the Galoa area.
20 (Sat)	Collected the necessary data and materials.
21 (Sun)	Coordinated and summarized opinions within the survey team.
22 (Mon)	Held a conference with high-ranking officials of the Forestry Department on the subjects retated to the findings of the survey.
23 (Tue)	Paid a courtesy call on the Director of Land Use Department. Prepared a draft interim report.
24 (Wed)	Paid a courtesy call on the Minister of Agriculture & Forestry and then briefed the officials of the Forestry Department on the draft interim report.
25 (Thu)	Following the presentation of the interim report, moved to Nadi and made a field observation on man-made pine forests.
26 (Fri)	Reported to the Japanese Embassy in Canberra.
27 (Sat)	Moved to Sidney
28 (Sun)	Moved to Manila
29 (Mon)	Arrived in Japan

3. EVALUATION OF HARDWOOD REFORESTATION PROJECTS

(1) Outline of Present Reforestation Projects

As mentioned previously, each of the two main islands, Viti levu and Vanua leve, is divided meteorologically into the north and west dry zone and the south and east wet zone.

In the dry zone, annual precipitation stands at about 2,100 mm and most of the slopes (hillside) are grasslands, main tree species used for reforestation in the dry zone are pine trees, especially Pinus caribaea v. hondurensis and the Fiji Pine Commission, which is under the direct control of the Ministry of Agriculture, Fisheries and Forests, is vigorously promoting reforestation to attain a goal of 75,000 ha of plantations.

The wet zone has an annual precipitation of more than 3,500 mm and is thickly covered with forests as a whole. The forests in this zone have been roughly classified into the lowland tropical rain forest and montane rain forest. There is a difference in the distribution of some of the more important tree species between these two forests, with the former having a greater proportion of hardwood. The volume ratios of typical usable tree species are shown below.

Lowland Tropical Rain Forest:

45% : Light hardwoods, including mainly Endospermum macrophyllum (local name is Kauvula) and Myristica spp. (Kaudamu)

40% : Medium and heavy hardwoods, including mainly Calophyllum spp. (Damanu), Syzygium - Acicalyptus - Eugenia spp. (Yasiyasi), Palaquium hornei (Sacau), Intsia bijuga (Vesi) and Gmelina vitiensis (Rosawa).

10% : Softwoods, including mainly Agathis vitiensis (Dakua makadre), Podocarpus spp. (Dakua salusalu, Kuasi, Amunu), and Dacrydium elatum (Yaka).

5% : Others

Montane Rain Forest:

45% : Softwoods, including mainly *Agathis vitiensis*, *Podocarpus* spp. and *Dacrydium elatum*.

30% : Medium and heavy hardwoods, including mainly *Calophyllum* spp., *Syzygium*, *Acicalyptus*, *Eugenia* spp., *Palaquium hornei*, *Intsia bijuga*, and *Gmelina vitiensis*.

20% : Light hardwoods, including mainly *Endospermum macrophyllum* and *Myristica* spp.

5% : Others.

The forests in the lowland area are generally called "tropical rain forests". There is no doubt that the forests in this area are tropical rain forests, but these forests show considerably some subtropical characters according to the observation of the survey team. In addition to the fact that the region is situated approximately in lat. 18° S, which is close to the southern border of the tropics, the followings may be pointed out as the differences between these forests and the tropical rain forests in the region near the equator.

1 The warmth index is 241 in Suva and 244 in Nadi. Since the warmth index on the boundary of the tropics and the subtropics is considered to be 240, it may be said that the Fiji Islands are situated almost on the boundary of these two zones. It is said that the temperature in Suva is as low as 15°C at times.

2 Tree fern, which indicates the subtropics, is frequently observed.

3 Emergent trees, which are the characteristics of tropical rain forests, are not conspicuous and tree height is comparatively small.

4 Climbers are comparatively few in number.

5 Population of termites and ants in the forest is relatively low.

6 Decomposition of organic matters is relatively slow and a considerable amount of organic matters is contained in the soil, with a little developed A layer.

In the wet zone, hardwoods are mainly used for reforestation. In most cases, the line planting method is used for planting. After the commertial trees were selectively harvested from the natural forest, a 2 ∿ 3 m wide strip cutting is made in still closed bush at intervals of about 10 m (30 - 36 ft), where trees are planted by row planting method. In this case, large unusable trees left in the forest land are girdled and poisoned with arsenic and small trees disturbing the growth of planted trees are removed. Planting is made in the wet season; November through April. Poisoning is normally made during the period six months prior to planting until immediately before planting. Experiments are still under way to determine the suitable timing for poisoning but the poisoning three months before planting generally seems to be favorable for better results. Weeding is made about four times a year within the strip. Vine cutting within the strip is also an important task.

In the wet zone where the amount of vegetation is quite great, the competition between the planted trees and other vegetation becomes a big problem. So, one of the ways to shorten the period of competition would be to select the fast growing species at an early age. This is the reason why the softwoods which have a low growth rate at an early age cannot be the main tree species for planting in the wet zone.

The tree species which is most commonly used and which has been most intensively planted in this region is Mahogany (Swietenia macrophylla). The plantation of this species, which involves no large troubles in planting technique and provides high quality timber at the time of final cutting, has been expanding rapidly since around 1960 and now covers an area of 9,700 ha (24,000 acres).

In recent years, however, the outbreak of Ambrosia beetles has caused damage to the planted Mahogany and as a result, planting of Mahogany has remained stagnant since 1972.

On the other hand, trial planting of other species has also been in progress to select tree species suitable for planting. The need of selecting appropriate species which may substitute for Mahogany for planting has increased rapidly with the standstill of planting of Mahogany as a result of damages by Ambrosia beetles. At present, trial planting is being made with approximately 200 tree species and six species including Mahogany have been selected as appropriate species for planting in the future. For the time being, planting project will be progressed mainly with these six species.

The six species selected are as follows.

Anthocephalus chinensis (kadamba)

Cordia alliodora

Endospermum macrophyllum

Eucalyptus deglupta

Maesopsis eminii

Swietenia macrophylla (Mahogany)

As of 1976, the man-made forests in Fiji cover an area of 34,500 ha, of which 24,000 ha is planted with softwood species (mainly Pinus caribaea in the dry zone) and 10,000 ha with hardwood species (mainly Mahogany, in the wet zone). Planting is now in progress at an annual rate of 6,000 ha, of which 80 percent may be accounted for by Pinus caribaea planted in the dry zone.

(2) Recommendations for Hardwood Reforestation Projects

1) Selection of Tree Species for Planting

It is worthy that so many as 200 tree species are being used for trial planting and selection of the six species from among these species for intensive planting. However, most of the trial plantations are very small in scale and moreover, selection of species was made during a very short period of three years, following the outbreak of Ambrosia beetles in 1972. On this point, a little more careful consideration would be desirable.

The Fiji authorities, of course, are fully aware of this point and intends to continue the observation of trial plantation in the future and the second selection of tree species is expected to be made following the first selection of the six species. It is hoped that additional new promising species will be selected in the foreseeable future.

As a criterion for the selection of tree species, such conditions as the general growth, tree form, uniformity of trees, supply of seeds, production of seedlings, planting, tending, climate, resistance against damage by living matters and quality of production timber should be considered. Of course, these points should have been taken into consideration in selecting the six species but there is an indication that more emphasis was placed on growing speed. The records at the greater part of trial plots only indicate the growth rate at an early age. In the high temperate and wet zone of hardwood natural forest where the growth of floor vegetation is particularly prominent and where competition between the vegetation and planted trees may not be avoidable, selection of species having a high growth rate at an early age, especially at the initial stage of planting, as suitable species for planting is quite understandable. However, a much more emphasis should be placed on the quality growth rather than volume growth of planting tree species.

The use of timber may be classified largely into saw timber and chip wood. The saw timber requires a certain strength and good appearance, while the chip wood requires a high specific gravity to some extent. A high growth rate at an early age does not give assurance to satisfy any of these requirements. It is very important to know the difference between the growth of timber volume and growth of the quality of timber.

Local demands for softwood timber in Fiji seem to be fairly great. Hence, the production of softwood timber of good quality would still be required in the wet zone even when Pinus caribaea timber is produced in large quantities in the future. Despite the fact that the softwood has a low growth rate at an early age and requires more labor for avoidance of competition with other vegatation, it would still be advisable to continue trial planting of such species of softwood as Agathis, Araucaria, Dacrydium and Podocarpus and make further efforts to expand the area of plantation of these species as a means of increasing domestic supply of softwood timber.

In addition to the present trial planting which will be continued, introduction of other exotic species with high quality for trial may be desirable. The new species which may be considered for introduction are, for example, Peronema canescens (Sunkai) which is generally considered to be promising in Indonesia and Pterocarpus indicus which have been successfully tried in the Philippines. For further information, a summary of tree species planted in countries in Southeast Asia and South Pacific (Philippines, Malaysia, Indonesia, New Guinea, Solomon, New Caledonia and New Hebrides) is shown in Table III-1.

Table III-1. Tree Species Planted in Various Countries

(1) Fast growing species and pioneer species

◎ indicates plantations on a project scale
o indicates mere plantation
Δ indicates trial planting

Species	Philli-ppines	Malay-sia	Indo-nesia	Thai-land	New Guinea	Solomon	New Cale-donia	New Heb-rides
Acacia auriculaeformis					Δ			
" decurrens			o					
" dealbata							Δ	
" mearnsii							Δ	
" melanoxylon							Δ	
Albizia falcataria	◎	Δ	◎		Δ		o	Δ
Aleurites moluccana	Δ							
" trisperma	Δ							
Anthocephalus chinensis	o				Δ	Δ		Δ
Bambusaceae			o					
Calophyllum kajewskii						Δ		
Campnosperma brevipetiolata						◎		
Cardwelia sublimis						Δ		
Cassia siamea								Δ
Castanospermum australe						Δ		Δ
Cedrela australis						Δ		
" odorata						o		
Ceiba pentandra			o					
Celtis latifolia						Δ		
" nymanii						Δ		
" philippensis						Δ		
Chlorophora excelsa						Δ		

Table III-1. (1) Cont'd

Cleistopholis glauca						Δ		
Cordia alliodora						Δ		Δ
Diospyros discolor	Δ							
Elaeocarpus sphaericus						Δ		
Endospermum medullusum						Δ		
" peltatum	Δ							
Entandophragma angolense						Δ		
" cylindricum						Δ		
" utile						Δ		
" sp.						Δ		
Eucalyptus alba							Δ	
" andrewsii							Δ	
" apodophylla							Δ	
" bigalerita							Δ	
" botryoides							Δ	
" brassiana							O	
" camaldulensis							O	Δ
" citriodora							Δ	
" cloexians							Δ	
" crebra							Δ	
" deglupta	◎				◎	Δ	Δ	Δ
" exsarta							Δ	
" grandis	◎						O	Δ
" gummifera							Δ	

Table III-1. (1) Cont'd

Eucalyptus houseana							Δ	
" leptophleba							Δ	
" maculata							Δ	
" major							Δ	
" microcarps							Δ	
" microcorys							Δ	
" microtheca							Δ	
" moluccana							Δ	
" orgadophylla							Δ	
" pachycalex							Δ	
" pantoleuca							Δ	
" patellaris							Δ	
" pilligaensis							Δ	
" pilularis							O	
" puctata s.didyma							Δ	
" robusta					◎		O	Δ
" saligna							Δ	
" tereticornis					Δ		O	
" tetrodonta							Δ	
" torelliana						Δ		Δ
" urophylla							Δ	
" sp.			O					

Table III-1. (1) Cont'd

Flindersia brayleyana						Δ		
" iffliana						Δ		
Gmelina arborea	◎	○	◎			Δ		Δ
" moluccana						Δ		
Khaya ivorensis								Δ
" senegalensis								Δ
Langerstromia speciosa	Δ							
Leucaena glauca	◎							
" pulverulenta	○							
Maesopsis eminii		Δ				○		
Melaleuca leucadendron			○					
Nauclea diderichii								Δ
Ochroma lagopus			◎		○			
" limonensis			◎					
" pyamidale	○							
Pahudia rhomboidea	Δ							
Pometia pinnata						Δ		
Rhizophora mucronata			○					
Serianthes								Δ
Terminalia belenca								Δ
" brassii					◎	○		
" calamansanai						◎		Δ
" ivorensis						Δ		Δ
" sepicana						Δ		

Table III-1. (1) Cont'd

Terminalia superba						Δ		
Tristania conferta								Δ
Vitex cofassus						Δ		
Vitex parviflora	Δ							
Xylia dorabriformis						Δ		
Xylopia ferruginea	0							

Other species adopted for trial planting in Solomon.

Acrocarpus fraxinifolius
Albizzia lebbek
" procera
Alstonta macrophylla
Anacardium oxidentalis
Broussonetia papyrifera
Callitris robusta
Callitris macleayana
Calophyllum vitiensis
Cedrela mexicana
Cedrela toona
Chlorophora excelsa
Cinnamomum camphora
Cinchona josephiana
Cochlospermum vitofolium

Cordia dodecandra
" subcordata
Cupressus lindleyii
Dacrydium elatum
Dalbergia sissoo
Endospermum macrophyllum
Entandrophragma cyclocarpum
Eucalyptus botryoides
" cloeziana
" fastigata
" melliodora
" paniculata
" resinifera
" sideroxylon
Flindersia australis

Flindersia brayleyana
Fragraea gracilipes
Grevillea robusta
Hibiscus elatus
Khaya anthotheca
Mangifera indica
Myristica castaniifolia
Pterocarpus dalbergioices
" vidalianas
Santalum album
" yasi
Schizolobium parahybum
Semanea saman
Sterculia perkinisoni
Syncarpia laurifolia

Table III-1. (1) Cont'd

Tabebuia heterophylla	Toxodium mucronatum
" pentaphylla	Vitex vitensis
Terminalia catappa	Widdringtonia whytei
" richii	

Table III-1. (2) Pine trees

Species	Philli-ppines	Malay-sia	Indo-nesia	Thai-land	New Guinea	Solomon	New Cale-donia	New Heb-rides
Pinus canariensis							△	
" caribaea								
v. hondurensis	◎	◎	◎		◎	△	◎	△
" elliottii v. elliottii							△	
" insularis(P.khasya)	△				◎		△	
" massoniana							△	
" merkusii	△	△	◎		◎		△	
" oocarpa		△	◎				△	△
" patula							△	
" radiata							△	
" taeda							△	

Table III-1. (3) Species with a comparatively long cutting period which are used specifically for saw timber

Species	Philli-ppines	Malay-sia	Indo-nesia	Thai-land	New Guinea	Solomon	New Cale-donia	New Heb-rides
Agathis alba		◎	◎					
" lanceolata							Δ	
" macrophylla						Δ		
" moorei							Δ	Δ
" obtusa								Δ
" palmerstonii						Δ		
" robusta						Δ		
Altingia excelsa			0					
Anisoptera sp.(A.laevis?)		◎						
Araucaria bidwillii						Δ		
" columnaris								Δ
" cunninghamii					◎	Δ		Δ
" excelsa						Δ		
" hunsteinii					◎	Δ		
Dalbergia latifolia			0					
Dryobalanops spp.		◎						
Dyera costulata		◎						
Intsia bijuga	Δ							
Pterocarpus indicus	Δ							
Spathodea campanulata	Δ							
Shorea spp.(Meranti,Seraya)		◎						

Table III-1. (3) Cont'd

Swietenia macrophylla	Δ		O			O		Δ
Tectona grandis	Δ		◎	◎	◎			Δ

Note: Some of the species which are considered to belong to sheet (3) are also listed in sheet (1).

Table III - 1. (1) ∿ (3) have been arranged by Dr. K.SAKAGUCHI.

Softwood species such as Chamaecyparis obtusa and Cryptomeria japonica, which are grown in Japan and have a high timber quality, have already been tried in Taiwan with some results. In the region of high temperature and high humidity like Fiji, however, it is feared that Chamaecyparis obtusa and Cryptomeria japonica may easily be attacked by some diseases and for this reason, introduction of these species to lowland forest zone may not be desirable. However, it may be worthy of trying these species in the area of higher elevations.

2) Planting of Six Selected Species

All of the six selected species have already given the results of planting either in Fiji or other countries and their wood quality and characteristics have also been clarified. Hence, there seem to be no need to reconfirm these points in detail.

Mahogany and Cordia have a bright prospect as species of high economic values. From the standpoint of economic growth of timber, adoption of a cutting age of 55 years, which is considered to be a comparatively long period of time as a final age, for Mahogany is worthy of high praise. Also for Cordia, a comparatively long period of time, at least 30 years or over, should be considered as a final age.

The damage to Mahogany coused by Ambrosia beetles is quite a serious problem. However, this species is considered most suitable for planting in that it involves no large trouble in planting techniques other than the damage by Ambrosia beetles and that it can produce timber of the highest quality when it reaches the final cutting age. It is considered essential, therefore, to take appropriate steps to prevent the damage by Ambrosia beetles and to make further efforts to expand the planting of Mahogany.

To control Ambrosia beetles, the first requirement will be to carry out a basic research in the hand of experts on the life history of these beetles, which leads to the effective countermeasures.

At the same time, prevention and extermination experiments for Ambrosia beetles by silvicultural treatments should be carried out as early as possible on the basis of available data. For example, experiments may be conducted by removing the poisoned trees which provide a breeding bed for Ambrosia bettles or by employing a planting method which will not involve poisoning or by adopting a planting technique which provides clean forest floors.

Anthocephalus, Endospermum and Eucalyptus may excell other species in that they are fast growing species. However, they can be considered mainly for use as raw materials for processed wood and they are not completely free from future problems in respect of yarding, processing and sale of large quantities at low cost. Unless these problems are solved satisfactorily, it can hardly be said that the planting of these species will be successful because of the prevailing conditions of world lumber market.

Maesopsis may be a little more promising than the previously mentioned three species whose main use are raw materials, but the expansion of plantations to a considerable extent will be a precondition to the success of planting of this species.

In summary, it must be pointed out that in developing man-made forests and expecting some profits from such forests, emphasis must be placed on the production of high quality timber and that the development of a tropical hardwood plantation having a single pourpose of the pulp wood production still involves many problems both technically and economically. Especially in the region with a limited land space like Fiji, forestry should be aimed at more intensive forestry which can realize a high earning rate from per unit area.

3) Reforestation Projects

In order to be successful in reforestation as a project, attention must be paid to several points.

One of them is the careful selection of planting species. When a wide variety of planting species is used for the reforestation project, the expansion of planting area will result in the diversification of timber produced. This means that such production processes as yarding, processing and marketing of forest products must also be diversified according to tree species. When the timber has a wide variety of species and has a small volume for each species or when the volume of timber production for each species fluctuates from year to year, the market will become unstable and will bring about undesirable consequences. This, in turn, will lead to instability of timber prices at the production site.

Because of the reasons mentioned so far, it is important to make careful selection of tree species and to limit the number of species for planting to two or three for each plantation to ensure sound management of man-made forests. When a large area is planted with a single species, however, there is a possibility of spreading of various damages. To prevent the spread of damages such measures as establishment of shelter belts or arrangement of plantations of two or three different species in a mozaic pattern may be considered.

The second importance is the uniform distribution of age-classes in the planting area. Irregular age structure leads to fluctuations of the volume of timber production and brings about adverse effects on the market. To provide a basis for the sustained yield management in a certain wide area of plantation, uniform distribution of age-classes must be considered as a basic requirement.

Thirdly, it is quite probable that such problems as the decreasing of soil productivily and the need of soil conservation, will still remain unsolved even when the reforestation project is successfully carried on and all of the aforementioned requirements are fulfilled. In the tropics, decomposition of organic matters on and in soil takes place rapidly and loss of soil nutrients is also great. These phenomena are especially remarkable when the forest is turned to a bare land after clear cutting. If the plantation is subjected to successive regeneration under clear cutting for two or three times, a serious consequence such as soil erosion, with the subsequent decreasing of soil productivity, may not be avoidable.

These problems should be given serious consideration particularly in the region like Fiji where steep slopes are dominant in topography and where a relatively large precipitation is recorded. What may be considered as a possible solution to the problem of soil erosion is to limit the unit area of individual plantation to a minimum and plan for a mixed arrangement of small lots in mozoic, which are planted with trees of various age-classes so that the possibility of leaving a large area of bare land at the time of final cutting may be avoided. The line planting system which does not leave a bare land at the time of planting is quite acceptable in that it helps prevent the soil erosion in the first generation planting.

On the other hand, the present line planting system is not so effective for timber production though it may be advantageous for reduction of the cost of reforestation. There is no denying that the line planting system is one of good methods for reforestation in the tropical forest zone, but it is suggested that a little more expense be allocated to land preparation and tending to make the effective use of planted area for production of high quality timber. Such measures as the intensive management of planted area by sacrificing the spread of planting area, if necessary, for improvement of the quality of planted trees may well be considered.

Fourthly, there is a problem of site classification. It may be said that "right tree on right site" is the fundamental principle of reforestation. In Fiji the area available for immediate use for a large reforestation project is quite limited because of the pattern of land ownership and other reasons. Even so, it will be necessary to conduct a survey of site conditions with emphasis placed on soil survey to determine, especially, the relationship between the soil conditions and the growth of trees to establish a site classification for that limited area.

At present, only a soil map, scale: 1/126,720 (The Soil Resources of the Fiji Islands), has been prepared in Fiji and no other detailed maps are available. Soil maps of higher accuracy are indispensable for detailed planning of the proposed reforestation area.

4) Silvicultural Experiments

Various silvicultural experiments are now being carried out mainly for the newly selected species. However, the addition of the following experiments to the present experiments is desirable.

1 Experiment on land preparation through clear cutting and burning.

Land preparation through clear cutting and burning may be advantageous in that it contributes to the intensive land use and elimination of poisoning trees which provide breeding beds of Ambrosia beetles. This experiment is generally designed to determine the cost and timing of land preparation and the effect of land preparation on soil productivity, growth of planted trees and outbreak of Ambrosia beetles.

2 Experiment on nest planting

Since the nest planting (clump planting) method is generally recognized to be effective for avoidance of meteorological damages and for mitigation of competition between planted trees and other vegetations, it may be worthy of trying this method in a high temperate wet zone to see its effect on the mitigation of competition. This method can be applied either to bare land planting or line planting. In the case of bare land planting, planting at a rate of 1,600 seedlings/ha, with four seedlings in the nest, 1.5 m seedling intervals and 5 m distance between each nest may be recommended as a standard planting density. In the case of line planting, meanwhile, planting at a rate of 800 seedlings/ha with four seedlings in the nest, 1.5 m seedling intervals, 5 m distance between each nest on the line and 10 m line intervals may be appropriate as a standard planting density.

3 Experiment on planting density

Experiments on planting density including planting at extremely low and high density, without regard to the economic aspect, are very important to obtain basic data for determining the effect of stand density on the growth of planted trees. The experiment on planting density may be designed for a wide range of density centering on the generally accepted planting density, and the following case may be suggested as an example.

Since a planting density of 1,000∿1,500 seedlings/ha is considered as a normal density for bare land planting, a density of 1,000 seedlings/ha may be taken as a medium density and the following five classes of density may be designed.

250, 500, 1,000, 2,000, 4,000 seedlings/ha

When the average volume of single tree is expressed as $\underline{v}$, the volume per ha as $\underline{V}$ and the stand density as $\underline{N}$, then, a relatively clear relation may be expected as shown below.

$$\frac{1}{\underline{v}} = A\underline{N} + B$$

$$\frac{1}{\underline{V}} = A + \frac{B}{\underline{N}}$$

A and B are coefficients which are determined at each stage of growth. In the high density block, the growth of trees is naturally accompanied by dead trees due to overcrowding. This process of growth may be expressed as follows.

$$\frac{1}{\underline{N}} = A\underline{v} + B$$

When the trees have grown sufficiently, the following relation may be established.

$$\log \underline{v} = a \log \underline{N} + b$$

In the above, A, B, a, and b are coefficients and the value of a is generally considered to be about $1.5 \sim 2.0$.

4 Experiment on fertilization of middle aged plantation.

In addition to the fertilization at the time of planting and at an early age of the planted trees, fertilization of a stand, particularly the stand of species intended for a long cutting period, at the time of thinning will be quite effective for acceleration of crown closure following the thinning. Fertilizers should be applied immediately before or after thinning and the use of fertilizers weighted with phosphate is recommended. The existing fertilizer generally available for use is IB compound synthetic fertilizer (50% of IB and nutrient composition is 10-10-10) and an experiment designed for a combination of fertilization in two stages and no fertilization stage in three blocks, heavy thinning, light thinning and no thinning, will be sufficient.

4. PROSPECTS FOR CHIP PRODUCTION FROM HARDWOOD

(1) Conditions of Forests under study

The main forests being considered for chip production from hardwood are so-called tropical rain forests located in the eastern part of Viti Levu and southern part of Vanua Levu. As for the composition of these tropical rain forests such as tree species, standing tree volume and stumpage ratio of each species, a survey was conducted by the Land Resource Division of Great Britain in 1969. These tropical rain forests consist of such species of softwood as Agathis vitiensis, Decussocarpus vitiensis, Dacrydium elatum, Podocarpus neriifolius and Podocarpus imbricatus, which account for 6.3 per cent of the total stand in. Viti Leve and 9.8 per cent in Vanua Levu, and more than 80 species of hardwood, some of them are the same as those found in Papua New Guinea, Solomon Islands and New Hebrides, which include mainly Endospermum spp. (15.1 %), Myristica spp. (9.9%), Calophyllum spp. (10.8%), Syzygium spp. (9.0%), Palaquium hornei (5.0 %), Palaquium spp. (1.9%), Gonystylus punctatus (4.0 %) and Canarium spp (2.8 %). (Figures in parentheses represent the share in the total growing stock in Viti Levu). The composition of growing stock in Viti Levu may be broken down roughly into 6.3 % of softwood, 32.1 % of low density hardwood, 20.3 % of medium density hardwood, 20.1 % of high density hardwood and 21.2 % of other species. As far as the hardwood is concerned, the low and medium density class accounts for 80% of the total growing stock.

The area and growing stock of production forests, which are the source of timber production, are 123,700 ha and 6,127,000 m^3 (49.5 m^3 per ha), respectively in Viti Levu and 107,100 ha and 4,554,000 m^3 (45.5 m^3 per ha), respectively in Vanua Levu (merchantable overbark volume of trees over 40 cm diameter breast high).

When the use of pole timber with a tip end diameter of up to 10 cm for wood chip production is considered, an increase of growing stock by 20 ∿ 30 % may be expected depending on stand type.

The forest ownership and felling right are determined by land ownership classification. The majority of land is native land owned by the indigene of Fiji and felling in the forest requires a concession and a long-term license. For most of the good stands where roads are already built and felling operation is relatively easy, major wood industry companies have already obtained a concession and license.

(2) Conditions of logging operation

According to the Fiji Forest Department, the maximum allowable cut for the existing concessions and long-term licenses is set at 208,000 m^3 (69,000,000 Hsℓ ft). The total log production in 1975 was 139,300 m^3 (46,392,000 Hsℓ ft), the greater portion of which or 85 % were accounted for by the following 10 species.

Conifer or Broad leaves	Local name	Botanical name	Production ratio
C	Dakua makadre	Agathis vitiensis (Seem.) Drake	22%
B	Kauvula	Endospermum macrophyllum (Muell-Arg.)	19%
B	Kaudamu	Myristica chartacea Gillespie	12%
B	Damanu	Calophyllum vitiense Turr.	10%
B	Yasiyasi	Syzygium/Eugenia/Acicalyptus spp.	6%
C	Dakua salusalu	Podocarpus vitiensis Seem.	5%
B	Sacau	Palaquium hornei (Hartog ex Bak) Dubard	3%
B	Bauvudi	Palaquium fidjiense Pierre	3%
B	Mavota	Gonystylus punctatus A.C. Smith	3%
C	Yaka	Dacrydium elatum Wall	2%
C/B	Others		15%
	Total		100%

The remaining 15 % are composed of a wide variety of species, with individual species accounting for very small percentage of the total growing stand. The production ratio of species shown in the table changes year from year.

The difference between the composition of overall tree species and the composition of production species indicates that the selecting cutting of those species with high commercial values is being carried out only in good, commercially advantageous stands and in the area where roads are complete for easy logging operation.

The method of logging employed is the same as that used for general tropical rain forests. Chain-saws are used for cutting and full stem length yarding with a slight cut of top is being employed. Tractors and skidders are used for hauling of logs to forest roads and truck terminals in the camp. Bucking is made at the camp timber yard. Small scale logging contractors also use chain saws for felling operation but use cattle for hauling of logs to the truck terminals in the camp. From the camp truck terminal, timber is transported directly to saw mills, veneer sheet mills and match manufacturing plants by truck. Timber is also transported by barge depending on locality.

Since the tropical rain forests in Fiji are generally characterized by a steep topography and high annual precipitation amounting to 3,000 mm, 3,800 mm, the logging operation seems to be greatly dependent on the completeness of roads for transportation by truck.

(3) Preconditions for Chip Production from Hardwood

When the Japanese paper and pulp manufacturers purchase wood chips from foreign countries, the chip must meet the following four requirements in general.

1 Quality

i) Chip must have a good pulp adaptability and yield and must be usable as raw materials for paper manufacturing.

ii) Chip must be fresh and must have configurations meeting the specification (uniform quality).

iii) When the chip is of mixed species, the difference of pulp adaptability between each species must not be great and the mixture ratio of different species must be balanced.

2 Quantity

i) Chip must be available in fixed quantities for a long period of time. More specifically, wood chip carriers must be able to call at port regularly and the chip must be available continuously for at least 10 years (one chip carrier per month base).

3 Price

i) Prices of chip must be in conformity with world market prices (with consideration given to quality, yield and bulk density).

ii) Prices must be stable for a long period of time.

4 Facilities

i) Fairways and port facilities must be complete to berth wood chip carriers.

ii) Chip loading facilities must be adequately provided.

A study of natural forests of hardwood in Fiji, which was made in relation to the above requirements shows the following results.

i) Requirement for quality

The hardwood grown in temperate and frigid zones is generally used widely as a raw material for pulp and paper manufacturing since their adaptability to pulp and paper making has already been proved. The tropical wood, on the other hand, grow in various parts of the tropics and includes a numerous number of species. A considerable difference is seen in chemical and physical properties between individual species of tropical wood and even the same species shows a considerable difference in character depending on the locality.

In evalvating the appropriateness of tree species for pulp making therefore, it is important to make a careful and systematic study on the relation between the properties of wood and the properties of pulp products. The tropical hardwood shows a definite character which is somewhat different from that of temperate hardwood. General characteristics of the tropical hardwood are as follows.

1 Fibre configuration

Despite the fact that wood fibre undergoes many processes such as chemical processing (cooking, bleaching) and mechanical processing (beating, dehydration, formation) until it is made into a final product, which is the paper, there is a definite relation between the strength and other physical properties of paper and the configuration of original wood fibre. With regard to the configuration characteristics of the fibre, the tropical hardwood has an average fibre length of 1.3 ∿ 1.4 mm, which is slightly longer than the average fibre length of 1.13 mm of Seibold's beech grown in Japan, but its fibre width is too great as compared with the length. Also because of a thick cell wall on the average, the tropical hardwood is inferior to Seibold's beech grown in Japan in respect of softness and flexibility of fibre. The final conclusion as to the appropriateness of tropical hardwood as a pulp wood cannot be reached until a complete study is made on the relative difficulty of cooking and bleaching and the lowering of surface strength of paper due to macro vessel elements (cavses vessel separation when ink is applied at the time of printing and provides a source of vessel picking which leaves blanks in the print), which is frequent with tropical hardwood (especially with Dipterocarpaceae) or pitch trouble, in addition to the evaluation of the afore-mentioned fibre configuration.

2 Chemical composition of wood

Chemical composition of tropical hardwood differs greatly from that of temperate and frigid hardwood, and this characteristics greatly influences cooking and bleaching effect or the properties of pulp. When compared with temperate and frigid hardwood, the tropical hardwood shows the following general characters.

(a) Lignin content is higher by about 10%.
(b) Low contents of cellulose and α-cellulose.
(c) Markedly low content of pentosans.
(d) Many extracts of various types.
(e) High ash content (inorganic salts).

High content of lignin and low content of pentosans are the distinguished characteristics of tropical hardwood. High content of various extracts is frequently observed especially in strongly colored wood.

(3) Special Components of Wood

(a) Mineral matter

Inorganic salts most commonly found in wood chip, both in quantity and the number of tree species, are lime (calcium) and silicic acid (silica). These are the only mineral matters found in wood cell. The existence of silica in the texture of wood is one of the main features of tropical hardwood and care must be exercised when using a large quantity of tropical hardwood as pulp wood since there is a possibility of developing a silica trouble in the recovery process of the KP-sulphate pulp mill.

(b) Organic matter

In addition to the high content of coloring matters, the tropical hardwood is generally featured by high contents of tannic or rubber-like amorphous organic sediments or fluids in its radial parenchyma or vessels which have become weak in vital function, which are considered to be main contributing factors for distinct coloring of tropical hardwoods. The wood with high contents of these organic matters is highly probable of developing a pitch trouble or causing a difficulty in bleaching process. For pulp making from tropical hardwood including Dipterocarpaceae it is necessary to provide a measure for removal of resin to eliminate the possibility of a pitch trouble.

4 Adaptability to pulp making

As described previously, the tropical hardwood is generally featured by a high content of lignin and a low content of cellulose. It is also featured by a considerably high content of extracts. Accordingly, the pulp made from the wood having these characters is destined to have a low yield and a high Roe number and is considerably difficult in cooking as compared with Japanese headwood. Because of a high content of pigment in pulp, an additional amount of bleaching agent will be required and the yield precentage of bleaching will be lower accordingly. It may generally be said that the bleaching of tropical hardwood is more difficult than that of the Japanese hardwood.

The above is a general and average observation on the basis of a comparison between tropical hardwood and temperate or frigid hardwood. When a mixture of different species of tropical hardwood is used in large quantities, it will be necessary to divide them into appropriate groups of the same species since the difference in characteristics is considerably great between individual species.

5 Bulk density

In addition to the previously mentioned adaptability to pulp making and paper making, the wood chip is also required to have a high bulk density to minimize the cost of sea transportation over a long distance. In the case of tropical hardwood, the bulk density has a wide distribution from very low density to very high density. A study of the correlation between the softness coefficient and paper strength (breaking length and burst factor), which represent the adaptability to paper making and the bulk density of tropical hardwood shows that the species with a high bulk density (lower transportation cost) is inferior in respect of the adaptability to paper making. As far as pulp wood are concerned, therefore, the adaptability to pulp making, adaptability to paper making and the bulk density are considered individually and only those species which can meet the specific requirement are being developed for wood chip production in the tropic zones. Examples of species of tropical hardwood which have been industrialized as wood chip are shown in the following table.

Wood Chip Production Participated by Japanese Firms in the Tropic Zones

Country	Location	Tree Species	Annual Production	Start of Operation
Malaysia	West Malaysia Port Klang	Rubber scrap wood chip	300,000 G.L.T. (330,000 m^3)	1968. 11
"	West Malaysia Johore Bahru	"	300,000 G.L.T. (330,000 m^3)	1974. 5
"	Sarawak Rejang	Mangrove chip	180,000 MT (162,000 m^3)	1969. 4
"	Sabah Tawau	"	180,000 MT (162,000 m^3)	1971. 12
"	Sabah Sandakan	"	180,000 MT (162,000 m^3)	1973. 10
Indonesia	East Kalimantan Tarakan	"	252,000 ADT (226,800 m^3)	1977. 4 (Scheduled)
Papua New Guinea	Madang	Mixed hardwood chip	420,000 m^3	1974. 4

As shown in the previous table, the wood chip imported from the tropical zones by the Japanese paper and pulp companies are limited to single species or species of the same group to the extent possible and are also confined to the species with a high bulk density. The bulk density in oven-dried condition is 560 Kg/m^3 for rubber wood and 730 ∿ 850 Kg/m^3 for mangroves. Japan also imports eucalyptus wood chip from Australia and Hawaii and the bulk density in this case is 600 Kg/m^3 or over. However, the bulk density of mixed tripical hardwood chip produced in Madang, Papua

New Guinea, is said to be 490 Kg/m^3. In Japan the mangrove chips are being used mainly for production of dissolving pulp and coated papers and rubber wood and eucalyptus chip are being used for manufacturing of printing papers. The mixed chip of tropical hardwood, on the other hand, is being used almost exclusively for the manufacture of liner and corrugating medium and is not generally used as a raw material for printing papers. At present, the hardwood chip from the temperate and frigid zones are mostly in the among the imported wood chip, followed by wood chip of eucalyptus from southeastern region of Australia and Tasmania, eucalyptus, from the western region of Australia, rubber wood, mangrove, tropical hardwood excluding Dipterocarpaceae and hardwood of Dipterocarpaceae in that order. This ranking reflects the consideration given to the adaptability to pulp making, adaptability to paper making, bulk density and other factors.

For the tropical hardwood grown in Fiji, pulpification tests have already been conducted for several tree species. The following are examples of test results.

Nokonoko (Casuarina spp.): Leaves black spots in bleached pulp and is weak in paper strength.

Vaivai (Serianthes spp.): Leaves black spots in bleached pulp and has a slightly high resin content.

Lauvu (Garcinia spp.): Has a high resin content and is inferior in bleaching. Also has many vessels

Other species such as Terminalia spp, Mryistica spp. and Calophyllum spp present the possibility of pitch trouble.

Because of these results, the species mentioned above are not considered appropriate as raw materials for pulp production. Also, the Kauvula (Endospermum spp), which is said to account for 15.1% of the total growing stock in Viti Levu, has such a low bulk density as 352 Kg/m^3 and its pulp yield is as low as 190 Kg/m^3.

With regard to the distribution ratio of tree species, approximately 80 % of hardwood species are accounted for by species of low and medium density and the average bulk density of hardwood in the region is considered to be less than 500 Kg/m^3. Also because of the composition of tree species in the cutting area and the use of log (priority will probably be given to the log for lumbering and veneer sheet manufacturing), the composition of tree species which can be used for chip production cannot be estimated and accordingly, the bulk density of mixed wood chip cannot be determined.

Even those species which are considered to be usable for pulp production (excluding those species which have been determined to be unfit for pulp production) generally have a high Roe number, less folding endurance and are slightly inferior in bleaching when compared with the Japanese hardwood species. In the case of Fiji, grouping of tree specie according to the adaptability to pulp making may not be possible because of the difficulty in securing sufficient volume for each group and also because of the composition of forests, and only the mixed wood chip can be considered. However, the stability of mixing ratio is considered very difficult as mentioned previously. Therefore, the probable use of mixed hardwood chip produced in Fiji for the time being will be for manufacturing of liner and corrugating medium or for mixing of small quantities with other types of good quality chip for the manufacturer of general printing papers as in the case of tropical mixed hardwood chip produced in Papua New Guinea.

2) Requirement for Quantity

When the transportation of wood chip from Fiji to Japan over a long distance is considered, the amount of annual export to Japan will be determined mainly by the tonnage of chip carriers and the frequency of trips. Moreover, when the length of guarantee period for chartering chip carriers and repayment of enormous capital investment for wood chip mills, loading facilities and port facilities are taken into consideration, the resources sufficient for export for at least 10 years on a stable supply basis must be secured. To estimate the approximate amount of wood chip for export, calculation was made in the following manner.

The distance between the port of Sava in Fiji and the port of Nagoya in Japan is 4,043 miles. To hold down the cost of transportation over such a long distance to the extent possible, a mass transportation system must be considered. In view of the prevailing market conditions for chip carriers, use of chip carriers of the 30,000 (D/W) K.T. class is most desirable since the operation of carriers with a tonnage less than 30,000 (D/W) K.T. would result in higher freight and would not be competitive. The following calculation is made for the case of a chip carrier of 30,967 (D/W) K.T. owned by a certain company. Elements used for calculation are:

Gross tonnage (G/T)	:	25,526 t
Full draft in the summer	:	10.0 m
Speed	:	14.5 knot
Total number of days for loading and unloading WWD. SHIN.	:	10 days
Number of voyages	:	11 trips/year (33 days per trip)
Hold capacity	:	2,114,320 cuft
Compaction factor	:	209 cuft/B.D.U (in the case of Jant)
1 BDU (Bone Dry Unit)	:	IBDU (Unit of wood chip transaction) = 2,400 ℓbs bone dry = 1,088.6 Kg bone dry

Therefore, the shipping volume is calculated as follows.

$$\frac{2,114,320 \text{ cuft}}{209 \text{ cuft/BDU}} = 10,116 \text{ BDU} \doteqdot 10,100 \text{ BDU}$$

If a bulk density of 490 Kg/m³ is used as in the case of Jant Company, 1BDU per log volume will be:

$$\frac{1,088.6 \text{ Kg}}{490 \text{ kg/m}^3} = 2,222 \text{ m}^3$$

Then, the shipping volume, 10,100 BDU may be calculated as 2,222 m^3 x 10,100 = 22,442 m^3 in terms of log volume.
Assuming the yield of chip production is 95%, the volume of log required will be 23,623 m^3. As a result, the volume of log required will be 23,600 m^3 per carrier, 259,600 m^3 per annum and approximately 2,600,000 m^3 for a period of 10 years.

In Fiji, however, the maximum annual allowable cut for the existing concession and long-term license holders is set at 208,000 m^3 and log production in 1975 was 139,300 m^3. This means that an additional 260,000 m^3 of timber will have to be secured for chip production in additional to the present production of log for lumbering and manufacturing of Veneer Sheet. Since the forests under study are not intended solely to provide log for wood chip production but are also intended to provide log for lumbering and veneer sheet manufacturing, a supply capacity exceeding the 400,000 m^3, which is the sum of 260,000 m and the present production of 140,000 m^3, will be required to secure a supply of about 260,000 m^3 of log per annum for chip production. This figure is more than twice the present allowable cut. Moreover, the above figure represents the total requirement in Viti Levu, Vanua Levu and other islands. When the requirement for wood chip mills, loading facilities and port facilities is taken into consideration, these islands must be treated individually. From this point of view, production of additional 260,000 m^3 of log from the existing forest resources (comprise only natural forests of mixed hardwood and lack man-made forests) would be extremely difficult.

3) Requirement for price

The price structure of wood chip imported by various Japanese paper and pulp manufactures has a historical origin in the purchasing price of wood chip produced from scrap wood of the timber industry operating on the west coast of North America and the present price structure is still based on this price. In other words, the present price is determined on the basis of CIF price Japanes port, which is a sum of FOB price on the west coast of USA and freight and insurance. The FOB price is determined by demand and supply, with consideration given to the adaptability to pulp making, paper making and the bulk density of wood chip of individual tree species.

A trial calculation of prices of wood chip is shown below. The conversion rate as of September 1976 shown below will be used for calculation.

US$1.00 = ¥300
Fiji $1.00=US$1.0952
Fiji $1.00= ¥329

For the purpose of calculating the freight and FOB price of mixed hardwood chip produced in Fiji, the CIF price Nagoya, freight and FOB price adopted by a certain company for eucalyptus wood chip imported from Hawaii will be used. The tonnage of a chip carrier is assumed to be D/W 30,967 KT which was mentioned in the previous section. Eucalyptus wood chip produced in Hawaii (CIF price Nagoya)

Bulk density	639 Kg/m^3, 1BDU = 1.704 m^3
FOB price	US$50.32/BDU
Freight	US$23.96/BDU
Import charges	US$ 4.74/BDU
Total (CIF price)	US$79.02/BDU
or	¥13,912/m^3

In this case, the shipping volume is 13,180 BDU (22,460 m^3)

Hence, the price of mixed hardwood chip produced in Fiji may be calculated as follows.

Bulk density: 490 Kg/m^3 or 2,222 m^3/BDU

Shipping Volume: If a capacity factor of 209 cuft/BDU is used; the holding capacity 2,114,320 cuft ÷ 209 cuft/BDU = 10,100 BDU, then shipping volume is 22,440 m^3

Freight : On the basis of lump sum charter freight (Suva - Nagoya), the freight plus bunker Surcharge is calculated as US$311,675.25. Then the freight per BDU will be US$311,675.25 ÷ 10,100 BDU = US$30.86/BDU

If the same CIF price as that of eucalyptus chip is used,

CIF price	US$79.02/BDU (¥13,912 per m^3
Freight	US$30.86/BDU
Import charges	US$ 4.85/BDU
Then, FOB price is	US$43.31/BDU

When the CIF price is adjusted according to the percentage of bulk density of mixed hardwood chip and eucalyptus chip, the result will be as follows.

CIF price	US$79.02/BDU $\times \frac{490}{639}$ = US$60.59/BDU
Freight	US$30.86/BDU
Import charges	US$ 4.22/BDU
FOB price	US$25.50/BDU

Then, the FOB price Fiji (estimated price) of mixed hardwood chip obtained by reverse operation, in which Ocean freight and import charges (marine insurance, L/C charge, customs fee, demurrage at the port of unloading and other charges) are deducted from CIF price Japanese port, will be as follows.

When the same CIF price as that of eucalyptus chip is used	When the CIF price is adjusted according to the percentage of bulk density
US$43.31/BDU or US$19.49/m^3	US$25.50/BDU or US$11.48/m^3

The FOB price/m^3 shown above includes such costs as loading charge, chip production cost, cost of log, and administration expenses. Since the loading charge and cost of chip production include depreciation charges of facilities and equipment as a fixed cost in addition to such direct costs as utility cost, wages and maintenance cost with their cost per m^3 fluctuating from year to year depending on the volume of production and export, it is not practical to estimate loading charges and production cost on the uniform base. According to some examples, however, the loading charge is said to be approximately US$4.00-6.00/$m^3$ and chip production cost is quoted as around US$10.00/m^3 (direct cost, indirect cost and depreciation charges are included in both cases). A calculation by reverse operation on the basis of these costs shows that the price of log must be either extremely low or minus figure. In the case of Fiji, however, it is difficult to base the estimation of price of log at mill site on the present logging cost and wood transport cost since the price of log in Fiji will be influenced by such factors as the location of felling site, stand type and the distance to a proposed chip mill. On this point, a detailed field survey must be made to obtain more accurate data. Since the final price of log at mill site is required to be as low as that mentioned previously under the existing circumstances, production and export of mixed hardwood chip utilizing the existing untapped natural forest resources would be extremely difficult.

For further information, export prices of wood chip in other countries (1976) are shown below.

North American Douglas Fir:	US$52.00/BDU(FAS price)
Australian eucalyptus :	A$40.00/BDU(FOB price)
Malaysian mongrove :	US$20.00/Green ton (FOB price) (US$33.50/BDU, FOB price when calculated with a moisture content of 35%)

Jant Company in Madang, Papua New Guinea has been exporting tropical mixed hardwood chip since 1974. For the first two years, that is 1974 and 1975, the company exported the chip for a FOB price of A$27.00/BDU.

4) Requirement for facilities

It is said that the Fiji government has not yet selected a site for construction of a port for shipment of wood chip. In the case of Viti Levu which is surrounded by coral-reefs, the area available for construction of a port to berth large chip carriers is extremely limited. The first and most important requirement for export of wood chip is completeness of loading point. In other words, the port must be equipped with navigation aids for safe navigation of chip carriers, sufficient water surface, safe anchorage and efficient chip loading facilities. These port facilities will be the subject of a further study.

For additional information, the cost of the necessary facilities is estimated as follows.

(1) Fairways, wharves and anclorage (12 m in depth)
Approximately ¥400 million or US$1.34 million

(2) Chip mill with an annual capacity of 270,000 m^3
The cost of equipment, building, outside chip storage (OCS), loading equipment is estimated at ¥3,310 million or US$11.03 million

The total cost, (1) plus (2), is estimated at ¥3,710 million or US$12.37 million.

In actuality, the capital investment exceeding this figure would be required at least. The above figure represents only a rough estimate on the basis of an example of existing cases, and an accurate estimate cannot be made until a detailed survey is made on the site for chip mills and the proposed location for port construction.

For additional information for the design of fairways and port facilities, the total number of chip carriers in Japan is 70 as of the end of 1976. The ship size of chip carriers has been increasing steadily in recent years and the largest chip carrier in operation is the Empress of Eaden, D/W 57,800 KT, of Showa Shipping Co., Ltd., which is now in service on the Australian route for transportation of eucalyptus chip. Table shows wood chip carriers chartered by the Japanese paper and pulp manufacturers.

Wood Chip Carriers Operated by Japanese Paper and Pulp Manufacturers

(As of end of 1976)

Name of carrier	Time of completion	Deadweight tonnage (L/T)	Holding capacity (1,000 cft)
OJI MARU	Dec. 1967	26,193	1,726
KATHRYN MARU	Apr. 1968	26,177	1,726
KASUGAI MARU	Jun. 1970	41,545	2,896
DAI-ICHI OJI MARU	Dec. 1972	41,217	2,950
PRINCE OF TOKYO	Jul. 1974	40,861	2,950
GRAND ZODIAC	Jul. 1975	30,479	2,114
SHINYO MARU	May 1968	23,692	1,738
HOYO MARU	Oct. 1972	23,868	1,644
GOYO MARU	Jan. 1973	36,603	2,704
MIMOSA AFRICANA	Jul. 1975	49,200	3,600
JUJO MARU	Feb. 1968	21,844	1,420
NEGO TRIABUNNA	Feb. 1971	41,411	2,724
SILVI CULTURE	May 1971	41,409	2,724
DAINI JUJO MARU	Jun. 1972	30,687	2,114
ORIENTAL SOVEREIGN	Sep. 1975	46,651	3,500
MERIDIAN	Oct. 1975	44,289	3,100
EHIME MARU	Sep. 1970	28,533	2,750
TAIKAI MARU	Jun. 1971	28,392	2,704
SOUTHERN CROSS	Aug. 1973	47,153	3,314
WORLD WOOD	Jan. 1974	45,864	3,142
ORIENTAL TAIO	Jul. 1974	45,889	3,140
PACIFIC TAIO	Sep. 1974	56,273	4,128
UNIVERSAL TAIO	Oct. 1974	45,888	3,140
TAIKO VENTURE	Jul. 1975	33,872	2,316
OJI GLORIA	Aug. 1976	41,239	2,878

Name of carrier	Time of completion	Deadweight tonnage (L/T)	Holding capacity (1,000 cft)
KEISHO MARU	Apr. 1967	24,955	1,606
TAIHO MARU	Jul. 1967	26,744	1,740
SUZUKAWA MARU	Feb. 1968	20,966	1,646
TAIKI MARU	May 1968	24,534	1,613
NANSHO MARU	Nov. 1969	26,112	1,969
TAISHIN MARU	Jan. 1971	27,534	1,956
EADEN MARU	Oct. 1971	56,983	4,156
BUNGA TEMBSU	Nov. 1972	32,500	2,741
EASTERN WORLD	May 1973	37,312	2,723
BUNGA MELAWIS	Sep. 1973	32,500	2,741
DONA MARY	-	24,705	1,039
TAIHO MARU	Oct. 1974	36,589	2,704
BUNGA DAHLIA	-	20,701	1,332
EMPRESS OF EADEN	Jun. 1975	57,800	4,110
(NEW INDEPENDENT)		40,254	2,900
CHUETSU-ZAN MARU	Jul. 1967	27,764	1,642
TONAMI MARU	May 1969	41,460	2,882
SENDAI MARU	Dec. 1975	40,489	2,954
(PACIFIC VENTURE)	-	40,500	2,900
YAKAI MARU	May 1967	20,777	1,341
HIJIRI MARU	Oct. 1969	21,715	1,400
NELSON MARU	Nov. 1971	23,698	1,464
AKASHI MARU	Sep. 1973	24,421	1,659
TOHOKU MARU	Jun 1971	41,440	2,882

Name of carrier	Time of completion	Deadweight tonnage (L/T)	Holding capacity (1,000 cft)
HIRO MARU	Mar. 1967	23,862	1,643
SHIMA MARU	Jul. 1969	38,699	2,707
MORI MARU	Apr. 1972	30,654	2,114
EATON GLORIA	Aug. 1975	41,400	2,880
HONSHU MARU	Aug. 1967	21,761	1,420
SHIN-HONSHU MARU	Jun. 1970	23,536	1,737
MADANG	Jul. 1973	23,428	1,775
DAI-HONSHU MARU	Apr. 1974	42,591	2,114
HONSHU GLORIA	Apr. 1975	41,400	2,880
MORUZUMI MARU	Oct. 1967	23,825	1,641
DAIRIN MARU	May 1973	41,655	2,987
INU-SUMI MARU	Apr. 1974	41,523	2,914
SILVERNA	Jul. 1975	36,700	2,704
VALENTINA	Jan. 1976	37,300	2,700
YACHINOE MARU	Sep. 1972	53,331	3,422
INU-GO MARU	Nov. 1972	47,194	3,314
GAJA SATU	May 1972	7,269	512
GAJA DUA	Feb. 1974	7,427	512
NO. 18 KINRIKI MARU		14,000	1,018
PAPYRUS MARU	Jun. 1972	23,934	1,644
HOKUETSU VENTURE	Apr. 1976	44,700	31,000

Total: 70 carriers

5) Conclusion

In the previous section, a study was made on four major requirements, namely quality, quantity, price and facilities. When all of the results of the study are taken into consideration, the export of wood chip relying entirely on a mixed species of hardwood in the existing natural forests seems to be extremely difficult. For the development of a wood chip industry in Fiji, the fulfillment of these four requirements is absolutely necessary. For this purpose, appropriate measures of the Fiji government, to develop its forest resources, especially to implement large scale reforestation projects of higher productivity (for both hardwood and softwood), to secure stable and long-term concessions and licenses, to improve and expand road networks for improvement of the efficiency of logging operation, wood transport and infrastructures, to provide the necessary fairways and port facilities and to secure land spaces for construction of wood chip mills and locating chip yards, are highly hoped for.

The following are the results of a study on the feasibility of chip production from hardwood to be supplied by the proposed man-made forests and the possibility of export of wood chip produced in this manner. Of the tree species selected for planting, the following three species are being considered for use as raw materials for production of chip for pulp because of their fast growing characteristic.

(a) Anthocephalus cadamba : Bulk density ranges 450 Kg/m^3, 350 Kg/m^3, 346 Kg/m^3, 306 Kg/m^3 and 263 Kg/m^3. The average bulk density is lower than that of the following two species.

(b) Endospermum macrophyllum: Abundant in natural forest. Bulk density is 352 Kg/m^3.

(c) Eucalyptus deglypta: Bulk density ranges 363 Kg/m^3, 454 Kg/m^3, 446 Kg/m^3, 382 Kg/m^3.

All of these species have a good quality for pulp making and paper making and are suitable as raw materials for pulp making as they can be supplied as a single species. However, their low bulk density and low pulp yield per m^3 of chip make them not so competitive in respect of transport cost and market price. For the implementation of a reforestation project, therefore, efforts must be made to increase the yield volume per unit area, to improve the efficiency of logging operation and wood transport through mechanization of work and to provide such infrastructures as road network, power supply facilities so as to reduce the cost of cutting and transportation, cost of chip production and cost of shipment and make the chip production competitive in the market. Only in this way, the export of hardwood chip, together with the chip of Pinus caribaea which is expected to be produced by the Fiji Pine Commission in the future, will be realized.

If the feasibility of constructing paper and pulp mills (to be described later) for these planting species is recognized by the Fiji government and these production fasilities are provided, the need of sea transportation of raw wood over a long distance would be eliminated and the advantages of these species in pulp making and paper making would be utilized more efficiently.

As mentioned previously, export of wood chip requres a large volume of timber resources. Moreover, the log used for chip production need not be of a good shape and the log having a shape not suitable for lumbering and manufacturing of plywood and furniture would be adequate. This is the reason why the chip production on the west coast of North America is based on the utilization of scrap wood from lumber mills. With regard to the hard wood resources in the existing natural forests and proposed manmade forests, efforts whould be made to exploit the possibility of utilizing and exporting the timber as sawn timber (knock-down unfinished wood parts, for example) for manufacturing of wood work, molding interior wood, fancy sliced veneer and furniture, all of which have a high added value, instead of concentrating efforts in the export of wood chip.

(4) Preconditions for Construction of Paper and Pulp Mills

In evaluating the feasibility of a project for constructing paper and pulp mills in a certain area, it is necessary as a first step to study the feasibility of the project from the stand point of market, raw material supply, technology and economics.

General items of study required for this purpose are described below. Through this study, planning of the location of mills, type of products, operating scale, manufacturing process and marketing can be developed to determine the amount of required capital investment and then the feasibility of the project can be judged on the basis of economic evaluation. Therefore, it is difficult in this stage to point out the conditions item by item, which must justify the feasibility of such a project. In the case of Fiji, the probable products, if Pinus caribaea supplied by the Fiji Pine Commission is used as a raw material, would be one of the following, in which case the production capacity presupposing export of products would probably be 200-400 ton/day if the product is to competitive in world market, TMP (Thermo Mechanical Pulp), RGP (Refiner Ground Pulp), UKP (Unbleached Kraft pulp), BKP (Bleached Kraft Pulp).

General items of Study

1 Market

Long-range demand forecast and propects for the growth and stability of demand

- Type of products
- Quantity
- Potential customers
- Price

2 Log

- Tree species which can be supplied steadily for a long period of time and forecast of supply volume and price of timber

- o Technical matters

  - * Composition of tree species
  - * Shape, diameter and length of log
  - * Moisture, bulk density and color of wood of each species
  - * Relative difficulty of barking and disposal of barks (For environmental protection)
  - * Pulpification test (to determine optimum type of pulp, yield, quality and operating conditions)

3 Land

- o Acreage
- o Price
- o Soil condition (bearing power of ground), frequency and magnitude of earthquakes
- o Shape
- o Availability
- o Need of site preparation

  - * Site preparation for mills
  - * Construction of roads, railways and bridges and pavement of roads.
  - * Construction of company housing, welfare facilities for employees and motor pool
  - * Construction of office buildings and warehouses

4 Water supply and drainage systems

- o Location of water supply sources (underflow water or surface water)
- o Water right
- o Available flow (seasonal fluctuations)
- o Quality, temperature, turbidity, hardness and PH of water
- o Standards for waste water discharge (for environmental protection)
- o Location of waste water discharge

5 Power supply and fuel

- o Availability of power
- o Existing power supply facilities
  - * Supply capacity
  - * Voltage, frequency
  - * Energy cost, standards for power purchasing contract.
  - * Distance from power transmission lines and reserve capacity of transmission lines
- o Fuel cost, distance from fuel depot (grades and viscosity of heavy oil)

6 Transport system, port facilities

- o Transport of log: Transport system, distance, route and cost.
- o Transport of products: Transport system, distance, route and cost
- o Port warehouse for export: Public owned or privately owned, warehousing and delivery charges, storage, availability and price of land for construction of warehouses.
- o Availability of berths: If berths are available, type length, water depth, rental, type of cargo handling equipment.
- o Stevedorage
- o Number and operating scale of shipping companies

7 Mechanical and electrical works

- o Availability of machine shops in the nearby districts. Details of facilities of machine shops, if any.
- o Number and level of skilled mechanical workers by Job classification
- o Availability of electric contractors
- o Ability of contractors for repair of electric equipment

8 Civil and architectural works

- o Number, operating scale and ability of civil and architectural contractors
- o Construction cost: Cost of excavation and transport of materials, cost of site preparation, cost of buildings (separately for mill, warehouse, office building and company housing)
- o Construction materials: Price of cement, gravel, sand, structural steel, slate and glass.
- o Building standards

9 Labor

- o Condition of labor market, rate of labor immobility
- o Labor laws, labor practices
- o Wages
- o Educational background, work level and efficiency of laborers.
- o Specially trained workers such as electricians.

10 Chemicals: Purchasing price, purity and packing style of the following chemicals.

Caustic soda, soda ash, salt cake, chlorine, sulphur, sulphuric acid, salt, limestone, sulphes dioxide, sodium sulphite, sodium chlorite, hypo chlorite, hydrochloric acid, alum.

11 Others

- o Meteorological data: Temperature, humidity, wind force, precipitation.
- o Political situation of the country.
- o Financial condition and amount of import and export of the country
- o Taxation system of the country (corporate tax, business tax, and others)

- o Import tariff
- o Prospects for procurement of funds
- o Bank interest
- o Number, operating scale, and operating conditions of paper and pulp mills in the country and amount of production, amount of consumption and amount of import and export of paper and pulp in the country.
- o Government policies for paper and pulp industries, organization, manpower and authority of government agencies responsible for paper and pulp industries.
- o Population of the country
- o Educational system, spread of education and the standard of education of the working class.

(5) Items of study for construction of wood chip mills

Items to be included in the study of the feasibility of producing wood chip from logs supplied by natural and man-made forests and exporting wood chip to foreign countries will be described hereinafter for additional information, through some of them may overlap the previously mentioned study items for the feasibility of constructing paper and pulp mills.

The feasibility study for such a project must be based on the study of the conditions of fairways and port facilities, supply of log as raw materials, conditions of forests as a supply source of log, marketability of wood chip under study, and the economic aspect of wood chip industry. Items to be included in the feasibility study are as follows.

1 Items of feasibility study of port and harbors

- o Topography: Geographical maps of proposed site for port construction, longitudinal section of the site for wharves (measuring by sight would be sufficient), distance to the tip of coral-reef, water depth, conditions of hinterland (for locating warehouses and chip yards).
- o Geology

- Wind direction and wind velocity: Statistical data on steady wind direction, strong wind direction and wind velocity for several years; Data on monthly wind rose, frequency of strong winds by direction, maximum wind velocity and records of typhoon available from a nearby weather station.
- Temperature: Monthly mean temperature, average of maximum and minimum temperatures for several years.
- Precipitation and stormy weather: Monthly precipitation, number of days of storming weather and number of days on which cargo handling is not possible.
- Fog: Period of dense fog during the year and number of days on which navigation is not possible.
- Tide level and tidal current: Datum of tidal level and height of tide, speed and direction of tidal current in the nearby water area.
- Waves: Maximum wave at the locality and maximum perennial wave, wave period and direction, abnormal waves such as tidal wave.
- Littoral drift and sediment transport: Conditions of shoaling and erosion in the nearby water area, if any and conditions of littoral drift and sediment transport from the river, which are considered to be the cause of shoaling and erosion.
- Others: Conditions of existing port and harbor facilities, conditions of loading equipment, and habitat of marine bore.

2 Survey of location conditions of wood chip mills

- Meteorology (Daily or monthly data for a 3 to 5 year period or possibly for a longer period should be obtained from a nearby weather station): Temperature, précipitation, wind velocity, wind direction, frequency of typhoon, humidity, number of fine days and rainy days
- Land: Topography (boundaries of site and others), geology (compactibility, natural water content, trafficability and others), soil strength, colummar section boring log, N-value, availability of land (ownership).

- Water supply: Amount of available water supply, quality of water, condition of rivers.
- Drainage: Standards for waste charge
- Power supply: Voltage, capacity, length of entrance cable, wiring and cost of power, including power for construction work.
- Transport: Road network (width, roadway, strength of subgrades, volume of traffic), means of transport between the camp and chip mill, transport capacity, transport cost
- Construction materials
- Company housing, dormitories, warehouses
- Obstructions for construction work: Above-ground and underground obstructuions, right of way.
- Condition of existing local mills.

3 Survey of raw materials

- Tree species: Name of species, log volume by species, relative difficulty of processing.
- Shape: Length and diameter (maximum, minimum and average, especially the percentage of log having a diameter of 40 cm and over) of log, warp, straightness of stem.
- Bark: Bark ratio (ratio of bark to solid log), condition of bark, easiness of barking
- Rotten wood: Extent and volume of rotten wood and burned wood
- Transport system: Means of log transportation to the mill.
- Frequency of transport: Number of days of log transport per annum (tabulation by month) volume of timber received in the dry season and wet season
- Moisture content: Moisture content of log by species and average moisture content.
- Price: Estimated price of log at mill site.

4 Survey of forests as supply sources of timber

- o Forest type: Tree species, tree height, diameter, cut volume per ha, total cut volume, shape, number of standing trees per ha.
- o Condition of logging operations: Topography (especially the ratio of sloped area with a gradient of 15° or more), geology, soil conditions, meteorolog (annual precipitation, number of rainy days, frequency of inundation in the wet season), felling method and process, yarding method and process, transport method and process.
- o Road: Relative difficulty of road construction and process of road building, soil conditions and condition of gravel pit, relations between existing roads and forests, conditions of bridges and rivers.
- o Others: Number of actual working days (by month), availability and operating scale of logging contractors, forest concession.

5 General items

- o Labor force: Quality and quantity of available labor force, availability of skilled workers, wage on job evaluation adopted or not, labor practices
- o Commodity: Prices and supply sources of main items of commodity.
- o Transport and communication: Conditions of transport and communication systems
- o Conditions of forestry related industries, if any.

5. GENERAL VIEW ON NATIVE TREES AND WOOD QUALITY OF SPECIES SUITABLE FOR REFORESTATION

(1) General View

When we think of broad-leaved trees growing in tropical regions, or "tropical asian woods" as we generally call them, we immediately recall to our minds Dipterocarpaceae such as Lauans, Merantis and others. Dipterocarpaceae is typical in tropical regions in Asia. Anisoptera, Hopea and Vatica are also found in Papua New Guinea located to the east of Asian tropical region, but they are only very few in species and stock-pile, and no longer considered as representative tropical woods in this area. Anisoptera that considered to grow in the farthest east of the region, grows on Louisiade Archipelago, and no farther. Therefore, trees that are considered miscellaneous species compared with Dipterocarpaceae that is dominant, are taken as major species in Fiji.

This stiatuation cannot be understood as capable of supplying efficient source for the wood industry today, when the industry is more and more based on mass production system, rather than house hold industry or handwork. While on the other hand, man cannot ignore a recent trend that Japanese enterprises, either in groups or individually, are advancing into tropical regions to seek for materials for furniture. A glance over the present situation of natural forests of Fiji--types and volume of resources--suggests us that the wood industry should consider such a direction as placing emphasis upon the production of furniture, cabinets that need less quantity of wood, or plywood faced with fancy veneer, sliced or rotary-cut. In the present world market situation in which large-sized enterprises of many countries are able to produce and export in large quantities with the help of latest machines and equipment, it is quite difficult to expect much from plywood, lumber, board or pulp--products that are not competitive from price point of view unless they are produced in mass production system. Price, distance to the areas of mass consumption, difficulty in manufacturing products of species with similar quality------these are considered to form major factors.

Japan should understand that exports from Fiji are in form of products and not logs. This is to follow a principle maintained in many of the countries today that resources of producing countries must be effectively used for the benefit of the countries concerned.

We must have some knowledge of trees growing in Fiji, so far as we consider lumber produced there. According to the distribution ratio, by region and species more than 35cm in diametre compiled by Land Resources Division, Fiji produces unexpectedly small numbers of well-known commercial species that grow to that size, although there are fairly numerous large-sized species which are locally utilized. At the same time, the ratio of total volume of so-called lesser-known species is low.

Our attention is drawn to the fact that species growing in Fiji are considerably close to those in Papua New Guinea: some are exactly the same species and others are those in the same families. Composition ratio of forest species in two areas of Papua New Guinea is given for comparison between Fiji and Papua New Guinea (Table V-1).

Table V-1 Composition Ratio of Species in Two Areas of P.N.G.

Species	Commercial Names	Ratio of Stock	
		T*	I**
Agathis spp.	Kauri Pine	6.9	–
Araucaria spp.	Hoop, Klinkii Pine	–	–
Aglaia spp.	Aglaia	–	0.3
Amoora cucullata	Amoora	0.1	0.1
Campnosperma breivipetiolata		–	–
Elmerrillia papuana	Wau Beech	4.9	0.3
Palaquium	Pencil Cedar	0.4	–
Pterocarpus indicus	N. G. Rosewood	–	–
Toona sureni	Red Cedar	–	0.1
Anisoptera polyandra	Anisoptera	6.0	23.0
Calophylum spp.	Bush Colophyllum	0.3	2.9
Castanspsis accuminatssima	Oak	12.4	0.2
Eucalyptus deglupta	Kamarere	–	–
Eugenia spp.	Watergum	8.0	4.0
Homalium foetidum	Malas	–	0.2
Hopea spp.	Hopea	16.6	12.9
Intsia spp.	Kwila	0.2	1.6
Nothofagus spp.	N. G. Beech	–	–
Pometia spp.	Taun	5.2	4.2
Terminalia, spp.	Terminalia	2.3	2.2
Terminalia brassii	Terminalia	–	–
Vitex cofassus	N. G. Vitex	–	–
Alstonia scholaris	Milky Pine	0.5	0.4
Anthocephalus cadamba	Labula	2.9	0.2
Endospermum medullosum	N.G. Basswood	0.5	0.2
Octomeles sumatrana	Erima	–	–
Planchonella spp.	Red-White Planchonelle	1.0	3.3
Pterocymbium beccarii	Amberoi	–	0.3
Spondias dulcis	Spondias	–	0.1
Dracontomelon mangiferum	N.G. Walnut	–	0.3
Others		33.4	42.9
		100.0	100.0

Note: T*: Toganumu
I**: Ioma

(2) Properties of Six Species for Reforestation in Fiji

The following six species are preponderantly cultivated on the basis of reforestation tests:

Swietenia macrophylla King
Eucalyptus deglupta Blume
Anthocephalus chinensis (Lamk.) Rich.
Endospermum macrophylla Pax et K. Hoffm.
Maesopsis eminii Engl.
Cordia alliodora (R. & P.) Cham.

Out of these six species, Endospermum macrophylla is not mentioned, because of well-known native species.

1) Mahogany (Mahogany, Honduras Mahogany)

Swietenia macrophylla King -- Meliaceae

Together with the species mentioned above, S. mahagoni Jacq. is also called with the same trade name Mahogany and considered as one of the best quality woods on the world market S. mahagoni however, is said to have been cut down almost entirely and no longer placed on market.

Plantation of mahogany has been attempted in various tropical areas in the world as the woods are valued highly. As far as Southeast Asian countries are concerned, S. macrophylla is planted rather than S. mahagoni. It will therefore become more and more difficult to obtain S. mahagoni in this district.

Mahogany ranks high with other world-famous woods such as teak, walnut, rosewood, etc. As Philippine lauan is called as Philippine mahogany, the name "mahogany" is used to give some other woods an impression of preciousness or valuableness.

Tropical America is the original home of S. macrophylla. It grows widely in Mexico, Honduras, Guatemala, Nicaragua, Costa Rica, Panama, Columbia, Venezuela, Peru, Bolivia and Brazil, while S. mahagoni grows only in West Indies including Cuba, Jamaica, Bahama, Puerto Rico, Dominica and Haiti. Compared with S. mahagoni (air dry density of 0.77 (0.70-0.85)), S. macrophylla is lighter in colour and weight, and softer.

Higher popularity has been ejoyed by S. mahagoni which is darker in color, and gives magnificient impression to the people.

The heartwood is either pink or reddish brown, with golden luster. The grain shallowly interlocked. The texture is rather coarse. Some have figure, which makes the wood look highly attractive.
Dark color contents lies along the vessel lines, showing up dark colored when cut axially. Its air dry density is 0.53 for both natural and plantation grown ones, and basic density is $450kg/m^3$ for natural and $420kg/m^3$ for planted ones. Shrinkage, green to 12% is 2.5% tangential and 1.6% radial. The following figures show the mechanical properties of the wood:

Country	Density	Moisture Content (%)	Bending		Compression Strength kg/cm^2 (//)
			Strength (kg/cm^2)	Young's Modulus $1000kg/cm^2$	
Naturally grown					
Mexico	0.50	10.5	868	109	503
Nicaragua	0.53	10.7	840	106	499
Peru	0.59	12.0	868	108	499
Honduras	0.50	12.0	805	96	432
Brazil	0.53	11.9	811	99	453
Plantation grown					
Honduras	0.50	13.4	722	81	397
Fiji	0.52	12.0	720	92	439

It is dried easily, lumbered and processed easily. Cutting, planing are done easily with excellent result. The heartwood, however, shows low durability when it contacts with the ground, while the sapwood of the trunk is attacked by power-post beetles. Some of S. macrophylla planted in Fiji being damaged by ambrosia beetles, it is likely that the fair amount of products will be with small black pin holes.

As has been described, it is widely used as high-grade lumber because of its beautiful figure, dimensional stability, and good workability.

2) Deglupta Eucalyptus (Kamerere, Kamarere, Bagras)

Eucalyptus deglupta Blume -- Myrtaceae

Eucalyptus deglupta grows in New Guinea, Celebes, Phillipines, and called Bagras in Philippines and Kamerere in Papua New Guinea. It is planted in Mindanao, Philippines and Papua New Guinea mainly for pulp wood in large quantity, by taking advantage of fast growing. It is said that even naturally grown Eucalyptus deglupta is quite difficult to manage, without sufficient technological experience, to use as lumber. Plantation grown Eucalyptus deglupta has low density and is likely to cause splits and warp frequently after logging and during processing. Therefore, to use it as lumber is difficult and is usually destined to pulp wood.

The heartwood of natural eucalytus is reddish brown in color, while that of plantation grown ones is mostly lighter in color as they are young even if the diameter is big. The texture is rather coarse and the grain is interlocked. It has air dry density (at moisture content 12%) is 0.63 (for natural Kamerere), 0.45 (for plantation grown Kamerere), 0.40 (Fiji grown --0.34 - 0.47); basic density of 500kg/m^3(natural Kamerere), 400kg/m^3 (for plantation grown Kamerere) and 320kg/m^3(Fijian270 - 384kg/m^3); shrinkage green to 12% is 2.9-11.1 tangential and 1.1-3.6% radial. Its air dry density is 0.41; bending strength is 583kg/cm^2; bending Young's modulus is 91 x 1000kg/cm^2; and compression strength (//) is 344kg/cm^2 (plantation grown Kamerere). It is susceptible to the damage by powderpost beetle.

Natural eucalyptus can be used as lumber for furniture, floor, shipbuilding, building and joinery. Plantation grown Kamerere is not much used for various purposes except for pulpwood.

3) Labula, Kalampayan, Kaatoan bangkal

Anthocephalus chinensis (Lamk.) Rich. (= A. cadamba (Rox .) Miq.) -- Rubiaceae

This species grows in tropical Asia, and in New Guinea. It is called Kaatoan bangkal in Philippines, and planted for pulp wood. It is one of the typical species in tropical Asia for afforestation.

When secondary forests start growing, this species grows very fast as one of the pioneer species among others. Demand for its light-colored, soft and light lumber is growing since it was imported from Papua New Guinea to Japan and Labula which is the Papua New Guinian trade name for this species is fairly common here.

The color of heartwood is yellowish white or light yellow; the grain is interlocked and its texture is coarse. Air dry density (moisture content 12%) of 0.44 (labula); basic density of $420kg/m^3$ (kalampayan) and $390kg/m^3$(labula); (from green to 15%) of 3.9% to tangential and 1.0% radial. As for its strength properties (air dry density 0.44), bending strength $659kg/cm^2$, bending Young's modulus 87 $1000kg/cm^2$ and compression strength (//) $347kg/cm^2$. It is easily processed; its durability when contacts with the ground is low; easily suffered from blue stain.

Its use is to meet with demand for light-color, soft and light wood but not as a surface material: such as match sticks, pulp, core for plywood, boxes and light frames, etc.

4) Musizi <u>Maesopsis eminii Engl.</u> -- Rhamnaceae

The original home of Musizi is Africa, particularly in Liberia, Congo, Tanganyika, Kenya, Guinea and Cameroon. It is known as African wood, but not estimated highly as a speciality wood.

Color of the heartwood is golden brown, getting darker and darker with golden luster after exposure. Its texture is coarse and the grain is interlocked. Air dry density (moisture content 12%) is 0.48, shrinkage green to 12% is 4.2% to tangential and 2.6% to radial. As for strength (moisture content 12%), bending strength is $728kg/cm^2$, bending Young's modulus is $100 \times 1000kg/cm^2$, compression strength (//) is $449kg/cm^2$. With tendency to split when cut and/or stocked. Milling and work with machine are easily. Durability is low when contacts with the ground.

In Africa, it is used for building houses, furniture and joinery. As painting is not satisfactory, the wood is not used for purposes where high level paint finishing is necessary.

5) Cordia, Laurel *Cordia alliodera* (R. & P.) *Cham.* ---

Boraginaceae

It originally grows in West Indies, Mexico and whole area of South America. Visiting Papua New Guinea, we frequently come across to wooden dolphine or sharks sold on the market which are from Solomon Islands. They are curved from cordia wood, possibly from different species of the same genus. Cordia is used for carving in Africa, too. In view of wood properties, genus Cordia is divided into two groups: one darker in colour and harder, and the other lighter in color and soft. *Cordia alliodora* belongs to the latter.

Color of heartwood is brown tinged with gold and green with darker streaks. The texture of the wood reminds us of Japanese *Ehretia* of the same Family. The color and the density change in accordance with growth and age of the tree. Generally speaking, aged cordia with slow growth rate offers darker and magnificient appearance. Air dry density is 0.40 to 0.70; its texture is rather coarse, and the grain is straight or crossed. Processing is easy, offering fine finish.

It is used for building, furniture, cabinets, plywood, interior decoration, and for carving. It is also sold with trade name Siera walnut, offering brighter future for ornamental purposes.

6. COCONUT PALM STEM AND ITS USAGE

Cocos nucifera Linn. is widely cultivated in Southeast Asia and Pacific islands. Its nuts are source for copra, an important export product of producing countries. While the cultivation area of coconut palm is expanded, the question of replacing overmatured coconut palm trees with fresh and young trees has come to the fore. Then, what to do with those overmatured palm trees producing little nuts? As areas of plantation has expanded, it becomes impossible to dump them into the sea or burn them. At the same time, cost for felling is not small sum of money for small-sized planters. The rise of felling cost plus lowering of copra price has invited difficulties in replacing old trees with young ones, resulting in the decline of production due to the increase of overmatured trees. Coconut palm planting becomes less attractive if these questions remain unsolved. Under these circumstances, voices are rising to broaden the much more profitable usage of coconut palms and increase cash income.

The following are figures showing planting areas, number of trees and distribution by ages, in Fiji.

Age	Acres	No. of Trees	%
10 and less	52,000	2,600,000	23.7
10 - 22	5,000	250,000	2.3
22 - 30	13,480	674,000	6.1
30 - 42	21,220	1,061,000	9.7
42 - 57	34,860	1,743,000	15.9
57 - 72	41,540	2,077,000	18.9
72 and over	51,540	2,577,000	23.5
	219,640	10,982,000	

Exceedingly matured trees of 75 years old or over cover almost 50,000 acres. Taking that 50 trees are planted per acre, and 40cft is produced per tree, 100 million cft will be produced from 50,000 acres of land, which will be 20 times the amount of timbers produced in 1975. This is not a question for Fiji alone, it is a question also for Philippines, Indonesia, and other tropical countries in Asia and Oceania. Reflecting the situation, a Seminar on the use of coconuts was held in Tonga just recently.

1) Technological Questions on the Use of Coconut Palm Stem

Coconut palm has a stem quite different from other softwood or hardwood species. Further, the distribution of vascular bundle sheaths is extremely dense on outer side and thinner in the center, leaving a great deal of difference in density within a trunk. Our observation has found that air dry specific gravity ranges 0.20-1.00. Due to this, wide variation of density within a trunk only the outer heavier part of trunk, which is stronger, and more attractive in color, has been used for handicrafts and some other purposes.

Some of the points that have to be kept in our minds in promoting the utilization of coconut palm trunks are as follows:

a) Sawn timber products. Those engaged in the wood industry, particularly in Japan, are extremely conservative in thinking. There are cases after cases in which useful species have not been estimated properly but treated as M.L.H.(Mixed light hardwood) only because industry do not know the names of the species. Coconut palm is typically classified into this group.

It might take considerably a long time for such types of material to be properly estimated and used in large quantity only because they are lesser known, besides much efforts are needed to promote their sales and develop products technologically. Moreover, it would not be easy for those engaged in the lumber industry to deal with materials with different gravity or color tones, etc., and make products that may appeal to consumers.

Some of other problems encountered by them are that i) coconut palm supplying areas scatter in extremely vast regions, which requires a great deal of expenses for collection and transportation of trunks, ii) devices and equipment that are different from those provided for processing of tree species must be facilitated for such materials, iii) yield rate of processed products will be small due to small log diameter and crooked trunks, and iv) special treatment for preservation would be necessary even if they are used as in round log form, as their durability is low.

All these disadvantages taken into consideration, it is more than natural that attention be directed towards the utilization of coconuts as pulp or other fiber products.

b) Pulp wood. Several tests has been carried out to examine whether coconut trunks are suitables for pulp wood or not. Properties required for kraft pulp are similar to or somewhat inferior to those of general broad-leaved trees produced in tropical regions. Philippino experts, for instance, reported that they were almost the same as those of white lauan or Pentacme contorta. Of the fiber characteristics, fiber length, diameter and wall thickness are 1.94 mm, 36μm and 6μm respectively.

Generally speaking, pulp produced from coconut palm appears to be quite similar in nature with that of bamboo. Yield based on oven dry weight is expected to be 41-45%. The problem is freeness rapidly decreased by beating because of the high ratio of soft tissues in coconut palm trunks, particularly located in the center. Practical ratio of fibres is said to be only 30%.

It appears unnecessary to mention any further the details of pulp making from coconut trunks, there is already enough information on the understanding of feasibility on the technical side. It will naturally lead the enterprises who intend to receive coconut trunks for pulping material to conduct further research to have enough information adaptable to their own manufacturing system and the types of products.

2) Characteristics of Coconut Palm Stem

According to a report from Philippines, the chemical characteristics of coconut palm trunks, including the volume of holocellulose, lignin and pentosans and extractives, are almost similar to those of broad and needle-leaved trees as well as bamboo. As for strength tested at outer hard part, bending strength is 82%, bending Young's modulus is 67%. Compression strength (//) is 94% as compared with Parashorea plicata. Strength tests performed at inner soft part, bending strength is 37-55%, bending Young's modulus is 28-33%, compression strength is 36-61%. Tests conducted in Fiji showed air dry weight as 830kg/m^3 at outer part, and 364kg/m^3 at inner part.

The existence of variation of density within the stem and scattered vascular bundles explains difficulties in machine processing.

At present, coconut palm trunks are largely used for folk arts, ornamental furniture, panels and floow borads, etc. in producing countries.

In recent years, attempts are made to burn them to get charcoal, bricket, activated carbon, particle boards, stakes and telephone poles after some treatments for preservation.

3) Questions in utilizing Coconut Palm Stem

As has been explained, the utilization of coconut palm stems has reached at such a stage that we can expect products from technical point of view. This is particularly true with the production of pulp out of coconut palm in Fiji.

This question, if export of products is essential, is accompanied with various problems such as the questions of efficient collection of the material in large quantities, their storage without deterioration manufacture at sufficient yield rate, reflection of world market trend and price competitions with other pulp wood from other countries.

This is the same for export of coconut palm chips. For instance, Fiji is composed of scores of islands. How to collect coconut palm trunks from scattered islands; how to make chips out of them; where to store them, from where to load and ship them; and export to what countries.....these are the questions which are more difficult than technical problems.

Therefore, the promotion of coconut palm utilization for pulp or chips for pulp or other products will not be considered simply from the stand point of regeneration of coconut palm plantation in producing countries or pure technical problem of utilization, but, so far as it is expected as an exporting product, also from that of manufacturing the internationally competitive product.

7. MEANS OF COOPERATION

The study was a general and preliminary survey made on the items proposed by the government of Fiji, which included 1) the evaluation of the reforestation project of hardwoods, 2) prospect of the project on the chipping of hardwoods and 3) test for the utilization of coconut palm stems.

In general, to further promote cooperation with Fiji, detailed study on the abovementioned items would be carried out. In this respect, the survey mission suggests the following three points to be carried out as practical means of cooperation: (1) full-scale survey on conditions for the production of wood chips and pulp from hardwoods, 2) the dispatch of specialists to promote reforestation of hardwoods, and 3) aerial photographing, mapping and photo-analysis for the exploitation of hardwoods and coconut palms, as well as to promote the reforestation of hardwoods.

(1) Full-scale survey:

The study found the difficulty of exploring possibilities in establishing a wood chip industry using the existing non-commercial MLH (mixed natural hardwoods) as material. However, more detailed surveys should be made on conditions for the wood chip industry with materials yielded from man-made hardwood forest together with MLH in the future, i.e. feasibility study on conditions (ports, site of factories, raw materials, logging and labor, etc.), as explained in Chapter 6 of the Report. Further, the proposed survey should also study the feasibility of utilizing pine trees under Pine Scheme, and developing the pulp industry in Fiji.

(2) Dispatch of experts:

The Government of Fiji brought forth two questions: 1) measures to be taken to cope with damages brought by ambrosia beetles and 2) causality between the growth of trees and environmental factors (particularly condition of soil). Taking the importance of these problems into consideration, our mission considered it extremely important to dispatch experts in noxious wood insects and forest soil science. We suggest experts to work with staffs of Fijian Forest Department or Forest Product Research Institute as counterparts. Further, these experts are preferably be those specialized in noxious forest insects with their far-reaching goals set at preventing damages by insects, rather than mere entomologists, and also those specialized in forest soil and are able to understand the relation between environment and afforestation, rather than mere soil scientists.

(3) Aerial photographing, etc.:

Pictorial informations, maps and scaled informations by means of aerial photographing, mapping, and photo-analysis are necessary in order to carry out forest exploitation and administration systematically and reasonably. Such information and data are indispensable when forest exploitation as well as reforestation are planned and practiced on industrial basis.

During the study, both Fijian and Japanese sides reached an agreement in views on the importance of aerial photograph, and selected (a) Tabeuni Island (for the study of coconut palm stem) and (b) Bichirebu Island and other areas (for the study of the exploitation of natural hardwood forest and reforestation of the said areas). It was agree that further studies shall be made for the realization of the above.

Proposed sites for aerial photographing are generally expected to be ideal places for reforestation to attain future forestry development, but photographing of coconut palm plantation shall be achieved in terms of urgent trial related to the future exploitation of resources.

At any rate, it seems necessary to dispatch a mission to Fiji, at the request of the Government of Fiji, to discuss practical matters on aerial photographing, mapping and photoanalysis.

The following is an example of "Scope of Work" to be discussed by both parties.

Scope of Work on

Forest Survey by Aerial Photograph

I. INTRODUCTION:

1. In response to the request of the Government of Fiji for cooperation in forest exploitation program, the Goverment of Japan agreed to undertake the forest survey by means of aerial photograph (including aerial photographing, mapping and photoanalysis) over ___ ha of forest area in ___ area in Fiji.

2. In carrying out the forest survey in Fiji (to be started in 1977), the Government of Japan designated JICA, an official organ engaged in the acts of overseas cooperation, as an executing organ.

3. Upon the instruction of the Government, JICA will carry out the survey related to the forestry development in ________ area of Fiji, on the basis of this Scope of Work.

II. OUTLINE OF THE SURVEY:

The survey is divided into the following two stages:

First stage: Aerial photographing

Second stage: Field work, Mapping, Photoanalysis

1. First stage:

A) Aerial photographing: Aerial photographing shall be taken place over _____ ha of the proposed area by using black & white (B/W) film on a scale 1/20,000.

2. Second stage:

A) Field work: Survey for ground control points (traverse survey, leveling, pricking), and forest surveys shall be taken place at the designated areas for the purpose of collecting necessary data for mapping and photoanalysis.

B) Mapping: A topographical map shall be made in Japan by the photogrametric method as a forest planing, photoanalysis, etc.

C) Photoanalysis: Photoanalysis including photo-interpretation, preparation of stereogram and photo-volume-table, estimation of standing stock, etc. shall be made by topographical maps and aerial photographs.

III. WORKING SCHEDULE:

First Stage: Aerial photographing ....

Second Stage: Field work ....

Mapping ....

Photoanalysis ....

IV. CONTRIBUTION:

1. In relation to the abovementioned surveys, Japanese side carries out the following at its own expense: (1) aerial photographing, field work, mapping and photoanalysis, (2) dispatch of necessary experts, (3) preparation and transportation of necessary data and equipment to the sites of surveys and bring them back to Japan after the completion of the work.

2. Fijian side shall carry out the arrangement of following items: (1) permission of the Government, and procedures thereof, which is necessary for aerial photographing and field work, (2) permision of the Government, and procedures thereof, which is necessary for taking photographed films, contact prints and other data from Fiji, (3) exemption of customs duty, permission of Fijian Government and procedures thereof, in relation to machines and equipment that Japanese side bring in and out from Fiji for the scheduled work (including aviation camera, theodolite, level, and other measuring machines and instruments), (4) necessary data, (5) free movement of Japanese team in Fiji (if required), (6) counterparts to the Japanese team, (7) vehicles, boats, interpreters, guides, workmen, office (if required), (8) permission of cutting of trees hindering the proposed land surveys, (9) assistance to prepare test trees for the stem analysis.

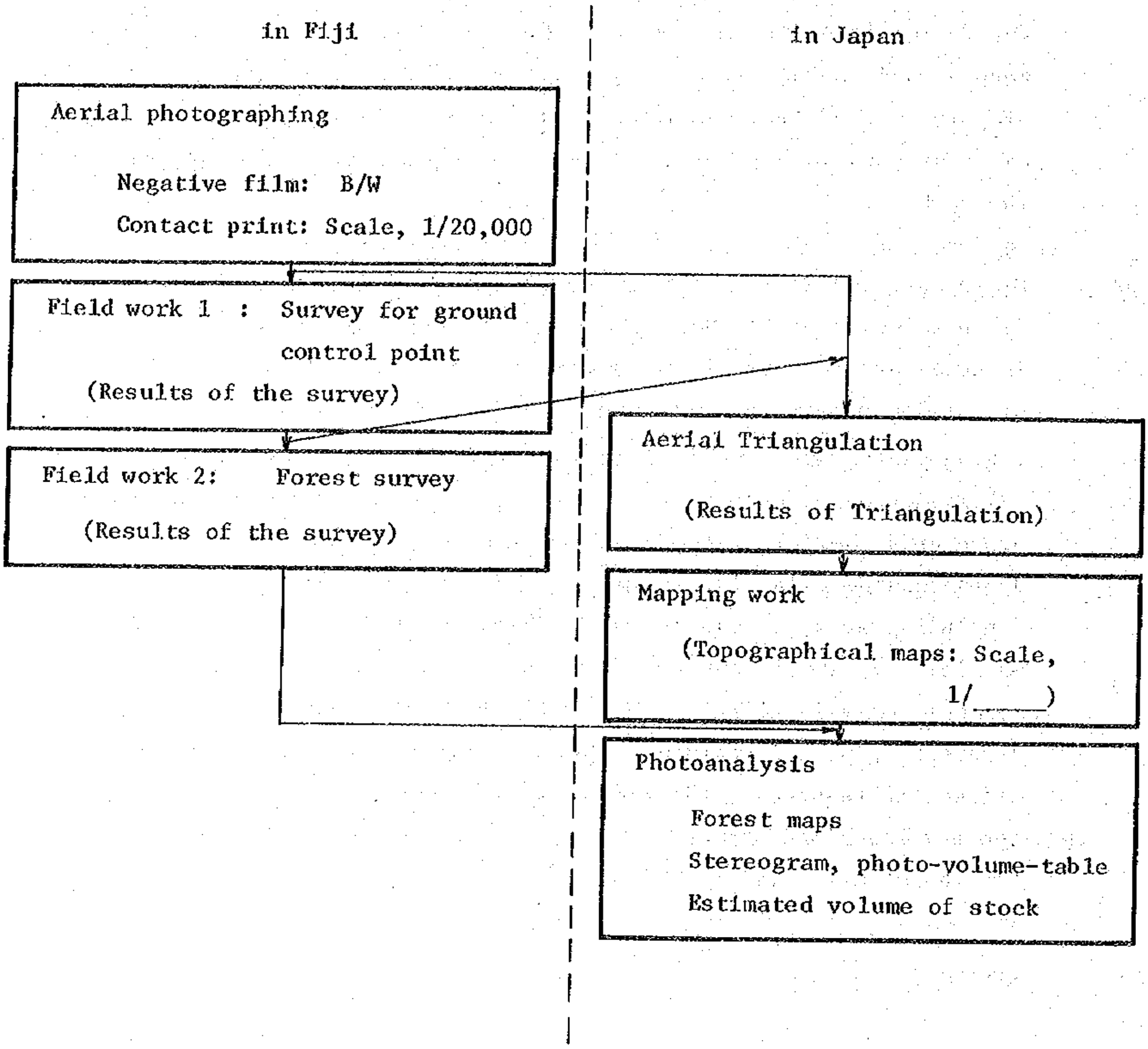
V. RESULTS:

A copy each of negative films, contact prints, topographical maps, forest maps, stereogram, photo-volume-table and, estimated volume of standing stock shall be submitted.

VI. OTHERS:

Amendment and correction to the Scope of Work shall be conducted only on the basis of agreement of those concerned of the two countries.

Appendix: I. Flow chart



II. Detail of Aerial photography

1. Aerial photography:

1.1. Planning, comprises of selection of flying courses, work schedule and aerial photo signals (if necessary). Flying courses should be arranged and selected under the following basis.

a. Flying courses should be straight.

b. Flying courses should be arranged in such a way to cover prospected areas with the minimum number of photos.

c. Flying programs should be arranged as to facilitate for control points, aerial triangulation, etc.

1.2. Aerial photo taking.

Aerial photography will be carried out to cover the area of approximately _______ ha.

- Aerial photo scale	:	1 / 20,000
- Photo overlap	:	60% ± 5%
- Photo sidelap	:	30% ± 5%
- T y p e	:	vertical, black & white, panchromatic.

1.3 Development and printing.

Development of panchromatic films should be processed in the following manner. (Following the instruction shall be given to the manufacturer).

a. Fixation shall be conducted perfectly so that no unexposed.

b. Films shall be sufficiently washed so that no chemicals will remain.

c. Films shall be dried quickly and both ends of films shall remain more than 1 m before cutting.

d. Special care shall be taken against shrinkage of films.

e. Marks of indicators shall be printed clearly.

f. The print size shall be 23 cm x 23 cm.

1.4. Orientation of aerial photos.

Aerial photos will be inspected based on the technical specification.
Special attention shall be given to the following items.

- sidelap and overlap
- cloud coverage
- scale / flight height
- tilt and grabbing

Each principle point of the aerial photos shall be plotted on the index map.
If the sidelap less than 25%, a new additional flight run shall be done as an insertion of the aerial photo strip.
If every 5 serial photos are covered with cloud more than 3%, reflight shall be done in the area.

Supplement: Interim Report

Suva, Fiji, November 24, 1976

Mr. W.Thompson,
Permanent Secretary for
Ministry of Agriculture, Fisheries and Forests,
Suva.

Re: The Preparatory Survey for Reforestation Project and for Utilization of Hard Wood and Coconut Stem in Fiji

Dear Sir,

We would like to submit herewith our preliminary findings of preparatory survey for reforestation projects and for utilization of hard wood and coconut stem in Fiji, which was conducted from November 14 to November 25, 1976.

The terms of reference of the mission are:
To review the hardwoods reforestation project which has been carried out by the Government of Fiji and to study father enlarged reforestation project for the future. To make a pre-feasibility study of hardwoods chip project from a point of industrial view. To discuss a pulping test using coconut stem. To exchange views with the officials of the Government of Fiji about the cooperative work concerning with the problems mentioned above.

General description of the result of the preparatory survey are as follows:

1. Review on the hardwood re-forestation project

1) Species elimination test

It is advisable that you would put much more stress on the quality growth rather than volume growth on which you are likely to put stress.

As we realize demand for native softwoods is very high during our stay in Fiji, we believe that testing of softwood species such as Agathis, Araucaria Dacrydium, Podocarpus etc. should be continued and expanded.

We wish to recommend you that exotic species with high quality would be introduced for trial. According to our knowledge there are some species which have been successfully tried in tropical and subtropical Asian countries, for example, Peronema Canescens in Indonesia, Pterocarpus indicus in Philippines, Chamaecyparis obtusa and Cryptomeria Japenica in Taiwan.

2) Hardwoods plantation of six selected species

Swietenia macrophylla and Cordia alliodora are promising for high quality timber species, particularly when their final cutting age is high, much higher than thirty years old.

Because of importance of Swietenia macrophylla as quality timber species, it is urgent to have certain measure protecting it from damage by ambrosia beeltes. We wish to put stress on immediate and intensive research on the life history of the beetles and on the establishing a method to control them.

Eucalyptus deglupta, Endospermum macrophylla and Anthocephalus cadamba can not be much promising under the present world timber situation, although they are promising fast growing species.

It is advisable for large scale forest management to mention that number of species for planting should be limited to small, and that the age distribution of plantations should be normal as possible as you can.

We recommend you that you would carry out the following test in addition to your present silvicultural tests.

a) Test of land preparation by clear cutting and burying to decrease the dead trees which produce the breeding beds of ambrosia beetles.

b) Test of spacing with wide range of spacing degree.

c) Site-classification based on soil survey in the area proposed for plantation.

d) Test of fertilization, especially for Swietenia and Cordia forest at the time of thinning.

e) Test of clump (nest) planting for the purpose of reduction of competition with surrounding plants.

We suggest that production of high quality wood would be carried out at much more expense for land preparation and tending.

3) Proposal for sending experts

An effort is to be made to realize sending experts for research on ambrosia beetles and soil survey in which the Government of Fiji is interested.

Prospects for a hardwoods chip industry

Of the factors required for export chip industry, the most important are four factors as follows:

1. Quality: 1) To be suitable to produce pulp and to have good yield.
2) To be fresh and with stable quality.
3) In case of mixed species to have a constant composition.

2. Quantity: Constant and stable supply in enough quantity for a long duration.

3. Price: To be competitive in the world market and stable.

4. Facilities: 1) To have a berth to facilitate a wood chip carrier for loading at port, including safe sailing and navigation.
2) To have a chip loading facility at the pier for the carrier.

Detailed discussion on these four factors has been repeated between the officials of Forest Dept. and us.

Moreover, to make the participation of foreign enterprise in joint-venture more feasible, the Government of Fiji is expected to take necessary measures ensuring logging, transportation and resources, together with four abovementioned factors.

However, we would like to recommend you that, rather than chip industry, for the much profitable hardwood utilization you would pay attention on promoting solid wood industry such as industries of interior finishing, sliced veneer, unfinished parts of furniture etc.

It would be our great pleasure to inform you that at your request we are ready at any moment to collect information on the marketing and utilization for tropical woods from organizations concerned in Japan.

3. Pulping of coconut stems

Information so far obtained, although it depends on more or less laboratory tests, has shown that pulp making from coconut stems are technically feasible and that obstacles to pulp making are rather chipping troubles, because of hard bark and also of wide variation in specific gravity within stem.

For feasibility study of pulp making from coconut stems much more stress should be placed on such factors relating to economy as collection, transportation, biological deterioration during outdoor storage and price, together with chipping.

The aerophotograph of coconut plantation which the Government of Fiji has requested for much more detailed information on the amount of coconut stems, the plantation area and the age distribution of coconut palms should be provided by J.I.C.A. to the extent that the allocated budget allows, for example the aerophotograph of Taveuni Island as the first step.

We wish to extend our gratitude to the officials of Forestry Department for their heartfelt help.

Respectfully yours,

TOMOHISA FUKUMORI
Chief of Japanese Survey Team.