Land Resource Study

12 Fiji Forest Inventory Volume 1 The Environment and Forest Types

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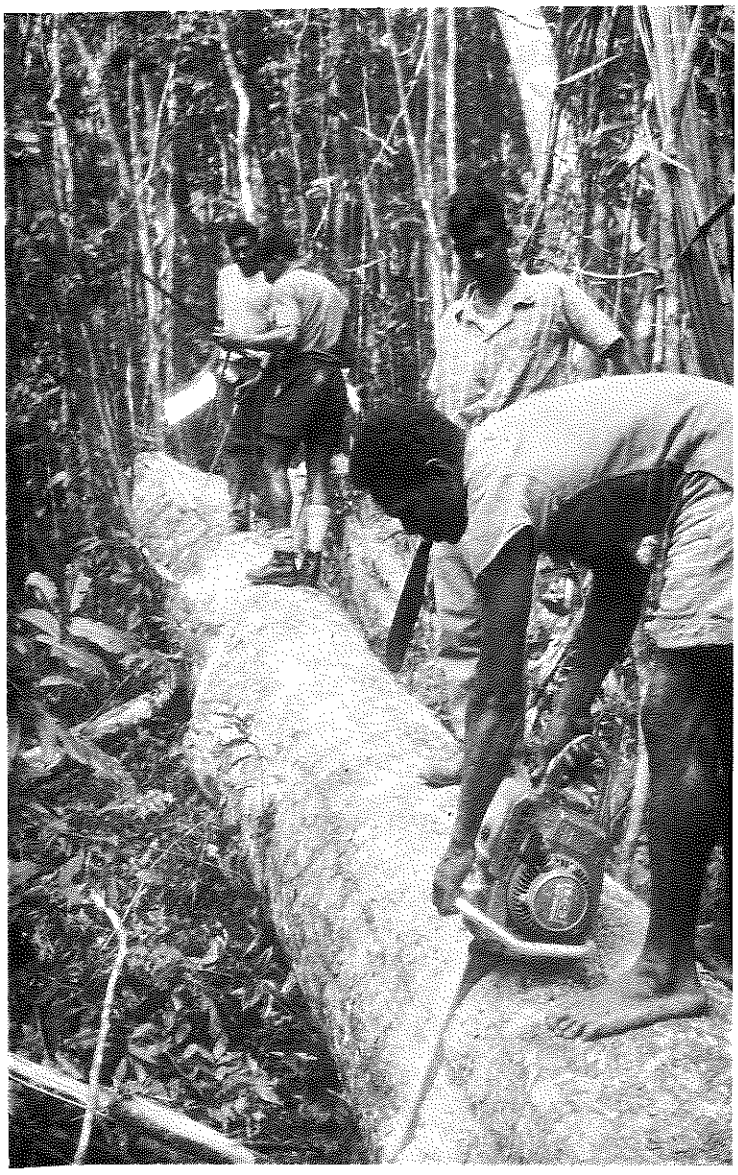
Fiji Forest Inventory
Volume 1



Volume table measurements in Sasa felling area, Vanua Levu

Foreign and Commonwealth Office
Overseas Development Administration

Fiji Forest Inventory
Volume 1
The Environment and Forest Types

by

M J Berry and W J Howard

Land Resource Study No. 12

Land Resources Division, Tolworth Tower,
Surbiton, Surrey, England
1973

THE LAND RESOURCES DIVISION

The Land Resources Division of the Overseas Development Administration, Foreign and Commonwealth Office, assists developing countries in mapping, investigating and assessing land resources, and makes recommendations on the use of these resources for the development of agriculture, livestock husbandry and forestry; it also gives advice on related subjects to overseas governments and organisations, makes scientific personnel available for appointment abroad and provides lectures and training courses in the basic techniques of resource appraisal.

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The Division ceased to be a part of the Directorate of Overseas Surveys in April 1971.

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INTRODUCTION

PREFACE

This report describes the forest inventory carried out by the LRD staff in Fiji (see Text Map 1) between 1966 and 1969 and gives detailed descriptions of the forests in the river catchments enumerated. Copies of the enumeration figures giving the volumes of the individual species were handed over to the Conservator of Forests while the LRD team was still in Fiji. In April 1971 a preliminary version of this Land Resource Study was sent to the Fiji Government, who have given their permission that it should be published.

As is indicated in the Contents, the Study is issued with one sample of the 29 maps of Forest Types (scale 1:50 000) covering Vanua Levu (14 sheets), Viti Levu (13) and Kandavu (2). Recipients of the report who are known to be involved in or connected with forestry in Fiji will however receive additionally one complete set of Forest Type maps. Others who do not receive these maps, but who require some or all copies for research or other bona fide purposes, may write to the Land Resources Division requesting numbered sheets to be issued to them (from a limited stock). A coverage diagram showing the position and numbers of the 29 sheets is issued with the sample map.

In this Study the environment has been described briefly and without maps because a Land Resource Study entitled *The Land Resources of the Main Islands of Fiji* is being prepared by R N Jenkin and A Lesslie of LRD, following their work investigating the soils and agricultural potential of Fiji.

Throughout the Study Fijian place names have been spelt phonetically, but for tree names local spellings have been adopted. The relationship between local names and botanical binomials is indicated in Appendix 4 at the end of this Volume.

ACKNOWLEDGEMENTS

The authors thank the Conservator and staff of the Fiji Forest Department, particularly the field staff who always worked hard under arduous conditions. They also wish to thank the Director and staff of the Department of Agriculture, especially Mr J W Parham and those working in the Herbarium, the Director and staff of the Electronic Data Processing branch of the Ministry of Finance, the Director and staff of the Department of Lands, Mines and Survey. The assistance of Mr Casley of the Agricultural Census in Fiji (FAO Project) is gratefully acknowledged as is that of Dr A C Smith, Wilder Professor of Botany, University of Hawaii, who identified many of the botanical specimens. Finally, the authors thank the many people living in or near the forest who gave assistance and hospitality during the fieldwork.

ABSTRACT

This report describes a forest inventory of the major part of the natural forests of Fiji including most of Vanua Levu, the forested eastern half of Viti Levu and the island of Kandavu. The river catchments are the units of survey and these have been grouped for this report into 16 catchment groups. The environment has been described for each of these groups. Forty-one forest types are described in terms of their recognition on air photographs, the structure of the forest and its species composition. The volume of timber is given by forest types and grouped together into management categories of non-commercial, production and protection forest. A reliable minimum estimate (r.m.e.) of timber volume is given for each management category for each catchment, and recommendations are made as to the possible combination of catchments, the improvement of access and the suitable treatment of each forest type.

The forest is not uniform in either species composition or stocking. Types range from secondary forest regrowth after cultivation containing about 15 m^3/ha (2 021 Hsl ft/ac) to forest with huge old trees and a high timber volume of 100 m^3/ha (13 476 Hsl ft/ac). The types also differ in the presence or absence of the coniferous genera *Agathis*, *Dacrydium* and *Podocarpus*.

Viti Levu has a standing volume of 7 million m^3 (2 025 million Hsl ft) with the catchment of the Navua River containing nearly 4 million m^3 (1 327 million Hsl ft). Vanua Levu contains 5.4 million m^3 (1 809 million Hsl ft) with the Wainunu, Kumbulau and Yanawai catchments containing nearly 1.5 million m^3 (498 million Hsl ft). These volumes are given overbark for a minimum diameter of 40 cm (16 in) at breast height and include only the species that have a commercial market. The total area of enumerated forest is 384 000 ha (949 000 ac), of which 234 000 ha (578 000 ac) is thought to be suitable for commercial exploitation whereas 88 000 ha (217 000 ac) is recommended for protection and 62 000 ha (153 000 ac) has insufficient standing volume of timber to be worth exploiting. The total forest area for the three islands Viti Levu, Vanua Levu and Kandavu is estimated at 838 750 ha (2 072 550 ac). Of this area 97% has been air photo-interpreted and mapped at 1:50 000 scale.

RÉSUMÉ

Ce rapport décrit un inventaire forestier de la majeure partie des forêts naturelles des îles Fidji comprenant presque toute l'île de Vanua-Lévu, la moitié orientale boisée de l'île de Viti-Lévu et l'île de Kandavu. Les bassins des fleuves constituent les unités d'étude et ils ont été groupés, pour ce rapport, en 16 Groupes de Bassins. L'environnement a été décrit pour chacun de ces Groupes. Quarante et un types de forêts sont décrits en fonction de leur reconnaissance sur des photographies aériennes, de la structure de la forêt et des espèces qui la composent. Le volume de bois est donné par types de forêts, qui sont groupés par catégories de gestion en forêt non-commerciale, forêt de production et forêt de conservation. Une estimation digne de foi du volume minimum de bois est fournie pour chaque catégorie de gestion de chacun des bassins, et des recommandations sont faites concernant la possibilité de combinaison de bassins, de l'amélioration de l'accès et du traitement convenant à chaque type de forêt.

La forêt n'est uniforme ni par la composition des espèces, ni par le peuplement. Les types varient depuis de hautes futaies secondaires de repeuplement après culture contenant environ 15 m^3/ha, jusqu'à des forêts de vieux arbres énormes avec un volume élevé de bois de 100 m^3/ha. Les types diffèrent aussi par la présence ou l'absence des genres conifères *Agathis*, *Dacrydium* et *Podocarpus*.

Le volume de bois sur pied de Viti-Lévu est de 7 millions de mètres cubes, avec le bassin du fleuve Navua contenant presque 4 millions de mètres cubes. Vanua-Lévu contient 5,4 millions de mètres cubes, avec les bassins des fleuves Wainunu Kumbulau et Yanawai contenant presque 1,5 million de mètres cubes. Ces volumes sont donnés pour des arbres d'un diamètre minimum de 40 centimètres avec l'écorce et ne renferment que les espèces ayant un marché commercial. Le total de la superficie forestière recensée est de 384 000 ha, desquels 234 000 ha sont considérés comme convenants à l'exploitation commerciale, tandis qu'on recommande la conservation de 88 000 ha, et que 62 000 ha, contenant un volume insuffisant de bois sur pied, ne vallent pas la peine d'être exploités. On estime que la superficie totale de forêts des trois îles Viti-Lévu, Vanua-Lévu et Kandavu est de 838 750 ha. La photo-interprétation aérienne de 97% de cette superficie a été réalisée, et une carte dressée à l'échelle de 1/50 000.

DESCRIPTORS FOR COORDINATE INDEXING

Climate, geology, soil classification, forest inventory, forest mapping, timber-producing forest, forest sampling, tree section measurement, tree height measurement, tree volume measurement, forest classification, forest enumeration, *Agathis*, *Casuarina*, *Calophyllum*, *Endospermum*, *Myristica*.

SUMMARY OF RESULTS

The volumes of timber and the area of forest recommended for exploitation in each catchment group are given in Table 1. The volume is shown in both cubic metres (m^3) and the local unit of timber volume, Hoppus super log feet (Hsl ft); the volume is of trees over 40 cm (16 in) diameter at breast height (d.b.h.) in species groups 1 to 4. (Species group 5 consists of species for which there is no commercial market.)

The reliable minimum estimate included in Table 1 is the estimate of the volume at its lower confidence limit after subtracting the sampling error. What the reliable minimum estimate means is that there is a 0.975 probability that *at least* this volume is present in the forest.

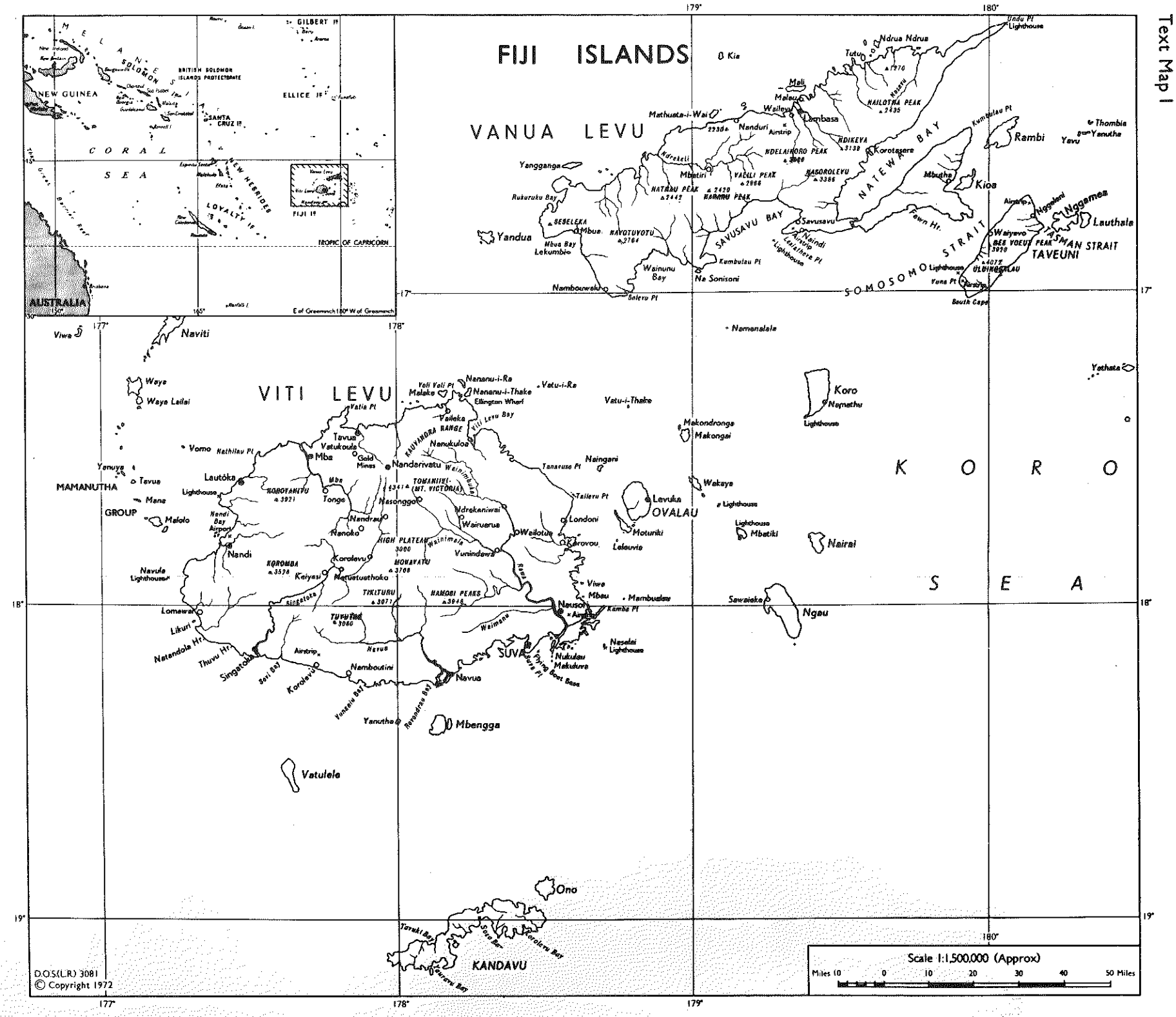
FIJI ISLANDS
VANUA LEVU
VITI LEVU
KORO
SEA
MELANESIA
CORAL SEA
NEW GUINEA
BRITISH SOLOMON ISLANDS PROTECTORATE
GILBERT IS
ELLICE IS
SANTA CRUZ IS
NEW HEBRIDES
LOYALTY IS
FIJI IS
TROPIC OF CAPRICORN
AUSTRALIA
E of Greenwich 180° W of Greenwich
MAMANUTHA GROUP
OVALAU
KANDAVU
SUVA
NAUSORI
NADI
LAUTOKA
NAVUA
SIGATOKA
NAMBOUTINI
TAVEUNI
LAUTHALE
NGAMEA
RAMBI
KIOS
NATEWA BAY
SAVUSAVU BAY
SOMOSOMO STRAIT
NAMENALALA
NGAU
MBENGGA
VATULELE
ONO
YATHATA
THOMBIA
YASAWA
NAIRAI
Scale 1:1,500,000 (Approx)
Miles 10 0 10 20 30 40 50 Miles
D.O.S.(L.R.) 3081
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TABLE 1 Merchantable overbark volume of trees over 40 cm (16 in) d.b.h., species groups 1-4, with the reliable minimum estimate and enumerated area for the production forest

Island and catchment group	Timber volume		Reliable minimum estimate		Enumerated area	
	'000 m^3	million Hsl ft	'000 m^3	million Hsl ft	ha	ac
Viti Levu						
Rewa	1 609	536	1 424	474	39 503	97 611
Tailevu	272	91	219	73	6 443	15 921
Nandarivatu	214	71	158	53	5,885	14 542
Navua	3 989	1 327	3 495	1 163	57 222	141 396
South Coast	934	311	831	277	14 704	36 334
Viti Levu total	**7 018**	**2 336**	**6 127**	**2 040**	**123 757**	**305 804**
Vanua Levu						
Mbua North	373	124	278	93	9 766	24 132
Mbua South	106	35	74	25	3 045	7 524
Coastal West Central	1 497	498	1 368	455	24 808	61 300
Ndreketi North	157	52	99	33	5 071	12 530
Ndreketi South	782	260	657	219	18 182	44 928
Coastal East Central	799	266	725	241	14 544	35 938
Lambasa and NE	236	78	144	48	5 276	13 037
Natewa Bay	144	48	63	21	3 530	8 723
Nasavu and Vunivia	470	156	381	127	10 252	25 333
Natewa Peninsula	878	292	765	255	12 652	31 263
Vanua Levu total	**5 442**	**1 809**	**4 554**	**1 517**	**107 126**	**264 708**
Kandavu						
Kandavu East and West	262	87	231	77	3 651	9 022
Production forest total	**12 722**	**4 232**	**10 912**	**3 634**	**234 534**	**579 534**

The total volume of usable timber in the forest that is considered suitable for exploitation is 12.7 million m^3 (3 921 million Hsl ft) on an area of 234 534 ha (579 534 ac). The reliable minimum estimate of timber is 10.9 million m^3 (3 634 million Hsl ft).

The volume of timber and enumerated areas for the non-commercial and protection forest are given in Table 2.

The non-commercial forest is forest with too low a stocking for commercial exploitation. It consists of forest regrowth and vegetation associations dominated by one or two trees that are unmerchantable, such as *velau (Casuarina nodiflora)*. The protection forest is recommended for protection because the slopes are steep and the soil shallow and unstable. Whereas the survey covered most of the production forest, the non-commercial and protection forest were only partially sampled (see Text Maps 2 and 3). As a result, the volumes and areas given in Table 2 fall far short of the total figures.

According to the Fiji Forest Department the maximum annual cut permitted for the existing concessions and long-term licences is 208 000 m^3 (69 million Hsl ft). This figure is based on underbark measure, which is obtained by deducting 8 cm (3 in) from the overbark mid-girth of the log. The percentage reduction this gives from overbark volume will vary according to the girth of the log but appears to be in the order of 9 to 10% Throughout this survey the volumes are based on overbark measure. In terms of overbark measure the maximum permitted cut becomes:

208 000 + 10% = 229 000 m^3

To maintain cutting at this level until the year 2 000 there needs to be a standing volume of 229 000 × 30 = 6.87 million m^3 (3 634 million Hsl ft). Since the r.m e. of standing timber is 10.9 million m^3 (3 634 million Hsl ft) there is an adequate supply of timber to meet the demand at the present rate of cutting for the next 30 years.

TABLE 2 Merchantable overbark volume of trees over 40 cm (16 in) d.b.h., species group 1-4, and enumerated area for non-commercial and protection forest

Island and catchment group	Non-commercial		Protection	
	Timber volume ('000 m^3)	Area (ha)	Timber volume ('000 m^3)	Area (ha)
Viti Levu				
Rewa	95	9 302	236	10 967
Tailevu	37	4 303	60	2 073
Nandarivatu	23	1 688	110	7 008
Navua	100	6 073	408	11 452
South Coast	223	14 020	308	7 558
Viti Levu total	**478**	**35 386**	**1 122**	**39 058**
Vanua Levu				
Mbua North	46	3 118	37	1 210
Mbua South	0	196	18	614
Coastal West Central	11	660	131	4 295
Ndreketi North	23	1 711	0	65
Ndreketi South	58	3 714	87	4 127
Coastal East Central	16	1 567	129	4 141
Lambasa and NE	35	5 412	174	6 723
Natewa Bay	14	2 809	83	2 011
Nasavu and Vunivia	73	3 546	250	6 087
Natewa Penninsula	27	3 238	489	12 352
Vanua Levu total	**303**	**25 971**	**1 398**	**41 625**
Kandavu				
Kandavu East and West	**3**	**353**	**174**	**7 810**
Total	**784**	**61 710**	**2 694**	**88 493**

Text Map 2

FOREST COVER

VITI LEVU

Miles 5 0 5 10 15 20 Miles

177°30' 178° 178°30'

17°30'

18°

18°30'

19°

Tavua Bay
Viti Levu Bay
No Photo Interpretation
Nasiia R.
Mba River
Wainimbuka
▲3921
▲434
No Photo Interpretation
Nandi Bay
Sambeto
Nandi R.
Nandi
Waimanu
Waimosi
▲3528
▲3709
R.
Singatoka
RIVER
▲3948
Waimanu
Wainavai
▲3060
Tuva
Nanua River
SUVA
Laucala Bay
Korolevu Bay
Vunaniu Bay
Rovondrau Bay
Mbengga
Vatulele
Ndaku Bay
Soso Bay
Korolevu Bay
Tavuki Bay
Yaurorv Bay
KANDAVU
Ono

Forest Cover
Enumerated Forest

D.O.S. 3137

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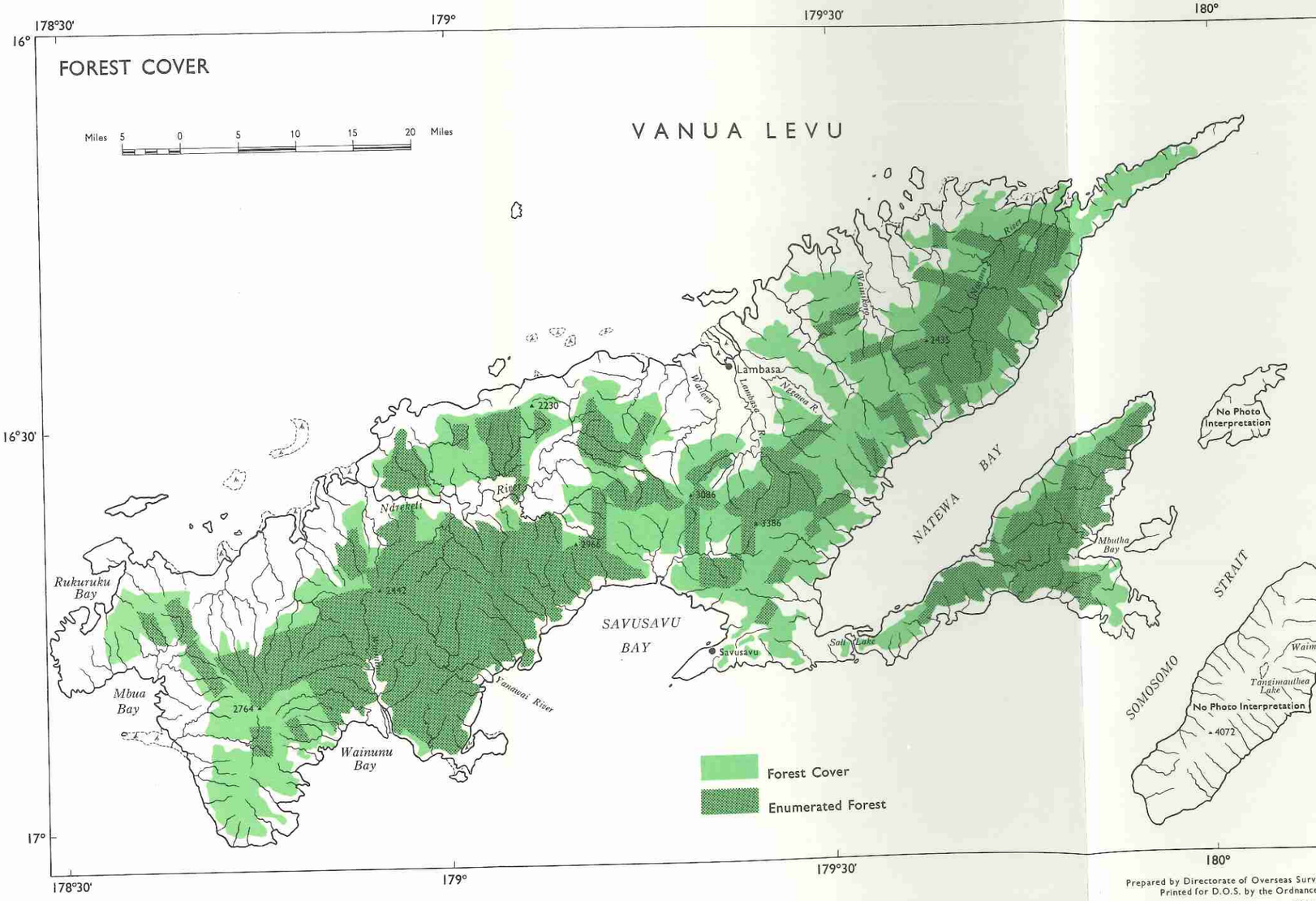
7/72/5685/OS

Text Map 3

FOREST COVER



D.O.S. 3138

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VOLUME 1

PARTS 1 - 4

PART 1. THE PROJECT

ORIGIN AND OBJECTIVES OF THE PROJECT

Fearing that timber from the natural forest would run out before the forest plantations became productive, the Fiji Forestry Department needed to know the standing volume of timber in the forest. As a result the Fiji Government in 1965 requested the Land Resources Division to carry out a forest inventory to provide the following information:

1. Volume and area of accessible forest for timber production
2. Identification of protection forest
3. Mapping on a scale of 1:50 000 to show stratification of forest into forest types
4. Preparation of volume tables

PROGRAMME OF WORK

The project started at Tolworth in July 1966 with the air photo interpretation of the southern half of Viti Levu based on the 1:40 000 aerial photographs taken in 1954.

The first member of the team, W J Howard, went to Fiji in October 1966 to do an indicative survey in the Navua River catchment and the second member, M J Berry, followed in May 1967. New aerial photography was flown in 1967 by Fairey Surveys Limited on a scale of 1:24 000, providing complete cover for the main islands of the country. The fieldwork completed in 1967 included the Waimanu and Navua River catchments and the southern coast, all in Viti Levu. By May 1968 the computer program was written and the first set of data computed. Vanua Levu was surveyed in 1968, the teams leaving Suva in May and returning in November. Nandarivatu Plateau was enumerated in December 1968. The catchments of the Rewa tributaries were enumerated in 1969 as well as the eastern coast of Viti Levu and the island of Kandavu. Computation of the Vanua Levu data was done in August 1969 and the final Viti Levu figures were computed in October 1969. Enumeration figures and draft forest type maps were left with the Conservator of Forests before the LRD staff returned to Tolworth in December 1969.

METHOD

Metric units of measurement were used throughout the survey: tree diameters in centimetres, heights in metres and volumes (by calculations) in cubic metres. Plots were laid out with metric tapes and areas were computed in hectares

The local measure of sawn timber is the 'super foot' which is equal to one-twelfth of a cubic foot. Logs are measured in 'super feet in the round', obtain by measuring log volume by the Hoppus quarter-girth system and multiplying by 12.

Throughout the report figures are given in metric units followed by the Imperial equivalent in brackets. Volumes are converted to Hoppus super log feet except in the forest types descriptions where the tables give the stocking in cubic metres per hectare only. In the data for the catchment groups, the volumes in the tables are in cubic metres, except for the volume of trees over 40 cm (16 in) d.b.h. in species groups 1-4 which has the Hsl ft equivalent. The minimum diameters of 35 cm and 40 cm d.b.h. are quoted in the text in metric units only. They are equivalent to 14 and 16 in respectively

The unit of survey was the river catchment. A preliminary airphoto interpretation indicated the catchments with sufficient forest cover to merit enumeration. These forests were divided by further airphoto interpretation into broad forest types on the basis of airphoto pattern and landform. Very steep hill ranges and areas of poor forest cover were excluded.

A base line was drawn on the 1:50 000 map down the main river of a catchment or parallel to a road or the coastline in the case of coastal catchments and divided into 2 000 m (6 560 ft) sections. Within each section the starting point of the line was chosen by reference to a table of random numbers. The lines were drawn parallel to each other, on a bearing that would cross the topography and, if possible, the forest types at right angles. These lines, which ran from the main river or from the forest edge to the watershed, were transferred from the map to the aerial photographs.

In the field the starting points of the lines were marked on the ground by reference to the aerial photographs. Each line consisted of a continuous strip 20 m (65 ft) wide of plots 50 m (162.5 ft) long. Within the plot every tree over 35 cm (14 in) d.b.h. was enumerated by name giving the breast height diameter (or above-buttress diameter) and length of merchantable bole. The diameter was measured with steel callipers and the height with a Haga or Blüme Leiss hypsometer. The length of the merchantable bole was taken from above the stump, usually about 1 m (3 ft) from the ground or above the buttresses, to below the lowest branches of the crown. Defective trees were not measured and partially defective trees were measured only for the part of the tree that was sound. In every 20th plot a regeneration count was carried out tallying the trees under 5 size classes; 10 cm (4 in) - 1 m (3.25 ft) high, 1-3 m (3.25-9.75 ft) high, 3 m (9.75 ft) high and less than 10 cm (4 in) diameter, 10-20 cm (4-8 in) diameter and 20-34 cm (8-13 in) diameter. Only the regeneration of the recognised useful timber species were tallied in the first 3 size classes.

Apart from their use in computing timber volumes, the data from the lines were used to finalize the division of the forest into distinctive forest types (see Part 4).

The volume of timber of a forest type was calculated by multiplying the enumerated volume by a factor representing the proportion of the total area to the sampled area. This can be written as follows:

$$\text{Total volume of forest type A} = \frac{\text{Total area of forest type A}}{\text{Sampled area of forest type A}} \times \text{Sampled volume in forest Type A.}$$

The sampling error was computed by forest type for the trees grouped into 5 timber density groups. The formula for variance and sampling error is given in Appendix 2. The aim of the sampling error is given in Appendix 2. The aim of the sampling was to achieve a 20% error limit in the production forest types.

The trees were recorded by Fijian name, but only the 40 names listed in Table 3 had their volumes computed individually; the rest were lumped into a category called 'others'. Table 3 gives the botanical names of the 40 species, which were considered the most important timber species in Fiji. Extensive collection of botanical specimens was carried out in order to check on the correct naming of the familiar species and to discover the botanical name of unknown species. The specimens were mounted in the herbarium attached to the Department of Agriculture and were identified by J W Parham, who was in charge of the Herbarium. A C Smith is writing a new flora for Fiji replacing that of Berthold Seemann who wrote his in 1865. Dr Smith looked through our collection and confirmed the naming of the specimens, using some as references in his flora. The naming and spelling of the botanical specimens referred to in this report follows that of A C Smith, and of J W Parham in his *Plants of the Fiji Islands* (1964). A further list of the botanical names of common trees and shrubs is given in Appendix 4.

The CSIRO, Australia, have carried out tests on the physical properties of the *Fiji timbers and their uses*, produced by the Fiji Forestry Department. No 38 in this series (Department of Forestry, 1969) summarises the properties of 34 indigenous timber species which included most of the species listed in Table 3.

TEAM COMPOSITION

Staff for the project consisted of the 2 already mentioned professional staff from LRD, assisted by 1 Forester, 6 Forest Guards, 1 clerk and 1 draughtsman all seconded from the Fiji Forest Department. Thirty permanent labourers were trained and employed throughout the period of the project and 40-60 casual labourers were employed locally as required for work in each of the catchments. Two typists, 4 drivers and 1 storeman were employed in the office based at Tholo-i-Suva.

TABLE 3 The 40 trees selected for volume computations, their botanical identity and timber density grouping

(Note: Some Fijian tree names refer to more than one species)

Fijian name	Botanical name	Timber density group
Amunu	*Podocarpus imbricatus*	Softwood
Bau	Sapotaceae (*Planchonella* spp.)	Light hardwood
Bau	*Burckella* spp. and *Palaquium* spp.	Light hardwood
Bauvudi	*Palaquium stehlinii*	Light hardwood
Bauvudi	*Palaquium vitilevuense*	Light hardwood
Buabua	*Fagraea gracilipes*	Heavy hardwood
Cevua	*Vavaea amicorum*	Heavy hardwood
Dakua makadre	*Agathis vitiensis*	Softwood
Dakua salusalu	*Podocarpus vitiensis*	Softwood
Damabi	*Endiandra elaeocarpa*	Non-obligatory*
Damabi	*Endiandra luteola*	Non-obligatory*
Damabi	*Endiandra monticola*	Non-obligatory*
Damanu	*Calophyllum vitiense*	Medium hardwood
Damanu	*Calophyllum neo-ebudicum*	Medium hardwood
Damanu	*Calophyllum cerasiferum* (rare)	Medium hardwood
Dawa	*Pometia pinnata*	Non-obligatory*
Duvula	*Hernandia olivacea*	Non-obligatory*
Kauceuti	*Kermedecia vitiensis*	Light hardwood
Kauceuti	*Kermedecia ferruginea*	Light hardwood
Kaudamu	*Myristica castaniifolia*	Light hardwood
Kaudamu	*Myristica chartacea*	Light hardwood
Kaudamu	*Myristica gillespieana*	Light hardwood
Kaukaro	*Semecarpus vitiensis*	Non-obligatory*
Kaunicina	*Canarium vitiense*	Medium hardwood
Kaunicina	*Canarium harveyi* var. *harveyi*	Medium hardwood
Kaunicina	*Canarium vanikoroense*	Medium hardwood
Kaunigai	*Haplolobus floribundus*	Medium hardwood
Kauvula	*Endospermum macrophyllum*	Light hardwood
Kauvula	*Endospermum robbieanum* (Vanua Levu)	Light hardwood
Koka	*Bischofia javanica*	Medium hardwood
Kuasi	*Podocarpus neriifolius*	Softwood
Laubu	*Garcinia myrtifolia*	Heavy hardwood
Ma	*Pterocymbium oceanicum*	Non-obligatory*
Mala	*Dysoxylum gillespieanum*	Light hardwood
Mavota	*Gonystylus punctatus*	Medium hardwood
Moivi	*Maniltoa floribunda*	Heavy hardwood
Moivi	*Maniltoa grandiflora*	Heavy hardwood
Raintree	*Samanea saman*	Light hardwood
Rogi (Rosarosa)	*Heritiera ornithocephala*	Heavy hardwood
Rosawa	*Gmelina vitiensis*	Medium hardwood
Sa	*Parinari insularum*	Non-obligatory*
Sacau	*Palaquium hornei*	Heavy hardwood
Sarosaro	*Planchonella membranacea*	Heavy hardwood
Sarosaro	*Planchonella vitiensis*	Heavy hardwood
Sarosaro	*Planchonella linggensis*	Heavy hardwood
Sasauwira	*Dysoxylum richii*	Light hardwood
Sorovulu	*Dysoxylum* sp. nov.	Non-obligatory*
Tabadamu	*Elaeocarpus graeffei*	Non-obligatory*
Tabadamu	*Elaeocarpus chelonimorphus*	Non-obligatory*
Tabadamu	*Elaeocarpus lepidus*	Non-obligatory*
Tivi	*Terminalia vitiensis*	Light hardwood
Tivi	*Terminalia pterocarpa*	Light hardwood
Vaivai-ni-veikau	*Serianthes myriadenia*	Light hardwood
Vesi	*Intsia bijuga*	Heavy hardwood
Vuga	*Metrosideros collina*	Heavy hardwood
Vutu	*Barringtonia edulis*	Non-obligatory*
Vutu	*Barringtonia petiolata*	Non-obligatory*
Yaka	*Dacrydium elatum*	Softwood
Yasiyasi	*Syzygium* spp.	Heavy hardwood
Yasiyasi	*Cleistocalyx* spp.	Heavy hardwood

*Non-obligatory species are those which the licensee of the forest does not have to remove.

The fieldwork was organised in such a way that 10 men comprised a team working on 1 line. One man with a compass was accompained by 2 line cutters, followed by chainmen correcting for slope and laying out the plots. The actual enumeration was done by 1 man who recorded, 1 man who measured the tree diameters with callipers and 1 man who measured the height of merchantable bole. One man cut the lianes round the base of the tree and held the tape for the height measurer. Each team had a cook who stayed in camp and was responsible for cooking and organising the flow of food supplies from the nearest village.

The number of plots enumerated each day depended upon the length of the line and the nature of the terrain but 20 plots per day was the usual average for a long line over steep country.

PREPARATION OF VOLUME TABLES

The diameter and height measurements of trees along the enumeration lines were converted to volumes by means of a volume table. This had been prepared by working out the simple regression of diameter 2 × height on felled volume, the data being obtained by measuring the breast height diameter and the height of merchantable bole of standing trees, which were then measured for volume after felling. In the estimation of volume from the measurements of the felled tree no allowance was made for bark or defect.

Two men, stationed at a sawmill and using the same kind of instruments as were used on the enumeration lines, measured the breast height or above-buttress diameter and the height of merchantable bole of trees that were about to be felled. After each tree had been felled they measured the mid-point of successive 4 m (13 ft) logs and the length and mid-point diameter of the remaining log. The volume of each log was worked out by using Huber's formula (volume = mid-point cross-sectional area × length). The volume of the tree was obtained by adding the volumes of the logs that were usable. Defective lengths and tops left in the forest were measured as well so as to obtain a figure for defect in the tree. Detailed measurements taken at two sawmills suggest that about 10% of the total volume is defective. The complexity of programming precluded the possibility of using separate volume tables for the different species and one set of data was therefore worked out covering all species.

In Viti Levu, the measurements were made at the Navutulevu and Ngaloa sawmills and at Tailevu. In Vanua Levu trees were measured in the Sasa felling area in catchment 11/1* and at the sawmill of Mr M J White in the Mbutha catchment. The method has its drawbacks: in many areas the felling rate is low, so that the men have to remain unsupervised for long periods to collect enough data: another drawback is that the forest in which felling is taking place may not be representative of the catchment being enumerated.

Because of these disadvantages a method of measuring the volume of standing trees with a relascope was used whilst enumerating a catchment in order to supplement the data obtained in the felling areas. The Spiegel relascope is well adapted for this use because heights and diameters can be read simultaneously. On the standing tree the diameters of the mid-points of 4 m (13 ft) logs were measured together with the diameter at the mid-point of the remaining log. From these measurements the volume of the standing tree was obtained by summing the log volumes. The results from this method compared favourably with those from the felled-tree method so the two sets of data were combined to produce the final equation.

As an alternative to the Spiegel relascope, a Wheeler penta-prism was tried. Its advantage is that it measures to the nearest centimetre whereas the relascope can be read only to the nearest 5 cm (2 in) standing 20 m (66 ft) from the tree). It was found that the penta-prism required a more thorough clearing of the understorey between the observer and the tree and that it was more cumbersome to carry in the field. Detailed comparative measurements were not carried out but, from the observations made, neither direct measurement of the felled tree, nor measurement by penta-prism, gave better results than the relascope.

Initially 3 formulae were tried for calculating the regression between timber volume and brest height diameter and height. First a multiple regression was tried using the following formula.

$$V = a + b_1 D + b_2 H$$

where V = volume of the tree

D = diameter at breast height

H = height of merchantable bole

and a, b_1 and b_2 are constants

This method gave a coefficient of linear correlation of 0.64 and a wide standard error. A formula of the type

$$V = D^a H^b C$$

where a, b and c are constants

gave no better results, in spite of high claims by Lojan (1966) based on work in the tropical rain forest of Costa Rica.

Finally, a formula in which volume is correlated with diameter^2 × height was used and was found to give the best results. The formula is of the type

$$V = a + bD^2H$$

where a and b are constants.

The regression was recalculated for each computer run with tree measurements of all species from localities in which the survey was done.

The equations used for computing the volume in the 4 computer runs are given in Table 4. A volume table, based on the equation used in computer run 4, probably the most accurate equation, is given in Appendix 3a.

A volume table was also prepared for *dakua makadre (Agathis vitiensis)* using the same method based on the measurement of felled trees at Nandarivatu and standing trees measured with a relascope in the Wainimala catchment of Viti Levu. This volume table is given in Appendix 3b.

TABLE 4 Volume table equations used in computing the timber volumes in the catchments

Computer run number	Location of volume table data collection	Catchments included in the computer run	Number of trees measured	Equation	Correlation coefficient	Standard error at 95% probability level
1 and 2	Navutulevu sawmill Ngaloa "	Navua, Waimanu, southern Viti Levu coastal strip	477	$V = 0.75 + 0.000033D^2H$	0.87	± 1.4
3	J S White sawmill (Natewa peninsula) Sasa felling area (11/1) Nasavu and Vatukaroa (relascope)	Vanua Levu all catchments	420	$V = 0.23 + 0.000049D^2H$	0.92	± 0.77
4	Tailevu adjacent to plantation Nandarivatu Wainimala (relascope) Kandavu (relascope)	Rewa, Nandarivatu, Tailevu, Kandavu	354	$V = 0.104 + 0.000049D^2H$	0.95	± 0.88

COMPUTATION AND PRESENTATION OF RESULTS

For utilisation purposes the species have been grouped into 4 timber density classes and 1 class comprising mostly those trees which do not have to be removed from the forest according to the conditions of the licence to exploit.

Species group 1 Softwoods: Coniferous species (gymnosperms)

" " 2 Light hardwood: less than 593 kg/m^3 (< 37 lb/ft^3)

" " 3 Medium hardwoods: 593-801 kg/m^3 (37-50 lb/ft^3)

" " 4 Heavy hardwoods: more than 801 kg/m^3 (> 50 lb/ft^3)

" " 5 Non-obligatory species and 'others'

The 2 measurements for each tree, breast height diameter and height, were converted to volume by using the volume table formula within the computer program. Timber volumes were added by species and species group to obtain totals for each forest type of each catchment. Parallel sets of figures have been worked out with a minimum diameter of 35 cm (14 in) and a minimum diameter of 40 cm (16 in) because, from volume table measurements, the latter had been found to be the common lower diameter limit in use in Fiji. Sampling error was calculated for each species group within each forest type. The square root of the sum of the squared species group sampling errors gave the forest type sampling error.

Tables showing individual species volumes and species group volumes and their sampling errors for the forest types of each catchment were included in the fieldwork data handed over to the Conservator of Forests in December 1969. Further volume information is given in Volumes 2 and 3 of this report dealing separately with the 16 catchment group (Table 5). For each group tables are given showing the following data.

1. The areas enumerated of each forest type, by catchment and management category
2. The timber volume in each catchment by management category
3. The timber volume in each catchment by forest type and management category

In the second of these tables the volumes given are those for the trees of 40 cm (16 in) d.b.h. and over of species groups 1-4. Confidence limits are also given at the 95% probability level together with reliable minimum estimates of the volumes, that is, the volume less the sampling error to show the lowest volume that can be expected in 39 cases out of 40 (as only one side of the confidence limits is involved, the probability level is doubled). The volumes are totalled for each management category.

In the third table, separate details are given for each forest type to show the volume of timber for all trees of all species groups, the volume for trees of 40 cm (16 in) d.b.h. and over for all species groups and, finally, the volume for the trees 40 cm (16 in) d.b.h. and over of species groups 1-4. The stocking per hectare for the last class is also given. The timber volumes are totalled by management category for each catchment.

To obtain the overall total of exploitable timber in Fiji the volumes of the second table, for the production forest management category, have been taken and listed against their catchment groups in Table 1 above. The total of the individual reliable minimum estimates, 10.9 million m^3 (3 634 million Hsl ft), represents the lowest estimate of timber available for exploitation in Fiji.

TABLE 5 Grouping of catchments

Catchment group	Catchment	Computer code no
	VITI LEVU	
Rewa	Waimanu	59/1
	Waindina	59/2
	Sovi	59/3
	Waindrandra	59/4
	Lomaivuna	59/5
	Wainimala	59/7
	Wainimbuka	59/10
	Wainivandu	59/11
Tailevu	Naitaleira	60/1
	Ndawasamu	60/2
	Londoni	60/3
	Waimbula	60/4

TABLE 5 (continued)

Catchment group	Catchment	Computer code no
Nandarivatu	Nanuku	59/6
	Tawa	59/9
	Nandarivatu	64/1
	Solikana	64/2
Navua	Wainikovu	65/1
	Wainikoroiluva	65/2
	Waionamoli	65/3
	Nambukelevu North-East	65/4
	Nambukelevu South-East	65/5
	Mavuvu	65/6
	Nambukelevu North-West	65/7
	Nambukelevu South-West	65/8
South Coast	Navua-Singatoka Coastal Strip	66/1
	Suva-Navua Coastal Strip	67/1
	VANUA LEVU	
Mbua North	Mbua	2/1
	Kavula	6/1
	Sarowangga	8/1
	Naimbulu	10/1
Mbua South	Ndama	4/1
	Nalomate	5/1
Coastal West Central	Wainunu	9/1
	Yanawai	13/1
	Kumbulau	14/1
Ndreketi North	Ndoloko	11/4
	Vatusomi	11/6
	Vunimako	11/7
Ndreketi South	Nanenivunda	11/1
	Narailangi	11/2
	Nasuva	11/8
	Seanggangga	11/9
	Ndrawa	11/10
Coastal East Central	Wailevu	15/1
	Nasekawa	19/1
Lambasa and the North-East	Tambia	16/1
	Lambasa	18/1
	Nggawa	21/1
	Nayarambale	23/1
	Wainikoro	25/1
	Numbu	26/1
Natewa Bay	Vaturova	20/2
	Nasoni	20/3
	Vatukaroa	20/4
	Savusavu	20/5
Natewa Peninsula	Navonu	28/1
	Mbutha	29/1
	Mbangasau	30/1
	KANDAVU	
Kandavu	Kandavu East	31/1
	Kandavu West	32/1

PART 2. THE ENVIRONMENT

PHYSICAL ASPECTS

LOCATION

The Fiji Islands, consisting of some 300 islands in the South Pacific Ocean, are clustered for the most part just inside the southern tropical belt and near the 180th meridian.

Viti Levu and Vanua Levu are the two largest islands occupying areas of 10 384 km^2 (4 011 mi^2) and 5 532 km^2 (2 137 mi^2) respectively. These two islands and Kandavu, a small island of about 100 km^2 (60 mi^2) south of Viti Levu, constitute the survey area.

CLIMATE

From January to April the Inter-Tropical Convergence Zone lies at its extreme southernmost position of latitude 16° just north of Vanua Levu, and the associated disturbed conditions and low pressure bring about 250 mm (9.8 in) of rain per month to all parts of Fiji. During the rest of the year the convergence zone lies well to the north and the prevailing winds are from the south-east, bringing rain to those areas with a south-easterly aspect.

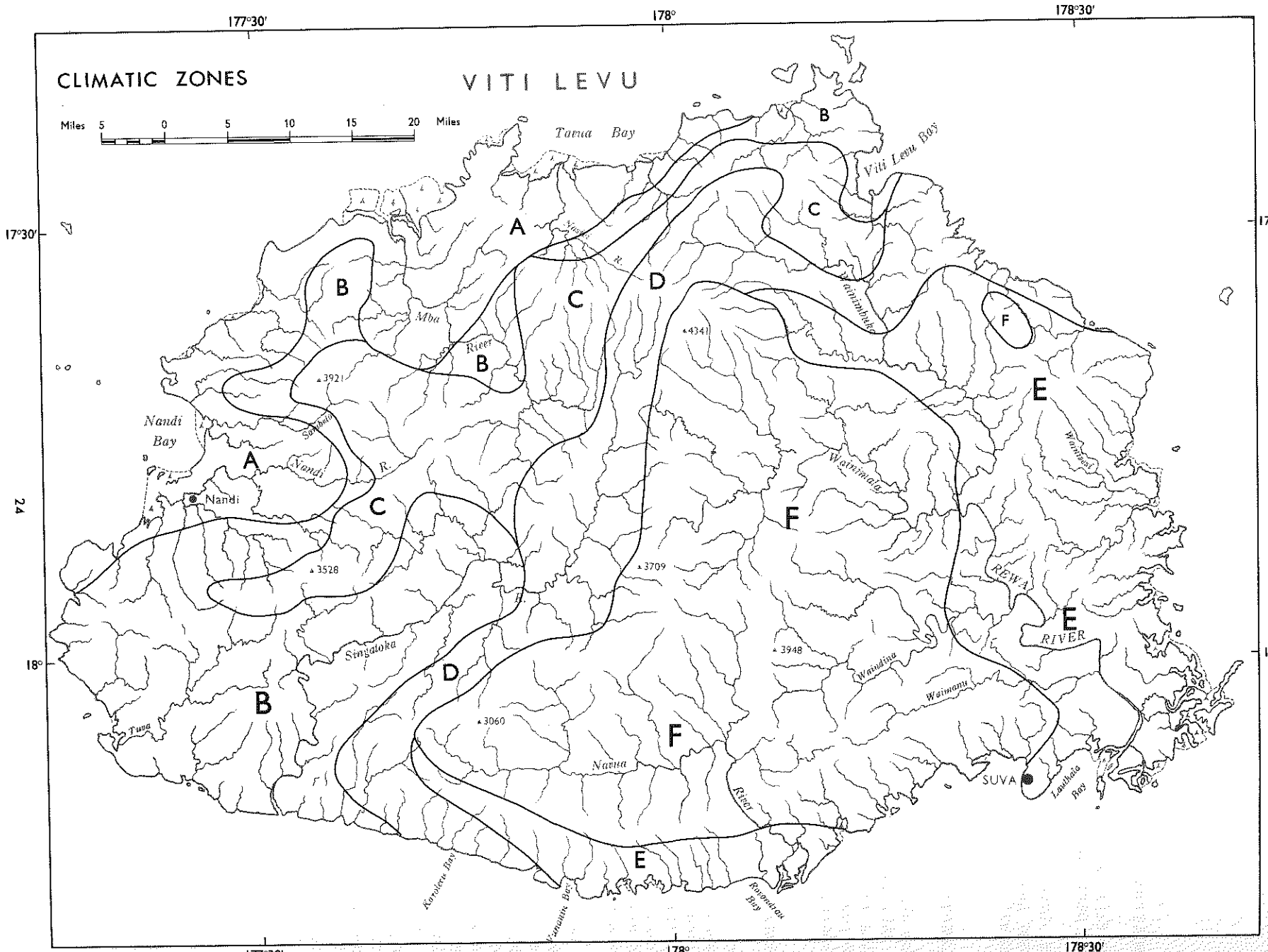
Rainfall

The rainfall pattern is determined by the prevailing south-east winds and by physical relief which causes heavier rainfall on the high ground that lies in the centre of Viti and Vanua Levu. These islands may be divided into 6 climatic zones based on rainfall and (Jenkins and Lesslie, in preparation) length and intensity of the dry season (see Text Maps 4 and 5). The zone of heaviest rainfall (F) has more than 3 800 mm (150 in) of mean annual rainfall with a very weak or absent dry season. It occurs over the high ground of central Viti Levu including the catchments of the Navua River and the western tributaries of the Rewa River.

In Vanua Levu it stretches from the highest peaks of southern Mbua Province in the west covering the high grounds of the central chain of hills as far as the source of the Nasavu River in the east. Zone E with a weak dry season of 1-2 months duration and 3 050 - 3 800 mm (120-150 in) of mean annual rainfall lies to the east of the high rainfall zone in Viti Levu on the Tailevu coast and in Vanua Levu along the south coast at Wainunu Bay and in the vicinity of Savusavu. On the leeward side of the island the zones have progressively less rainfall and longer, more intense, dry seasons. Zone D with a 3-month dry season and 2 550 - 3 300 mm (100-130 in) of mean annual rainfall occurs to leeward of the wettest zone on Viti Levu extending in a semicircle from east of the mouth of the Singatoka River up the valley to Mt Victoria where it runs in an easterly direction to Viti Levu Bay. In Vanua Levu this zone occurs over much of the Natewa Peninsula and along the north side of Natewa Bay as well as a thin strip to the leeward of the wettest zone. Zone C with a long intense dry season of more than 5 months, having less than 150 mm (6 in) of rainfall per month and a mean annual rainfall of 2 550 - 3 300 mm (100-130 in) occurs on the high ground on the north-east side of Viti Levu, along the leeward side of Vanua Levu, particularly in the Ndreketi catchment and the hills of the north-east coast. Two further zones, A and B, with long intense dry seasons and mean annual rainfalls as low as 1 650 mm (65 in), occur on the low-lying areas on the leeward side of both islands.

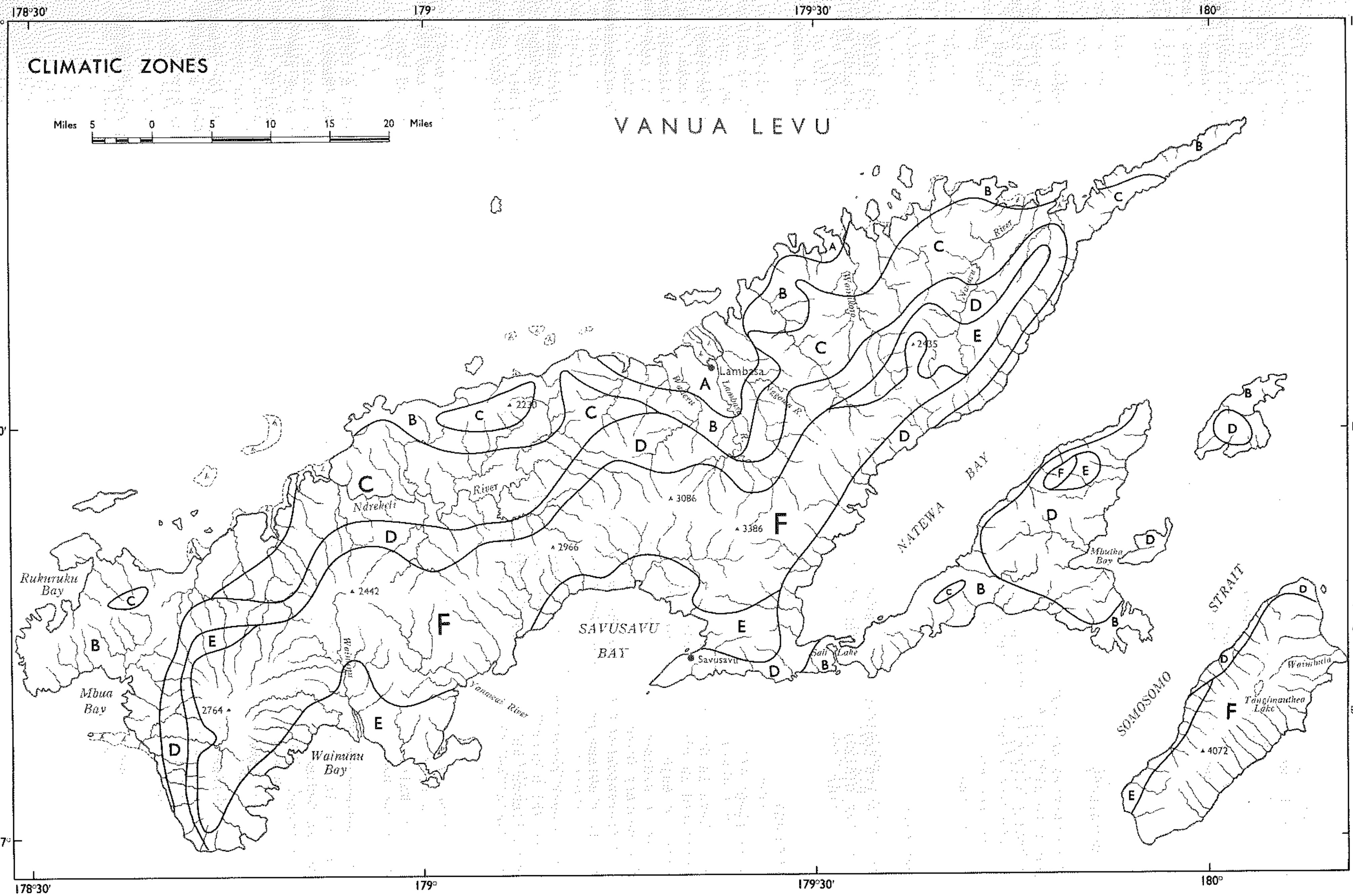
Wind

For 8 months of the year, from May to December, the prevailing wind is from the south-east quarter veering from east to south. During the period January to April when the intertropical convergence zone is nearest to Fiji the direction of the wind is variable with a strong northerly component.



D.O.S. 3109 BA

Prepared by Directorate of Overseas Surveys 1971


CLIMATIC ZONES
Miles 5 0 5 10 15 20 Miles
VANUA LEVU
178°30'
179°
179°30'
180°
16°
16°30'
17°
Lambasa
Savusavu
SAVUSAVU BAY
NATEWA BAY
SOMOSOMO STRAIT
Tasman Strait
Rukuruku Bay
Mbua Bay
Wainunu Bay
Mbutha Bay
Ndreketi River
Salt Lake
Tangimauthea Lake
2230
3086
3386
2966
2442
2764
2435
4072
A
B
C
D
E
F

D.O.S. 3109 BB

Prepared by Directorate of Overseas Surveys 1971

Text Map 5

Hurricanes are likely to occur in the Fiji Islands from November to April, coming usually from the north-east and curving around the main islands to move away in a south-easterly direction. Twenty-eight hurricanes have visited the Islands between 1900 and 1967 and severe ones are rare (Adams *et al.*, 1969). They damage agricultural crops mainly by flooding, rather than by the force of the wind. The damage of natural forest by hurricane does not seem to be common although small areas of damage have been observed in the forest by both authors. Trees are prone to damage when the soil is saturated with water and they become unstable. A map of the paths of hurricanes that have passed the Fiji Group since 1900 shows that they have often passed over south-east Viti Levu (Adams *et al.*, 1969).

Temperatures

Temperatures are high throughout the year, ranging from 27°C (80°F) in the period December to March to 23°C (74°F) in July and August. The maximum and minimum temperatures during the year are normally within the range of 32°C (90°F) to 76°C (60°F) (Harris, 1963). The leeward sides of the islands are slightly hotter and have a greater range than the wet coastal lowlands. At high elevations above 610 m (2 000 ft) the mean annual temperature is lower at 20°C (68°F), but the diurnal range is similar to that in the lowlands.

Humidity

The relative humidity rises gradually through the night to a maximum of 90% at dawn and falls to a midday minimum of 70%. The diurnal range is greater on the dry sides of the main islands where it may range from 63 to 90%, compared with the wet side where the range is usually 77-90%.

GEOLOGY

Viti Levu

Viti Levu is divided geologically into older metamorphic rocks dating from the Lower Tertiary, separated in places by a clear mid-Miocene unconformity from younger unmetamorphosed rocks. Three types of major rock units have been distinguished by Rodda and Band (1967) : (i) the Volcanic Group in which sedimentary rocks are subordinate in status to a diagnostic volcanic rock, (ii) the Sedimentary Group in which volcanic rocks are either absent or subordinate, and (iii) the Undifferentiated Group comprising the Lower Tertiary volcanic and sedimentary rocks distinguished by their metamorphic characteristics and their stratigraphic position.

The oldest rocks ranging from Eocene to Lower Miocene belong to the Undifferentiated Wainimala Group which occupies most of the lower half of the island. It is divided into two Sub-Groups, the Matailombau, which trends east-north-east along the Singatoka valley and across the lower Wainimala, and the Mount Gordon Sub-Group which underlies the hills of the Navua basin and occurs along the south coast.

Intruding into this Group, probably at a deep level, are the Tholo Plutonics consisting mostly of tonalite to diorite with a little gabbro. These rocks form the hills in the centre of the island east of Wainikoroiluva and are exposed in the Sovi basin and at the north-west corner of the Navua catchment.

The Sedimentary Group of Mio-Pliocene age is represented mainly in the south-west with a little exposed in the north-east (Ra Sedimentary Group). It is made up of the Singatoka, Ra, Nandi and Navosa Sedimentary Groups comprising mainly sandstone and conglomerate rocks with a little limestone. The Verata Sedimentary Group of Pleistocene age occurs in the east centre of the island underlying the Rewa basin. Horizontally bedded sandstone laid down in a period of subsidence have now been eroded to form a dissected landscape of flat-topped hills.

In the Volcanic Group the Mendrausuthu Andesitic Group of Mio-Pliocene age has formed the dramatic peaks and escarpments of the Korombasambasanga and Mendrausuthu ranges, which are both andesite. Navua mudstones and Waindina sandstones form flat areas along the Navua and Waindina Rivers. Suva is underlain by sedimentary deposits (Suva Marl) in this Group.

In the mid-west the Koroimavua Andesitic Group underlies the hills that lie inland from Lautoka (Sambeto and Nalota Ranges).

The most recent formation is the Mba Basaltic Group of Pleistocene age, which covers the northern part of the island from east to west and extends down in the centre of the island as far as the Nandrau Plateau. Lava flows have caused the formation of such flat plateaux in the centre of the island as Nandrau and Rairaimatuku, while volcanic centres have led to the emergence of rugged hill ranges along the north coast and in the centre of the island, notably Mt Evans in the west, Tomanivi in the centre and the Kauvandra and Nakorotumbu Ranges in the north-east.

Vanua Levu

Vanua Levu is younger geologically than Viti Levu and consists of lavas and their weathered products that erupted from a number of volcanic centres more or less at the same time and for the most part in shallow seas. The geology of Vanua Levu consists basically of 4 broad east-west zones (Rickard, 1966).

In the south-east corner are the Mbua Basalts, with very steep country around the Navotuvotu peak at 842 m (2 764 ft), giving way to almost horizontal lava flows in the Wainunu catchment. Mbua Basalts outcrop again at Ndakunimba in the south of the Natewa Peninsula.

Sedimentary rocks deposited from the erosion products of the Natewa Volcanics occupy a basin of flat or gently undulating country traversed by the Ndreketi River in the north-west central part of the island.

The central section of the island and most of the Natewa Peninsula is occupied by Natewa Volcanics which cover the largest area. This group consists of breccias, flows, grits and tuffs and includes the very steep terrain that forms the backbone hill range of the island, Ndelaikoro, at 941 m (3 086 ft), Nasorolevu, at 1 032 m (3 386 ft), and Ndikeva, at 957 m (3 139 ft), as well as the Nawavi Range along the central north coast.

At the north-east end of the island, running out to Undu Point, are the Undu Volcanics comprising rhyollite to dacite, forming a series of steep hills that extend to the coast in a north-easterly direction. At the north end of the Nasavu catchment they underlie a dissected peneplain similar to that in the Rewa basin.

Kandavu

Kandavu consists of 3 hill masses joined by narrow 'waists' of land. At the extreme western end an extinct volcanic cone, Ndelainambukelevu, at 805 m (2 642 ft), rises sheer from the water practically to the summit. This western land mass is underlain by hornblende andesite containing a greater number of flows (Romanu *et al.*, 1959). The middle and eastern land masses consist of augite andesitic flows and agglomerate and hornblende andesite containing few flows. All the rocks date from the Late Tertiary. Subsidence has occurred submerging the land that supported the Astrolabe Reef to the north-east and leaving only the tops of the hills of Kandavu above the sea.

LANDFORM

Viti Levu

Viti Levu is a high island with several peaks rising to heights of over 914 m (3 000 ft). The highest point is at Tomanivi, 1 323 m (4 341 ft), on the Nandarivatu Plateau.

The landform is best described in relation to the underlying geology. The oldest rocks of the Wainimala Group, intruded by Tholo Plutonics, have given rise to mountain ranges in the south of the island, notably the Korombasambasanga and Wainikoroiluva hills in the centre, Tuvatau (Mt Gordon) and Tikituru on the northern watershed of the Navua and the Nausori Highlands in the west. All of these have peaks of over 914 m (3 000 ft). The intervening country is steeply dissected with many creeks flowing in V-shaped valleys.

The Mendrausuthu Andesitic Group has given rise to the Mendrausuthu Range in the east central part of the island with dramatic escarpments of andesite, as well as the flat areas in the Navua and Waindina basins. The Rewa plains form an area of low relief with short steep slopes in the east of the island underlain by horizontally bedded sediments of the Verata Sedimentary Group.

The youngest rocks geologically are the Mba Basalts which cover the northern half of the island. They form the Nandarivatu Plateau consisting of flat lava flows at an elevation of 7 502 m (2 500 ft) with a rugged peak at Tomanivi (Mt Victoria) at an elevation of 1 323 m (4 341 ft). In the north-east are the Kauvandra and Nakorotumbu ranges and, in the west, Malua and Koroyanitu hills, all with elevations of over 1 000 m. Recent alluvium has caused flat areas in the mouths of the Rewa, Mba, Nandi and Navua Rivers. Erosion surfaces are found at Drasa in the north-west and in the upper Wainikovu and Waimanu Rivers.

Vanua Levu

Because it is less well differentiated stratigraphically the landform of Vanua Levu is not so easily described in terms of the underlying geology. The Natewa Volcanics, the major Group in the island, has given rise to a main chain of steeply rising hills aligned in a north-east to south-west direction, which fall steeply to the sea on the south side and grade more slowly to the north with subsidiary parallel hill ranges lying in a north-westerly direction. In the west the Ndreketi basin has gentle and moderate slopes underlain by the erosion products of the Natewa Volcanics. In the extreme west the Mbua Basalts have given rise to the extremely steep-sided mountain Navotuvotu Peak.

The flat areas of the upper Wainunu valley are thought to be the remains of almost horizontal lava flows from the Navotuvotu volcanic centre. In the north the Undu Volcanic Group has given rise to steep hill ranges near the coast underlain by dacites, pumice and tuff. In the north-east, areas of flat land extend inwards from the coast surrounded on three sides by steeply rising hills. This landform picture is illustrated by the photograph of forest type GDS (Plate 9).

Kandavu

Kandavu is a steep-sided, long, narrow island with elevations of about 500 m (1 640 ft) along the main ridge. At the extreme western end the extinct volcano, Ndelainambukelevu, rises to a height of 805 m (2 642 ft) sheer from the sea on the north side. The land is dissected in this western land mass with streams flowing in U-shaped valleys on the north side. The central land mass has peaks at Vunindilo and Manggove in the west and Nakorotu in the east. Between these peaks lies a central plateau at an elevation of about 314 m (900 ft). The land falls steeply to the north and west and more gently southwards. The eastern land mass, like the western one, is dissected country with peaks of 446 m (1 464 ft) at Koronimbanuve in the west, rising to 635 m (2 082 ft) at Mbiloniyanggona in the centre and falling to 324 m (1 064 ft) in the east. There is very little flat land and, what there is, is confined to narrow coastal shelf.

SOILS

Twyford and Wright (1965) have mapped the soils to Fiji, recognising the following soil groups.

Recent soils

These include soils developed from coastal deposits on the shores of the islands and soils derived from river deposits which are deep and fertile. They are of limited occurrence, being confined to the major rivers.

Nigrescent soils

On steep slopes these are shallow black soils rich in nutrients: on gentler slopes they are dark brown with strong structural grade and clay texture. Nigrescent soils cover the north and west coast of Viti Levu, occurring on the lee side of the island where the vegetation is grass or reeds. In Vanua Levu they are of limited occurrence, being confined to the south coast from Dakunimba to Savusavu and in small patches in the Ndreketi basin and the north-east.

Chemical analysis of steepland nigrescent soils shows a high pH, usually greater than 5.0, a base saturation of 40-80% and a cation exchange capacity of 50-80 meg %. Exchangeable cations are high for calcium and magnesium.

Latosolic soils

These are intermediate in characteristics between the nigrescent soils and humic latosols. In the field they feel like loams, have a colour ranging from brown to reddish brown and contain fragments of unweathered material. They are derived from volcanic ash and found in Fiji on the island of Taveuni, Koro and Lauthala. They occur as part of the toposequence of soils in the two main islands but are not usually in big enough areas to map separately (Adams, 1968).

Humic latosols

Humic latosols are deep red-coloured soils usually of clay texture but having the feel of loams in the field. Their chemical properties are low base saturation, moderate to low cation exchange capacity and a moderate to strong acid reaction. All primary minerals have been weathered to produce abundant kaolin and gibbsite clay. Humic latosols occur on the wet side of Viti and Vanua Levu usually under a vegetation of fern and *nokonoko (Casuarina equisetifolia)*. They have a low to very low cation exchange capacity and are highly weathered soils.

Red yellow podosolic soils

These are deep, sandy soils, in which the clay content increases in the subsoil. They can be recognised in the field by the pale colours, pink or yellowish red, loose consistence and lack of structural aggregates. Derived from quartz-rich parent materials, they are strongly weathered and leached, with low pH and low cation exchange capacity. They occur in central and western Viti Levu over acidic rock types (diorite) and in north-east Vanua Levu over the rocks of the Undu Volcanics Group (rhyollite to dacite).

Gley soils

These occur where a high watertable prevails for most of the year. Their properties vary depending upon the nature of the parent material, tending towards nigrescent soils where a high level of calcium and magnesium is maintained in the soil and towards latosols where there is no influence from calcium or magnesium. Gley soils related to latosols are more common, occurring in Viti Levu at the mouths of the Rewa and Navua Rivers and in Vanua Levu in the floodplains of the Lambasa, Wailevu and Ndreketi Rivers.

Organic soils

Organic soils are developed in local patches, when the watertable lies at the soil surface during much of the year. Of the 2 types found, the more nutrient-rich is the rush and fern peat, found in shallow depressions or on sloping land, which receives a large volume of water from adjacent foot-hills. The less fertile is the reed peat. Occurrence is rare and local.

Saline soils of the marine marsh

These are the soils of the regularly inundated coastal flats at or near the main tide level, for the most part supporting mangrove forest or salt marsh vegetation. They occur on the east, west and north-west coast of Viti Levu and on the north-west side of Vanua Levu.

FLORA

Tropical rain forest covers the sides of the two main islands that are exposed to the south-east trade winds, while grass and shrubs and sometimes a light tree canopy cover the leeward sides, except for extensions of forest at high elevations in Viti Levu and in the Ndreketi basin of Vanua Levu. The species composition and structure of the forest is best understood in terms of the landform and parent material. On dissected country with short slopes, developed over basic rocks, a broadleaved forest occurs, with the main canopy trees reaching a height of 25 m (80 ft) and a total stocking of trees over 35 cm (14 in) d.b.h. exceeding 100 m^3/ha (13 500 Hsl ft/ac).

Common families and genera of broadleaved species are *Calophyllum Myristica*, Myrtaceae, *Endospermum, Canarium*, Sapotaceae, *Parinari* and *Heritiara*. Of the coniferous species *Agathis* is common. On soils of low fertility on dissected plateau surfaces and areas overlain by acid parent material, the coniferous species dominate, often spreading their crowns above the low broadleaved forest. Typical coniferous genera are *Agathis*, *Podocarpus* and *Dacrydium*, often associated with *Palaquium hornei*. As the slopes become steeper and longer towards the watershed, the forest becomes shorter with short-boled trees having wide crowns. The species are the same broadleaved species that occur in the adjacent short steep slopes, except on the very steep scree slopes where *Bischofia, Dysoxylum* and *Laportea* are found. Along the crests of the high ridges a sub-montane pole thicket occurs with many species of the family Myrtaceae. The forest that grows on the dry side of Vanua Levu, and to a lesser extent in Viti Levu, is characterised by the species *Casuarina nodiflora* and coniferous species, particularly *Dacrydium elatum* and *Podocarpus* spp. The coniferous species flourish at high elevations, the high land in the centre of Viti Levu at an elevation of 600-900 m (1 969-2 953 ft) containing forest rich in *Agathis* and *Podocarpus*.

Early stages of secondary growth after clearing for gardens are easily recognised by the partially closed canopy woodland vegetation interspersed with dense shrubs and blanketed with climbers. The species are usually of the families Euphorbiaceae and Meliaceae. The canopy closes to form a low fringe forest in which many of the species that dominate the mature forest are already present together with species of genera such as *Trichospermum*, *Degeneria* and *Neonauclea*. This forest is distinguished from the mature mixed species forest by the low canopy 10-17 m (33-56 ft) high and poor stocking of 15 m^3/ha (2 021 Hsl ft/ac). The coniferous species and *Calophyllum* are absent from this type. It cannot be said that all the poorly or moderately stocked mixed species forest is secondary in origin, but it is likely that much of this forest has been modified by human activity in the past and its rate of regrowth retarded by one or a combination of factors, such as climate or soil conditions. Supporting this thesis is the presence of old village sites plotted on the Native Land Commission maps coinciding with areas of poorly stocked forest or partially closed woodland.

The hills of the dry sides of the islands are covered with grasses and shrubs, which indicate the intensity of burning and grazing and the resultant fertility of an area. On the poorest, most infertile soils are found mission grass *(Pennisetum polystachyon)*, the ferns *Pteridium esculentum* and *Dicranopteris linearis* and the easily recognised tree *Casuarina equisetifolia*. The reed *Miscanthus floridulus* grows on hillsides of better fertility. Shrubs and small trees that invade where fire has been excluded are *Alphitonia* spp., *Commersonia bartramia, Geissois ternata* and species of the families Sapindaceae and Meliaceae.

Mangrove forest covers the tidal flats around the coast where the common tree genera are *Rhizophora*, *Lumnitzera* and *Bruguiera*. The beach forest that occurs just above the high tide level has species in common with other Pacific islands. Typical trees are *Intsea bijuga, Calophyllum, inophyllum, Barringtonia* spp. and *Hibiscus tiliaceus*. The area of this kind of forest was much greater in the past but many hectares of this site have, over the last 100 years, been converted to coconut plantations.

HUMAN ASPECTS

HISTORY

The Fijian people are Melanesians who came from the west in a series of migrations. From sites on the south-east and north coast of Viti Levu, pottery, associated in style with that found in New Caledonia, has been dated at 1200 BC (France, 1969). The discovery of the Fiji Islands by Europeans is credited to Tasman who passed over the Nanuku Reef at the eastern end of Vanua Levu. Captain Bligh, nearly 180 years later, passed between Viti and Vanua Levu in an open boat after the famous mutiny and returned to chart many of the reefs and islands in 1792.

The first real contact with Europeans came in the 1800s when the sandalwood trade brought ships to the Mbua coast of Vanua Levu. The first missionaries arrived in 1835 and were followed by settlers who bought land along the southern coast of Vanua Levu and to a lesser extent in Viti Levu. The famous botanist Berthold Seemann came to Fiji in 1860 and spent a year plant-collecting for the British Government. The purpose of his visit was to investigate the economic advantages in ceding the Fiji Islands to Britain, but his recommendations were turned down and it was not until 1874

that the Deed of Cession was signed. Sugar plantations were established at the end of the 19th century and Indian labour was imported on an indenture system from 1890 to 1916.

The Forest Department was created in 1938 following reports on the forests of Fiji by two foresters of the British Colonial Service, Mead (1928) and Sykes (1933). It was not until the early 1960s that it underwent expansion, when it was seen that the plantations, both of pine on the dry side and mahogany in the wet forest zone, were successful.

POPULATION AND LAND TENURE

The Fijian population at the time of Cession is thought to have been in the order of 130 000-135 000 (McArthur, 1968). The estimated death toll of 40 000 for the measles epidemic of 1875 (Corney *et al.*, 1896) is thought to be high. When the first census was conducted in 1879 the population was 112 000. In 1881, when a second census was conducted, almost half of the non-Fijian population were Melanesians working in the sugar plantations and the remainder consisted of roughly 2 500 Rotumans, 2 700 Europeans, 800 Part-Europeans and fewer than 600 Indians. During the next 10 years many of the Melanesian labourers were repatriated and in their place indentured labourers from India were brought in. They had to work for 5 years for one employer after which time they could either stay or be repatriated back to India. Most elected to stay, with the result that, by 1921, 30% of the population was Indian and 54% Fijian. Meanwhile the Fijian population continued to decline until the period 1905-11 when an improvement began, which continued to the 1966 census except for the influenza epidemic of 1918. Since then the population increase of both the Fijians and Indians has been rapid so that in 1966 the total population stood at 202 176 Fijians, 240 960 Indians and 33 591 of other races, with an age structure such that more than half the population is under 15 years of age.

A study of the aerial photographs shows how little land the Fijian population in the forested interior has under cultivation at any one time. Ward (1965) quotes a figure of 0.2 ha per man per year as being an average figure of land required for subsistence crops per person in the Pacific territories generally. The area of what appears to be secondary forest is large, indicating that either the pre-Cession population was very much larger than it is in 1972 or the people were very much more active in their destruction of the forest than they are in the early 1970s. Evidence of old village sites on the Native Land Commission sheets and the tribal histories recorded by the same Commission suggests that both are true. Village sites correlate with poor forest or open woodland in the forest, and tribal histories of many groups indicate a constant movement of the people following tribal warfare. Two lessons may be learnt by studying the relation between past population patterns and the extent of secondary forest. The first is that the inland parts of the two main islands supported bigger populations (who presumably raised subsistence crops) than they do in the 1970s and the second is that the forest regenerates slowly when left without any form of forest management. Postulating a very much larger population before any Europeans brought disease at about the time of the sandalwood trade in 1820, the forest has had 150 years in which to develop.

In the early days land was held by a group of people while they were cultivating it and tenure reverted to the Chief when it fell fallow or the people moved away. The system of land tenure became crystallized in the 1880s when the Land Commission toured the country sorting out the area of land claimed by a *matanggali* (clan) as being in use by them or necessary for their future needs. The land not claimed by the *matanggali* became Crown land, Schedule B, while land owned by a *matanggali* all of whose members subsequently died was to become Crown Land, Schedule A. The area of Crown land is small; most of it was purchased by the Government in the period 1905-08 when restrictions on the sale of native-owned land were lifted. Most freehold land dates from the period prior to Cession when early settlers and planters obtained land from chiefs by purchase for small amounts or for services rendered. Freehold land accounts for less than 10% of the land area and is concentrated around the coast and along the alluvial flats of big rivers.

Fijian-owned land is administered by the Native Land Trust Board set up in 1940 with the purpose of protecting the Fijian's rights to their land. Much of the land used by the Indian population for cane farming and grazing is land leased from the Fijians. In 1940 provision was made for the setting up of Native Reserves which could not be leased to non-Fijians so as to ensure an adequate supply of land for Fijian use in the future. This has proceeded a long way and areas of Native Reserve now surround most villages. Areas under the different classes of tenure are given below (Burns *et al.*, 1960).

	ha	*ac*
Crown land	118 749	293 424
Freehold land	175 645	434 014
Native customary tenure	1 532 599	3 787 000

FOREST ADMINISTRATION

The Forest Department, under a Conservator of Forests, is part of the Ministry of Agriculture, Fisheries and Forests. The Country is divided into 3 Divisions, Southern, Western and Northern, each with an Assistant or Senior Assistant Conservator of Forests in charge. The Research Division includes silviculture and wood technology. In 1969 the Management Division was formed using some staff, offices and equipment of the LRD project as a start. Foresters are promoted from the ranks of Forest Rangers and Forest Guards and usually attend the Foresters' course at the Forest of Dean in England to qualify for promotion. There is a school for Forest Guards at Lololo near Lautoka which serves other Pacific Island countries as well as Fiji.

COMMUNICATIONS

A main road runs round the periphery of the island of Viti Levu with extensions inland to Vunindawa on the Rewa River, Nandarivatu in the centre of the island, the Nausori Highlands in the west and up the Singatoka River on the south coast. Vanua Levu has a main road running from Nambouwalu at the south-west tip, up the northern side of the island through Lambasa to Langalanga. On the south side the picturesque Hibiscus Highway runs from Savusavu to the furthest tip of the Natewa Peninsula with branches to the south part of Natewa Bay.

River transport plays a big part in the internal communications of Viti Levu, particularly the Rewa and its tributaries. In Vanua Levu it is not so important except in the Ndreketi and Nasavu Rivers. The most popular type of boat on the rivers is half-punt, half-canoe, flat-bottomed and narrow, usually 7.6-9 m (25-30 ft) in length and powered with an outboard motor of about 20 hp to cope with the strong river currents. These boats were very useful in the survey as, loaded with stores and equipment, they could be hauled up over shallow river beds miles beyond the rivers' navigable limit.

PART 3. FOREST TYPES

INTRODUCTION

Forest typing is a combination of recognising patterns on the aerial photographs and associating field characteristics from the enumeration lines with the delineated pattern. There are basically 3 elements which must be reconciled in order to delineate the various forest types, namely, airphoto pattern, landform, and the fieldwork characteristics obtained from the survey cards. In the majority of cases allocation to a forest type is the result of weighing up the observed characteristics of a piece of forest with the definitions for the forest types. Agreement should be obtained in at least 2 of the 3 basic elements. In the beginning a preliminary interpretation of the aerial ph tographs indicates roughly what the forest types will be. The aerial photographs are taken into the field and the airphoto interpretation checked with the forest on the ground. Finally, in the office the enumeration cards are laid out to check that the boundaries marked on the photographs coincide with those revealed by the fieldwork.

In the following pages a brief description of each type, including information about the sites they occupy, their species composition and stocking of merchantable timber, is given under 9 main headings (see Table 6) which can be used as a key.

Following the brief guide to the 9 types, Table 7 lists them under the 3 management categories, non-commercial, production and protection forest. This grouping is based on stocking in the case of the non-commercial forest types and steepness and length of slope in the case of protection forest. Non-commercial forest types have a stocking of less than 30 m^3/ha (4 043 Hsl ft/ac) including species groups 1-4 and trees over 35 cm d.b.h., whereas the types in the production forest have a stocking of from 30 to 110 m^3/ha (4 043-14 824 Hsl ft/ac). The protection forest has slopes in excess of 30^o usually 40-60^o, with a shallow soil and long slopes (except GS which has short, very steep slopes). The quality of the forest cover ranges from type CS, which has a stocking of about 60 m^3/ha (8 086 Hsl ft/ac) to type S1 which is a partially closed canopy woodland.

Table 7 is followed by detailed descriptions of the forest types arranged in alphabetical order of the map symbol within the main headings of non-commercial, production and protection.

GUIDE TO THE FOREST TYPES

1. FOREST OR WOODLAND WITH A PARTIAL CANOPY COVER

This group is recognised on the aerial photographs by the partially closed canopy.

Type S: Low-stocked open woodland

The canopy is partially closed, ranging from $\frac{5}{10}$ to $\frac{9}{10}$. This woodland occurs on moderate to steep slopes. *Sasauwira* (*Dysoxylum richii*) and *koka* (*Bischofia javanica*) are the common named species with 'others' comprising species like *bo* (*Neonauclea forsteri*), *yaro* (*Premna taitensis*) and *mako* (*Trichospermum* spp.). The stocking ranges from 5 to 30 m^3/ha (674 - 4 043 Hsl ft/ac). The type, which represents a stage in secondary regrowth, occurs in many of the catchments but rarely covers large areas.

Type KF: Blocks of forest in grassland

This kind of vegetation cover occurs on moderate to steep slopes of the foothills beneath a high hill range. *Velau* (*Casuarina nodiflora*) with *kaudamu* (*Myristica* spp.) and *Dysoxylum* spp. are common. The stocking is 20 m^3/ha (2 695 Hsl ft/ac). The type is confined to the Nasekawa catchment in Vanua Levu.

TABLE 6 Grouping of the forest types showing management categories and mapping symbols

Forest type group	Non-commercial	Production	Protection
1. Forest or woodland with a partial canopy cover	S KF O		
2. Logged or partially logged forest	H G(L)	C1(L) GB(L)	
3. Closed canopy, low-height mixed species forest	BE G2 J K		
4. Mixed species forest with a moderate or high stocking		C1 C2 G E	
5. Forest of gymnosperm associations			
a. *Yaka* associations	GD HS		
b. *Dakua makadre* associations		CDK SK DM GDK DK	
c. *Dakua salusalu* associations		DS DS2	
6. Forest of *velau* associations	V VB VF	GV GV(L) GV(H)	
7. Forest of *sacau* associations		CY GY SV	
8. Other species associations	DR RT	KV GB VS KD	
9. Protection forest on very steep slopes			B BS CS GDS GS S1

Type P: Low-stocked old orchard dawa-ivi forest

This orchard forest has an almost closed canopy. It occurs on gentle to moderate slopes beside rivers and near inhabited or abandoned villages. Common species with edible fruits are *dawa* (*Pometia pinnata*), *ivi* (*Inocarpus fagiferus*), *wi* (*Spondias sp.*) and *kavika* (*Syzygium malaccense*) and with inedible fruits *sasauwira* (*D.richii*) and *koka* (*Bischofia javanica*). The stocking ranges from 25 to 50 m^3/ha (3 369 - 6 738 Hsl ft/ac) and the type occurs in Vanua Levu in the Ndreketi catchments.

2. LOGGED OR PARTIALLY LOGGED FOREST

On the aerial photographs the types are differentiated by the extent to which the canopy has been damaged by logging operations.

Type H: Logged-out forest

Large-scale commercial logging operations have broken the forest canopy revealing logging tracks and extraction routes. The stocking is about 35 m^3/ha (4 717 Hsl ft/ac). It is confined to the places where large companies are felling the forest.

Type G(L): Low-stocked, logged mixed forest on moderate to steep short slopes

Selective logging using bullocks for timber extraction has left only slight scars in the canopy. The stocking is 30-50 m^3/ha (4 043 - 6 738 Hsl ft/ac) and some of the commercially valuable species are still present. It occurs mainly on the south coast of Viti Levu.

Type C1(L): Moderately stocked, logged mixed forest on moderate to steep short slopes

Deeper into the forest the process of selective logging is not so far advanced. The stocking is 80 m^3/ha (10 781 Hsl ft/ac) and most of the commercial species are present. It covers a limited area on the south coast of Viti Levu.

Type GB(L): Moderately stocked logged buabua forest

Selective logging in forest type GB has removed some *buabua* (*Fagraea gracilipes*). The canopy is only slightly damaged and the stocking is 60 m^3/ha (8 08(Hsl ft/ac). The type covers a limited area in the Narailangi catchment in Vanua Levu.

3. CLOSED CANOPY LOW-HEIGHT MIXED SPECIES FOREST

On the aerial photographs the canopy has a uniform fine-grained appearance. The types usually occur at the forest margin.

Type BE: Beach forest

This lies just above the high tide level inland from the mangrove area. Common species are *ivi* (*I. fagiferus*), *lauci* (*Aleurites moluccana*), *dilo* (*Calophyllum inophyllum*) and *tavola* (*Terminalia* spp.). The type has not been enumerated but occurs in small pockets along the coast.

Type G2: Low-stocked mixed forest on moderate to steep short slopes

This type is similar to type S, has a stocking of 12 m^3/ha (1 617 Hsl ft/ac) and is limited to the Londoni catchment on Viti Levu's east coast.

Type J: Low-stocked fringe forest

Usually on gentle or moderate slopes this type occurs at the edge of the forest and represents a further stage in secondary regrowth after type S. A high proportion of the species booked as 'others' occurs, including *mako* (*Trichospermum* spp.), *bo* (*N. forsteri*) and *vavaloa* (*Degeneria*

vitiensis). The timber species are *kauvula* (*Endospermum macrophyllum*), *sa* (*Parinari insularum*) and kaudamu (*Myristica* spp.). The stocking ranges from 7 to 25 m^3/ha (943 - 3 369 Hsl ft/ac) with an average of 15 m^3/ha (2 021 Hsl ft/ac). The type is widespread in Viti and Vanua Levu in catchments that include grassland vegetation.

Type K: Low-stocked intermediate dry-zone fringe forest

This type is similar to type J, but occurs where there is a distinct dry season. The stocking is higher than for type J, being about 30 m^3/ha (4 043 Hsl ft/ac). The type is confined to the western end of the south coast of Viti Levu.

4. MIXED SPECIES FOREST WITH MODERATE OR HIGH STOCKING

The 'texture' of the crowns on the aerial photographs is an indication of the stocking: forest with a coarse texture, indicating large emergent crowns, has a good stocking while fine texture indicates moderate stocking. It must be pointed out that this is by no means an infallible guide and the airphoto interpretation has to be supported by fieldwork.

Type C1: Well stocked mixed forest on moderate to steep short slopes

The type is indicated on the aerial photographs by a coarse texture. The slopes are moderate to steep but short. Common species are *damanu* (*Calophyllum vitiense*), *kauvula* (*Endospermum macrophyllum*), *yasiyasi* (Myrtaceae), *kaudamu* (*Myristica* spp.) and *dakua makadre* (*Agathis vitiensis*). The stocking is 75-100 m^3/ha (10 107 - 13 476 Hsl ft/ac) and the type is widespread in Fiji, being the type covering the largest enumerated area (82 000 ha, 203 000 ac).

Type C2: Well stocked mixed forest on flat to gentle slopes

The flatness of the topography and the presence of the emergent flat-crowned *kauvula* (*E. macrophyllum*) give this type a rather even canopy lacking in texture. Apart from *kauvula* common species are *kaudamu* and other species that occur in type C1, except *dakua makadre* (*A. vitiensis*). The stocking is 80-120 m^3/ha (10 781 - 17 171 Hsl ft/ac).

Type G: Moderately stocked mixed forest on moderate to steep short slopes

On the aerial photograph the texture is finer than for C1 forest. The species composition is similar to C1 but 'others' (consisting of the species listed as 'others' in type J) and *sa* (*Parinari insularum*) and *kauvula* have higher stockings. The overall stocking is 40-80 m^3/ha (5 390 - 10 781 Hsl ft/ac) and the type is common in Viti and Vanua Levu.

Type E: Moderately stocked mixed forest on flat to gentle slopes

The species composition is similar to that for type C1 but stocking is much lower, varying from 50 to 80 m^3/ha (6 738 - 10 781 Hsl ft/ac). It occurs over a limited area in the Rewa and Navua Catchment Groups of Viti Levu.

5. FOREST OF GYMNOSPERM ASSOCIATIONS

These types usually show a fine texture on the aerial photographs, and are extrapolated through similarities in topography rather than through recognition of tree species on the aerial photographs. However, *dakua makadre* can be recognised on the photographs when the crown is developed above the surrounding forest canopy. The types are further subdivided into:

a. *yaka* associations
b. *dakua makadre* associations
c. *dakua salusalu* associations.

5a. YAKA ASSOCIATIONS

Type GD: Moderately stocked velau-yaka dry-zone forest

The type occurs in areas of low relief with short steep slopes. Common species are *velau* (*C. nodiflora*) and *yaka* (*D. elatum*) on the ridge and upper slopes with broadleaved species such as *sa* (*P. insularum*), *damanu* (*C. vitiense*) and *yasiyasi* (Myrtaceae) on the middle and lower slopes. The stocking is about 55 m^3/ha (7 412 Hsl ft/ac) and the type occurs in the Wainunu, Sarowangga and Nasavu catchments of Vanua Levu.

Type HS: Low-stocked sacau-yaka forest

This type occurs on gentle or moderate slopes of dissected plateau surfaces confined to the Wainikovu catchment in Viti Levu. The type consists of a low forest of *sacau* (*Palaquium hornei*) and *yaka* (*D. elatum*) with a stocking of 40 m^3/ha (5 390 Hsl ft/ac).

5b. DAKUA MAKADRE ASSOCIATIONS

In the following 5 types occasional emergent crowns of *dakua makadre* can be recognised on the aerial photographs.

Type CDK: Well stocked dakua makadre forest on flat to gentle slopes

This forest occurs on a recently uplifted mature river system at low elevation (below 152 m, 500 ft). Occurring with the *dakua makadre* (*A. vitiensis*) are *kaudamu* (*Myristica* spp.) and *yasiyasi* (Myrtaceae). The stocking is 100 m^3/ha (13 476 Hsl ft/ac) and the type occurs in the Navonu catchment, Vanua Levu.

Type SK: Moderate to well stocked sacau-yaka forest

This type occurs on moderate or steep slopes at intermediate or high elevation. Species include *dakua makadre* (*A. vitiensis*), *sacau* (*Palaquium hornei*) and a small proportion of *yaka* (*D. elatum*). The stocking, which ranges from 40 to 100 m^3/ha (5 390 - 13 476 Hsl ft/ac) tends to be higher in Vanua Levu. The type occurs in the Coastal West Central and Coastal East Central Catchment Groups in Vanua Levu and the Sovi and Wainimala catchments in Viti Levu.

Type DM: Well stocked dakua makadre forest at high elevation on steep slopes

This forest is confined to the Nandarivatu Plateau in central Viti Levu at an elevation of 914 m (3 000 ft). It consists of almost pure stands of *dakua makadre* (*Agathis vitiensis*) with some *damanu* (*C. vitiense*) and *kauvalu* (*E. macrophyllum*). The stocking ranges from 35 to 62 m^3/ha (4 717 - 8 355 Hsl ft/ac).

Type GDK: Moderately stocked dakua makadre forest on steep slopes at high elevations

The elevation ranges from 450 to 600 m (1 476 - 1 969 ft) mn the Lambasa catchment in Vanua Levu, to 750-900 m (2 460 - 2 953 ft) on the Nandarivatu Plateau of Viti Levu. The species composition includes less *dakua makadre* (*A. vitiensis*) than type DM and more of the broadleaved species such as *kauvula* (*E. macrophyllum*) and *yasiyasi* (Myrtaceae). The stocking is 50-80 m^3/ha (6 738 - 10 781 Hsl ft/ac).

Type DK: Moderately stocked dakua-yaka forest on undulating country

This is another high elevation *dakua makadre* forest type differentiated from the previous two by the finer texture of the crowns on the photographs. It occurs on the Wainunu Plateau at 450 m (1 476 ft) and on the Nandrau Plateau at 914 m (3 000 ft). The stocking is 45 m^3/ha (4 717 Hsl ft/ac) in the Wainunu catchment of Vanua Levu. The type has not been enumerated in the Nandrau Plateau.

5c. DAKUA SALUSALU ASSOCIATIONS

These types are recognised on the aerial photographs by the light grey tone and smooth 'texture' of the tree canopy.

Type DS: Well stocked dakua makadre and salusalu forest on steep slopes

The slopes are short but steep with low relief, occurring on dissected plateau surfaces. Common species, apart from those mentioned in the heading, are *damanu*, *yasiyasi* and *kaudamu*. The stocking is 80-110 m^3/ha (10 781 - 14 824 Hsl ft/ac). The type occurs mainly in the Coastal West Central, Coastal East Central and Ndreketi South Catchment Groups of Vanua Levu and to a limited extent in Viti Levu.

Type DS2: Moderately stocked dakua makadre and salusalu forest on gentle to moderate slopes

Similar in species composition, but with a lower stocking than type DS, this type occurs on less steep slopes. The stocking is 40 m^3/ha (5 390 Hsl ft/ac) and the type is limited to the Wainunu and Seangganga catchments in Vanua Levu.

6. FOREST OF VELAU ASSOCIATIONS

Pure stands of *velau* (*Casuarina nodiflora*) can be recognised on the air photographs by the whorled appearance of the crowns. Forest types with *velau* are usually distinguished by a dark tone and fine texture.

Type V: Velau woodland

This occurs at the forest margin on flat or gently undulating country and on the tops of ridges in steep country in the dry climatic zones of both islands. Associated with *velau* (*C. nodiflora*) are *yasiyasi* (Myrtaceae), *sasauwira* (*D. richii*), *kaudamu* (*Myristica* spp.) and *kauvula* (*Endospermum* spp.). The stocking is 50 m^3/ha (6 738 Hsl ft/ac). Characteristic dry-zone species occur in the understorey, such as *qumu* (*Acacia richii*), *yaka* (*D. elatum*), *buabua* (*Fagraea gracilipes*), *laubu* (*Garcinia myrtifolia*) and *kaukaro* (*Semicarpus vitiensis*).

Type VB: Moderately stocked velau-buabua forest

This type occurs in the Ndreketi catchment where the slopes are gentle to moderate. Common species include *velau* (*C. nodiflora*), *buabua* (*Fagraea gracilipes*) and *sasauwira* (*D. richii*). The stocking varies from 40 to 70 m^3/ha (5 390 - 9 433 Hsl ft/ac).

Type VF: Low-stocked velau-vesi forest

This species association has been mapped in Ndrawa catchment, Vanua Levu, where it occurs on gentle to moderate slopes in country of low relief. As well as *velau* (*C. nodiflora*) and *vesi* (*Intsia bijuga*), *sa* (*Parinari insularum*) and *kaunicina* (*Canarium* ap.) are common species.

Type GV: Moderately stocked kaudamu-velau forest on moderate to steep, short slopes

The slopes are not so steep and appear more rounded than in types C1 or G. Common species are *kaudamu* (*Myristica* spp.), *velau* (*C. nodiflora*), *sa* (*Parinari insularum*), *dakua makadre* (*A. vitiensis*) and *yasiyasi* (Myrtaceae). The stocking is 60 m^3/ha (8 086 Hsl ft/ac). This type occurs down the north-west side of Vanua Levu where there is a marked dry season and to a limited extent in south-west Viti Levu. The area of this type covered by the enumeration is 20 000 ha (49 420 ac).

Type GV(L): Moderately stocked kaudamu-velau forest on river valleys

This type is similar to GV but has a higher stocking of *vesi* (*Intsia bijuga*). It occurs in the Ndreketi, Wainunu and Kumbulau catchments of Vanua Levu.

Type GV(H): Moderately stocked kaudamu-velau forest on hillsides and ridges

This type is similar to GV but confined to hillsides and ridges. The stockings of *vesi* (*I. bijuga*) and *damanu* (*C. vitiense*) are higher. It is confined to the Ndreketi and Kumbulau catchments in Vanua Levu.

7. FOREST OF SACAU ASSOCIATIONS

These types have a fine texture of crowns on the aerial photographs, even when stocking is good as in type CY. This is because the tree crowns are packed tightly, with few emergents, as is illustrated in Profile Diagram 4.

Type CY: Well stocked sacau forest

This type occurs on upper slopes and ridges of dissected plateau surfaces. Species include *sacau* (*Palaquium hornei*), *damanu* (*Calophyllum vitiense*), *dakua makadre* (*A. vitiensis*), *kauvula* (*E. macrophyllum*), *kaudamu* (*Myristica* spp.) and *yasiyasi* (Myrtaceae). The stocking ranges from 60 to 150 m^3/ha (8 086 - 20 214 Hsl ft/ac) with an average of 115 m^3/ha (15 497 Hsl ft/ac) and the type is found mainly in the Navua and Rewa Catchment Groups of Viti Levu and in south-west Vanua Levu.

Type GY: Moderately stocked sacau forest

It occurs in similar topography to that associated with type CY, but at higher elevations. The stocking is 70 m^3/ha (9 433 Hsl ft/ac) and the type is confined to small areas in the Navua basin in Viti Levu and south-west Vanua Levu.

Type SV: Low-stocked sacau-velau forest

This unusual species composition occurs in the Wailevu catchment, Vanua Levu, on moderate sloping foothills. The stocking is 74 m^3/ha (9 972 Hsl ft/ac).

8. OTHER SPECIES ASSOCIATIONS

These types are difficult to distinguish on the aerial photographs. Type KV has a pale tone, and, where the canopy is open, the *kauvula* crowns can be distinguished. Type GB is distinguished by a 'bright' light grey tone. Types VS and KD are indistinguishable in airphoto pattern from type G. Type RT has fluffy dark grey crowns on the photographs and type DR has a pale uniform tone.

Type KV: Moderately stocked kauvula-sa forest

Forest dominated by *kauvula* (*Endospermum macrophyllum*) is found on gentle to moderate slopes on the Nandarivatu Plateau and on short steep slopes with low relief in the Rewa basin. Predominant species are *kauvula, sa* (*Parinari insularum*) and *kaudamu* (*Myristica* spp.). The stocking ranges from 30 to 70 m^3/ha (4 043 - 9 433 Hsl ft/ac).

Type GB: Moderately stocked buabua forest

Buabua forest occurs on the moderate or gentle slopes that are found in the Ndrekiti basin on the dry north-west side of Vanua Levu. *Buabua* (*Fagraea gracilipes*), *kaudamu* (*Myristica* spp.) and *yasiyasi* (Myrtaceae) are the common species. The stocking ranges from 75 to 130 m^3/ha (10 107 - 17 519 Hsl ft/ac) but 25% of the trees are between 35 and 40 cm d.b.h.

Type VS: Moderately stocked vesi forest

Pure stands of *vesi* (*Intsia bijuga*) occur on lower slopes near creeks or on rocky sites. The type is widespread in Vanua Levu but difficult to recognise on aerial photographs so it has been mapped in two small areas only in Vanua Levu. The stocking of *vesi* is 25 m^3/ha (3 369 Hsl ft/ac) and the total stocking is 46 m^3/ha (6 199 Hsl ft/ac).

Type RT: Raintree woodland

A woodland of pure raintree (*Samanea saman*) is found on flat areas and lower slopes, often invading inland from coconut plantations. It occurs in small areas on the dry side of Vanua Levu and the southern shore of Natewa Peninsula and in the intermediate and dry zones of Viti Levu.

Type KD: Moderately stocked kaudamu forest

This type has been mapped on gentle to moderate slopes in the Mbua catchment of north-west Vanua Levu. The type consists of stands of almost pure *kaudamu* (*Myristica* spp.), but *yasiyasi* (Myrtaceae) and *bau* (Sapotaceae) are found with it.

Type DR: Sapindaceae pole forest

Steep hillsides of north-east Vanua Levu and level hilltops in Kandavu have a pole forest of Sapindaceae species. In Vanua Levu the species are *Aryterya brackenridge, velau* (*C. nodiflora*) and *cevua* (*Vavaea amicorum*). In Kandavu the species are *drausasa* (*Ellatostachys falcata*) and *sasauwira* (*D. richii*). The stocking in Kandavu is 32 m^3/ha (4 312 Hsl ft/ac).

9. PROTECTION FOREST ON VERY STEEP SLOPES

With the exception of type S1, which has a partially closed canopy cover, the types are separated by differences of landform rather than by the appearance of the forest cover.

Type B: Ridge thicket

This is confined to the summit of knife-edge ridges. Species are *yasiyasi* (Myrtaceae) poles and occasional large trees and damanu (*Calophyllum* spp.). The stocking is variable because only small areas have been sampled in any catchment. The type is widespread but difficult to map because it occurs in long thin strips at the crest of every ridge.

Type BS: Low stocked forest on very steep or precipitous slopes

This consists of steeper slopes than occur in type CS and includes escarpments. On scree slopes *salato* (*Laportea harveyi*), *mako* (*Trichospermum richii*), *sasauwira* (*D. richii*) and *koka* (*Bischofia javanica*) are found. *Vuga* (*Metrosideros collina*), as its botanical name implies, often occurs on rocky peaks and escarpments. The stocking is 15 to 30 m^3/ha (2 021 - 4 043 Hsl ft/ac) and the occurrence of this type is widespread.

Type CS: Moderately stocked forest on long, very steep slopes

The landform is a pattern of ridges with very steep sides radiating from a high hill mass. Species include *damanu* (*Calophyllum* spp.) *kaudamu* (*Myristica* spp.), *yasiyasi* (Myrtaceae) and *kauvula* (*E. macrophyllum*) with similar species to BS on the scree slopes. The stocking ranges from 30 to 100 m /ha (4 043 - 13 476 Hsl ft/ac) with an average of 60 m^3/ha (8 086 Hsl ft/ac). This kind of landform occurs towards the watershed in many catchments. 40 000 ha (98 840 ac) have been enumerated.

Type GDS: Low-stocked dry-zone forest on long, very steep slopes

This type is similar to type CS in landform and has been differentiated on grounds of climate, occurring where there is a long dry season. Species composition includes *velau* (*C. nodiflora*), *yasiyasi* (Myrtaceae), *dakua makadre* (*A. vitiensis*) and *damanu* (*Calophyllum* spp.). The stocking ranges from 20 m^3/ha (2 695 Hsl ft/ac), where the forest has been logged near cultivated land, to 70 m^3/ha (9 433 Hsl ft/ac) where it is inaccessible. It occurs along the chains of hills that lie just inland from the coast in north-east Vanua Levu.

Type GS: Low-stocked forest on short, very steep slopes

This type occurs on a herring-bone landform pattern in rugged country at the source of some rivers. On the ridges *yasiyasi* (Myrtaceae), *damanu* (*Calophyllum* spp.) and kaudamu (*Myristica* spp.) occur and on the very steep slopes the same species as occur in the scree in type BS are found. The stocking is 20 to 50 m^3/ha (2 695 - 6 738 Hsl ft/ac). The type occurs in central Viti Levu and south-west Vanua Levu.

Type S1: Low-stocked open canopy woodland on very steep slopes

The canopy is partially closed. The species are mostly 'others' including *tarawau* (*Dysoxylum* spp.), *makosoi* (*Cananga odorata*), *doi* (*Alphitonia* spp.) *vota* (*Geissos ternata*), *salato* (*Laportea harveyi*) and *yaro* (*Premna taitensis*). The stocking is low, being usually less than 30 m^3/ha (4 043 Hsl ft/ac). The type occurs on the escarpments around the Nandarivatu Plateau and is widespread in Vanua and Viti Levu.

MANAGEMENT CATEGORIES

The forest types that have been mapped are grouped into management categories, as shown in Table 7.

TABLE 7 Management categories of forest types

Map symbol	Forest type	Enumerated area	
		ha	ac
	NON-COMMERCIAL FOREST		
BE	Beach forest		
DR	Sapindaceae pole forest	264	652
GD	Moderately stocked *velau-yaka* dry-zone forest	2 238	5 530
G2	Low-stocked mixed forest on moderate to steep short slopes	2 308	5 703
G(L)	Low-stocked, logged mixed forest on moderate to steep short slopes	3 060	7 561
H	Logged-out forest	10 886	26 899
HS	Low-stocked *sacau-yaka* forest	1 592	3 934
J	Low-stocked fringe forest	17 315	42 785
K	Low-stocked intermediate dry-zone fringe forest	2 859	7 065
KF	Low-stocked blocks of forest in grassland	1 431	3 536
P	Low-stocked old orchard *dawa-ivi* forest	3 457	8 542
RT	Raintree woodland	140	346
S	Low-stocked open woodland	11 283	27 880
V	*Velau* woodland	2 814	6 953
VB	Moderately stocked *velau-buabua* forest	1 471	3 635
VF	Low-stocked *velau-vesi* forest	592	1 463
	PRODUCTION FOREST		
C1	Well stocked mixed forest on moderate to steep short slopes	82 266	203 279
C1(L)	Moderately stocked, logged mixed forest on moderate to steep short slopes	1 543	3 813
C2	Well stocked mixed forest on flat to gentle slopes	4 628	11 436
CDK	Well stocked *dakua makadre* forest on flat to gentle slopes	770	1 903
CY	Well stocked *sacau* forest	12 658	31 278
DK	Moderately stocked *dakua-yaka* forest on undulating country	1 661	4 104
DM	Well stocked *dakua makadre* forest at high elevation on steep slopes	695	1 717
DS	Well stocked *dakua makadre* and *salusalu* forest on steep slopes	17 974	44 414
DS2	Moderately stocked *dakua makadre* and *salusalu* forest on gentle to moderate slopes	788	1 947
E	Moderately stocked mixed forest on flat to gentle slopes	1 402	3 464

TABLE 7 (continued)

Map symbol	Forest type	Enumerated area	
		ha	ac
G	Moderately stocked mixed forest on moderate to steep short slopes	55 269	136 570
GB	Moderately stocked *buabua* forest	2 022	4 996
GB(L)	Moderately stocked, logged *buabua* forest	277	684
GDK	Moderately stocked *dakua makadre* forest on steep slopes at high elevations	4 376	10 813
GV	Moderately stocked *kaudamu-velau* forest on moderate to steep short slopes	20 824	51 456
GV(L)	Moderately stocked *kaudamu-velau* forest on river valleys	3 123	7 717
GV(H)	Moderately stocked *kaudamu-velau* forest on hillsides and ridges	1 115	2 755
GY	Moderately stocked *sacau* forest	1 060	2 619
KD	Moderately stocked *kaudamu* forest	187	462
KV	Moderately stocked *kauvula-sa* forest	10 293	25 434
SK	Moderately to well stocked *sacau-yaka* forest	7 928	19 590
SV	Low stocked *sacau-velau* forest	1 273	3 146
VS	Moderately stocked *vesi* forest	95	235
	PROTECTION FOREST		
B	Ridge thicket	2 523	6 234
BS	Low stocked forest on very steep or precipitous slopes	9 972	24 641
CS	Moderately stocked forest on long, very steep slopes	44 641	110 308
GDS	Low stocked dry-zone forest on long, very steep slopes	2 890	7 141
GS	Low stocked forest on short, very steep slopes	13 983	34 552
SI	Low stocked open canopy woodland on very steep slopes	17 176	42 442

NON-COMMERCIAL FOREST TYPES

Type BE: Beach forest

Airphoto appearance Patches of forest located near the coast with a continuous smooth grey airphoto pattern are included in this type. Beach forest occurs inland of mangrove areas and has not the uniformity of texture and tone that makes mangrove so easy to recognise on aerial photographs.

Topography The type occurs on flat* ground inland of the beach or mangrove and extends up rocky slopes bordering on the coast.

Species composition and stocking Prominent species are *ivi* (*Inocarpus fagiferus*), *lauci* (*Aleurites moluccana*), *dilo* (*Calophyllum inophyllum*), *tavola* (*Terminalia catappa* and *T. litoralis*), *vau* (*Hibiscus tiliaceus*), *vesi* (*Intsia bijuga*), *vesiwai* (*Pongamia pinnata*), *vutuwai* (*Barringtonia speciosa*) and *evuevu* (*Hernandia peltata*).

No enumeration has been carried out in this type so no stocking figures are available, but the forest is not well stocked. In most accessible places *dilo* and *vesi* have been removed for their valuable timber. The stocking of this type in an inaccessible part of the group would be comparable with type J.

Structure and height The upper canopy is closed at about 12 m (39 ft) height with a few isolated emergents. The trees are short-boled and often crooked. *Vau*, *Pandanus* and other shrubs may form an understorey.

Location and extent Beach forest occurs in the coastal catchments of all 3 islands. It is not extensive because most sites have been converted to coconut plantations.

*In this section of the Study topography is defined as follows:

flat :	$<1^{o}$
gentle :	1^{o} - 10^{o}
moderate :	10^{o} - 20^{o}
steep :	20^{o} - 30^{o}
very steep :	$>30^{o}$

Type DR: Sapindaceae pole forest

Airphoto appearance The type can be recognised on the photographs by a continuous very light grey tone with a smooth fine grain.

Topography It occurs on steep hillsides in Vanua Levu and on level hill tops in the eastern part of Kandavu.

Species composition and stocking In the Nggawa and Nayarambale catchments the vegetation consists of almost pure *Aryterya brackenridgei* associated with *velau* (*Casuarina nodiflora*), *kaudamu* (*Myristica* spp.) and *cevua* (*Vavaea amicorum*). In Kandavu the predominant species is *drausasa* (*Ellatostachys falcata*) associated with *mala* (*Dysoxylum* sp.) and occasional *kauvula* (*Endospermum macrophyllum*). In Kandavu the stocking is 32 m^3/ha (4312 Hsl ft/ac) (trees over 35 cm d.b.h.). The type was not enumerated in Vanua Levu.

Structure and height The forest reaches a height of 13 m (43 ft) with a closed canopy. In Vanua Levu most of the trees are between 10 and 20 cm (4 and 8 in) diameter but in Kandavu they are bigger with a few emergents of *mala* (*Dysoxylum* sp.) appearing above the narrow-crowned main canopy.

Location and extent On Vanua Levu this type occurs on steep hillsides in the Nggawa, Nayarambale and Wainikoro catchments covering an area of 605 ha (1 495 ac). In Kandavu it occurs on the extreme eastern hill range covering an area of 264 ha (652 ac).

Type GD: Moderately stocked *velau-yaka* dry-zone forest

Airphoto appearance: The type can be distinguished on the photographs by its fine grain caused by small crowns and pale tone.

Topography In the Nasavu catchment this type occurs on short steep slopes with no great rise in elevation from the main river to the watershed. It occurs on red-yellow podsolic soils overlying flows and tuffs of rhyollite to dacite. In the Wainunu and Sarowangga catchments it occurs on moderate slopes, particularly on high plateaux.

Species composition and stocking Stocking of trees over 35 cm d.b.h. is 55 m^3/ha (7 412 Hsl ft/ac) but, because much of this is made up of species that are not used for sawmilling, the type is put into the non-commercial class for management. The volume of *velau* (*Casuarina nodiflora*) is reflected in the high figure for 'others' of 10 m^3/ha (1 348 Hsl ft/ac). Common species are *sa* (*Parinari insularum*) (8 m^3/ha, 1 078 Hsl ft/ac), *damanu* (*Calophyllum vitiense*) (6 m^3/ha, 809 Hsl ft/ac), *yasiyasi* (Myrtaceae) and *Kauvula* (*Endospermum macrophyllum*). *Yaka* (*Dacridium elatum*) does not contribute much to the stocking except in the Wainunu catchment, but is very noticeable on the ground.

Structure and height Along the ridges *velau* and *yaka* form a woodland of short-boled trees with a closed upper canopy of about 16 m (52 ft) height. On the steep-sided slopes a mixed broadleaved forest grows with a partially closed canopy and the clear boles of the upper storey trees rarely exceed 10 m (33 ft) in length.

Location and extent This type has been enumerated in the Nasavu catchment at the north-east end end of Vanua Levu and in the Wainunu and Sarowangga catchments in the south-west. It also occurs in the Mbua and Ndama catchments. It covers an area of 2 200 ha (5 436 ac) of which 1 600 ha (3 954 ac) are in the Nasavu catchment.

Type G2: Low-stocked mixed forest on moderate to steep short slopes

This type has a similar appearance to type G on the ridges but a more open canopy on the middle and lower slopes. The species composition includes *Kauvula* (*Endospermum macrophyllum*), *Kaudamu* (*Myristica* spp.) and 'others', but the stocking is very low (*kauvula* 2 m^3/ha 270 Hsl ft/ac) and *kaudamu* 1 m^3/ha (135 Hsl ft/ac). The overall stocking trees of over 35 cm d.b.h. is 12 m^3/ha (1 617 Hsl ft/ac), which is similar to the stocking for type S or J. The type covers an area of 2 308 ha (5 720 ac) in Londoni catchment of Tailevu catchment group in eastern Viti Levu.

Type G(L): Low-stocked, logged mixed forest on moderate to steep short slopes

Airphoto appearance The appearance of this type is similar to that found in type G but occasional gaps in the cover or narrow tracks spreading out from the ridges are visible.

Topography The definition of the slopes for type G applies to this type.

Species composition and stocking The species composition in the Navua-Singatoka coastal strip consists of *kaudamu* (*Myristica* sp.) (8 m^3/ha, 1 078 Hsl ft/ac), 'others' (6 m^3/ha, 809 Hsl ft/ac), *yasiyasi* (Myrtaceae) (5 m^3/ha, 674 Hsl ft/ac), *sa* (*Parinari insularum*) (4 m^3/ha, 539 Hsl ft/ac), *kauvula* (*Endospermum macrophyllum*) (2 m^3/ha, 270 Hsl ft/ac), *bauvudi* (*Palaquium* sp.) (2 m^3/ha, 270 Hsl ft/ac), and *bau* (*Sapotaceae*) (2 m^3/ha, 270 Hsl ft/ac). The overall stocking is 30-50 m^3/ha (4 043 - 6 738 Hsl ft/ac, trees over 35 cm d.b.h.). This type is similar in species composition and stocking to type H. The main difference is that type G(L) is the result of the continuous process of selective logging usually with bullock extraction that has occurred along the south coast of Viti Levu for the past 60 years.

Structure and height The structure is similar to type G with a closed canopy and a height of the main storey trees at 25 m (82 ft). Gaps occur where trees have been removed but the logging tracks, unlike most of type H, do not open the canopy.

Location and extent The main occurrence of this type is on the Navua-Singatoka coastal strip, where it occurs adjacent to the grasslands and on the middle slopes of the hills that run down to the coast.

Type H: Logged-out forest

Airphoto appearance Extraction by means of caterpillar tractor leads to the destruction of the forest canopy and creation of tracks and roads that are clearly visible on the aerial photographs. Logging with teams of bullocks (see Plate 1) is more difficult to recognise because the logging tracks are narrow and do not disturb the upper canopy and because the logging is selective. The airphoto appearance of this form of exploitation can be recognised by the uneven canopy 'texture' and by a certain 'baldness' on the ridges, where short lengths of logging track show as straight, narrow slits in the canopy.

Topography Logging operations by large-scale concession holders are carried out over coupes allocated by the Forest Department. These exclude the steepest slopes but are not limited by topographic features in any other way. Bullock logging is limited to the easy lands near the edge of the forest. This is due to the fact that bullocks cannot haul logs up very steep slopes or very far.

Species composition and stocking Logged forest does contain some timber volume because commercially unacceptable species have been left uncut and because pockets of good forest beyond the range of existing access roads have not been felled. 'Others' with a stocking of 4 to 7 m^3/ha (539-943 Hsl ft/ac) and the high incidence of *sa* (*Parinari insularum*) are examples of the former situation whereas the stocking of *Kaudamu* (*Myristica* spp.) of 3 to 11 m^3/ha (404-1 482 Hsl ft/ac) is an indication of the latter. Because the purpose of the survey was to find the standing volume of timber rather than to check the effectiveness of the felling, logged-out forest has been sampled only marginally. The stocking of logged-out forest is about 35 m^3/ha (4 717 Hsl ft/ac) of trees over 35 cm d.b.h.

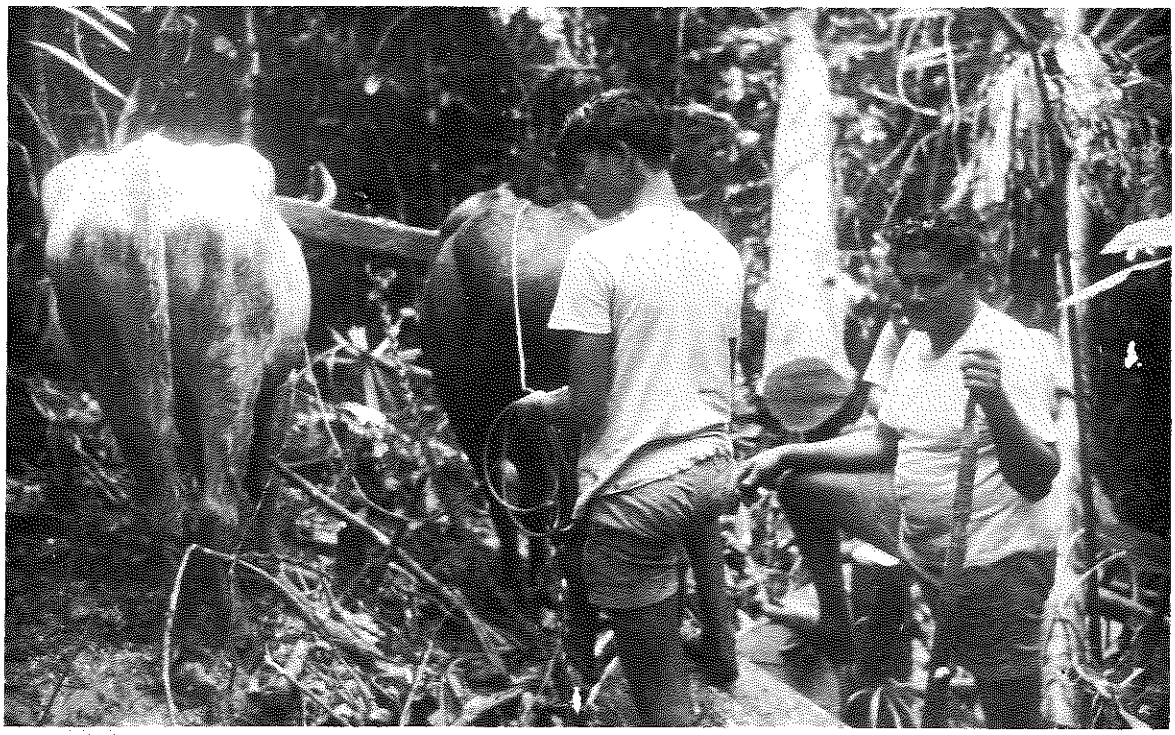


PLATE 1 Bullocks pulling out a small log. Tailevu felling area, Viti Levu

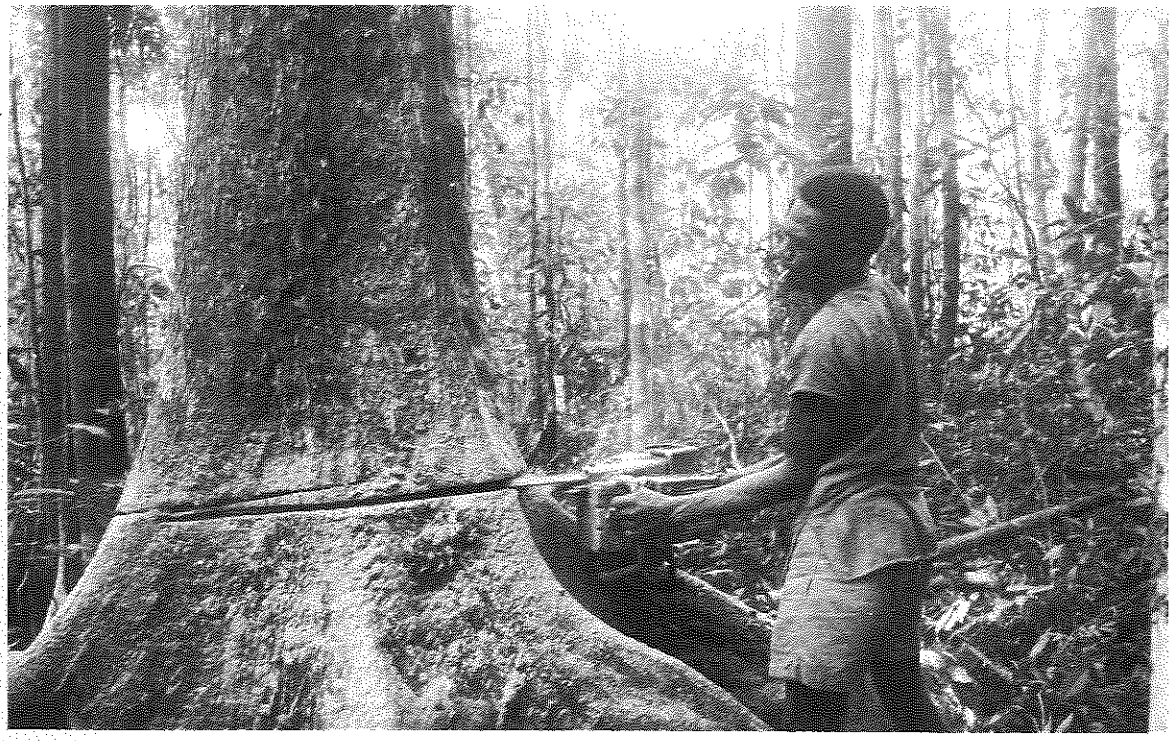


PLATE 2 Felling *kaudamu* (*Myristica* sp.) with a chain saw. Tailevu felling area, Viti Levu

Structure and height. In forest that has been subjected to large-scale commercial exploitation the multistoreyed nature of the canopy has been destroyed. Isolated trees that have, for reasons of defect or unsuitability as saw timber, been left standing have shattered crowns. Much of the understorey has gone, either because a tree crown has been dropped on it, or because the logs have been hauled out over it. By contrast, logging with bullocks does less damage to the remaining forest. This is because the logging is selective, involving the choice of the trees that are wanted and are small enough for the bullocks to drag. A bullock requires a much narrower track through the forest than a caterpillar tractor.

Location and extent Exploitation of the forest by companies with heavy logging equipment was observed during fieldwork at Namboutini, Ngaloa, Tailevu, Nandarivatu and the Nausori Highlands in Viti Levu and at Koroutari, Sasa and Mbutha Bay in Vanua Levu. On Kandavu the middle part of the island is currently being exploited (1969). At the same time small owners with bullocks and light equipment are eating into the forest margin to supply some 40 sawmills with small-sized logs.

The inventory has sampled very little of the area felled-over by large sawmilling enterprises because the boundary of the exploited forest is clearly defined on the photographs. However, it is not possible to exclude the parts of the forest that have been subjected to a process of steady creaming by the small operators. A total area of 10 886 ha (26 899 ac) has been sampled of which 5 000 ha (12 355 ac) occur in the Suva-Navua coastal strip.

Type HS: Low-stocked *sacau-yaka* forest

Airphoto appearance Under the stereoscope this type has a smooth texture and pale tone, recognisable tree crowns being confined to the bottoms of stream valleys.

Topography The area in which this forest type occurs is made up of gentle to moderate short slopes. The general landform has the appearance of a dissected plateau surface.

Species composition and stocking *Sacau* (*Palaquium hornei*), a heavy hardwood with a limited timber market, has a stocking of 10 m^3/ha (1 348 Hsl ft/ac). Other trees with a stocking ranging from 5 down to 2 m^3/ha (674-270 Hsl ft/ac) are *kauvula* (*Endospermum macrophyllum*), *damanu* (*Calophyllum vitiense*), *sa* (*Parinari insularum*), *mavota* (*Gonystylus punctatus*), *kaudamu* (*Myristica* spp.), *yasiyasi* (Myrtaceae), *dakua makadre* (*Agathis vitiensis*) and *yaka* (*Dacrydium elatum*). *Yaka* is used in naming the type because of the many *yaka* poles that occur, mostly on the ridges, by which the forest type can be recognised in the field. *Pandanus* is common in the understorey.

The stocking of trees over 35 cm d.b.h. is 38 m^3/ha (5 121 Hsl ft/ac). The type is put into the non-commercial category because of the high proportion of trees in species group 5 (10 m^3/ha 1 348 Hsl ft/ac) and the high proportion of *sacau*.

Structure and height The forest has an open or partially closed canopy with a top height of 20 m (65 ft). On the ridges the trees are shorter with a dense tangle of creepers. Accumulation of humus at the base of the *yaka* and *sacau* trees has given rise to a mass of roots around the foot of the tree growing in the raw humus, which catches the feet and makes walking difficult.

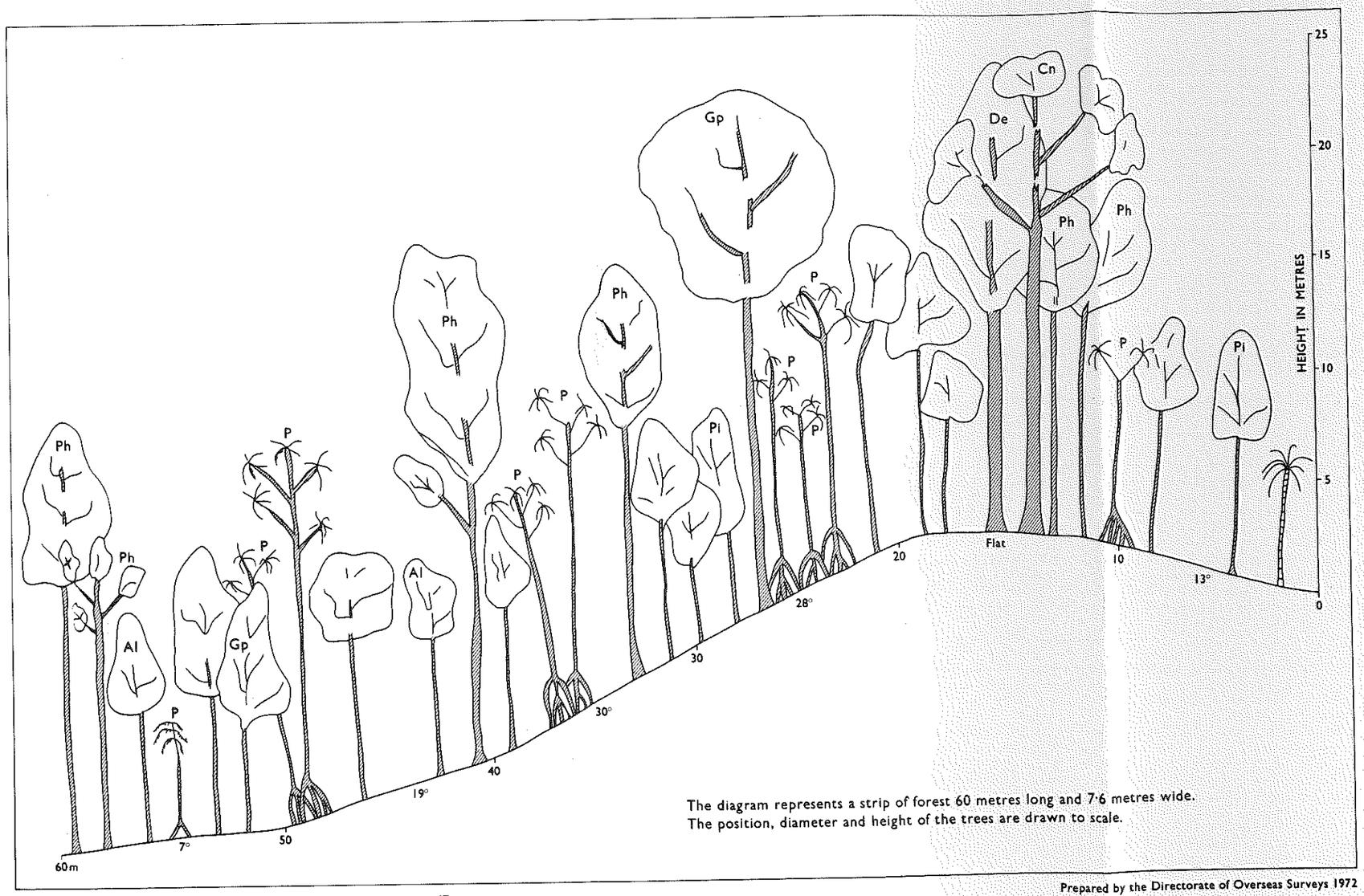
Location and extent The type is confined to the Wainikovu catchment of the Navua catchment group where it covers an area of 1 600 ha (3 954 ac). It has affinities with type SK and probably represents a poorly stocked variation of the same type.

Type J: Low-stocked fringe forest

Airphoto appearance The type is recognised on the aerial photographs by the fine texture of the tree crowns that look like the bristles of a brush.

Topography. It is not confined to a particular landform although it usually occurs on gentle or moderate slopes adjacent to cultivation or grassland.

Profile Diagram 1
Forest type HS.
Low stocked Sacau-yaka forest.



The diagram represents a strip of forest 60 metres long and 7·6 metres wide.
The position, diameter and height of the trees are drawn to scale.

EXPLANATION

	SCIENTIFIC NAME	FIJIAN NAME
A	Annonaceae	qereqaqa
Ag	Aglaia sp.	
Al	Alphitonia sp.	doi
Av	Alstonia vitiensis var. vitiensis	
Be	Barringtonia edulis	vutu
Bi	Bischofia javanica	koka
C	Canarium sp.	
Cn	Casuarina nodiflora	velau
Cv	Calophyllum vitiense	damanu
Db	Dillenia biflora	kuluva
De	Dacridium elatum	yaka
Dy	Dysoxylum richii	sasauwira
E	Endiandra sp.	damabi
Fg	Fagraea gracilipes	buabua
Fi	Ficus sp.	
Gc	Gironniera celtidifolia	sisisi
Gg	Gnetum gnemon	sikau
Gm	Garcinia myrtifolia	laubu
Gp	Gonystylus punctatus	mavota
La	Laportea harveyi	salato
M	Myrtaceae	yasiyasi
Ma	Maniltoa sp.	moivi
Mc	Myristica castaniifolia	kaudamu
Mch	Myristica chartacea	kaudamu
Mg	Myristica gillespieana	kaudamu
My	Myristica spp.	kaudamu
P	Pandanus spp.	
Pg	Parinari glaberrima	makita
Ph	Palaquium hornei	sacau
Ps	Palaquium stehlinii	bauvudi
Pi	Parinari insularum	sa
Pl	Plerandra sp.	
Pt	Pagiantha thurstonii	vasa
Xp	Xylopia pacifica	dulewa

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Species composition and stocking The biggest volume comes from the 'others', which group is made up of such species as *mako* (*Trichospermum richii* and *T. calcyculatum*), *bo* (*Neonauclea forsteri*), *vavaloa* (*Degeneria vitiensis*) and *sama* (*Commersonia bartramia*). *Kauvula* (*Endospermum macrophyllum*), *sa* (*Parinari insularum*) and *kaudamu* (*Myristica* spp.) have stockings ranging from 1 to 3 m^3/ha (135-404 Hsl ft/ac). Other species that have stockings of about 1 m^3/ha (135 Hsl ft/ac) are *kaunicina* (*Canarium* spp.), *yasiyasi* (Myrtaceae), *bauvudi* (Sapotaceae), *koka* (*Bischofia javanica*) and *sasauwira* (*Dysoxylum richii*). In Vanua Levu *vesi* (*Intsia bijuga*) occurs in this type but with a stocking of only about 1 m^3/ha (135 Hsl ft/ac). *Damanu* (*Calophyllum* sp.), which provides such a big proportion of the well stocked forest is virtually absent. The gymnosperms are absent too, although *dakua makadre* (*Agathis vitiensis*) occurs at high elevations in central Viti Levu. Overall stocking of trees over 35 cm d.b.h. range from 7 to 25 m^3/ha (943-3 369 Hsl ft/ac) with an average of 15 m^3/ha (2 021 Hsl ft/ac). Of this an average of 5 m3/ha (674 Hsl ft/ac) is made up of 'Others', the 'species' not computed by name and not recognised for commercial use.

Structure and height The trees in the upper storey reach a height of between 10 and 17 m (33-56 ft) with a canopy closing at varying heights depending upon the size of the surrounding trees. In one place the canopy may be high, whereas in others the climbers still blanket the shrubs at ground level. The diameter of most of the trees is below 35 cm d.b.h. with only 20 to 30 trees/ha exceeding this diameter. The height of the merchantable bole is less than 10 m (33 ft) except for *kauvula* which usually exceeds this figure.

Location and extent This type of forest covers extensive areas along the coastal strip between Suva and Navua where the poor stocking is due undoubtedly to continuous logging operations. In the Rewa plains and the Wainimala catchment it covers large areas probably due to greater farming activity in the past. It is common in the eastern half of Vanua Levu on both the windward and leeward sides of the main hill range. Above 610 m (2 000 ft) in central Viti Levu a variation of the type occurs with a relatively high stocking of *dakua makadre*. As its name implies this forest type occurs along the edge of the forest and, in consequence, completely forest-covered inland catchments have little of it. Where it has been recognised on the aerial photographs prior to the fieldwork it has not been included in the enumeration, with the result that the enumerated area does not represent the total area of the type.

The total enumerated area is 17 315 ha (42 785 ac) evenly distributed among the peripheral forest/grassland catchments.

Discussion In areas where logging has not been carried on over the years this type possibly represents an early stage of forest regrowth after clearing for farming. This is probably the case in inland Viti Levu (Wainimala catchment) and north-east Vanua Levu. On the other hand there are areas, such as the headwaters of the Wainmanu River, where this forest type is associated with edaphic factors.

Type K: Low-stocked intermediate dry-zone fringe forest

Airphoto appearance The appearance of this type on the aerial photographs is a continuous dark grey tone and coarse grain with rare white patches of grass of pale grey tone indicating shrubs.

Topography The type appears on low-lying hills near the coast with a west or south aspect.

Species composition and stocking The merchantable species are absent, or nearly so, and are replaced by 'others', including many *salato* (*Laportea harveyi*), *mako* (*Trichospermum* spp.) and *sama* (*Commersonia bartramia*). *Dawa* (*Pometia pinnata*) has a stocking of 6 m^3/ha (809 Hsl ft/ac) and *koka* (*Bischofia javanica*) 3 m^3/ha (404 Hsl ft/ac), whereas species like *kauvula* (*Endospermum macrophyllum*) and *kaudamu* (*Myristica* spp.) have stockings of only 2 m^3/ha (270 Hsl ft/ac). The overall stocking of trees over 35 cm d.b.h. is 30 to 40 m^3/ha (4 043-5 390 Hsl ft/ac).

Structure and height The forest has a closed canopy at about 10 m (33 ft) height with emergents. Below the canopy there is a dense growth of *yasiyasi* (Myrtaceae) and guava (*Psidium guajava*).

Location and extent This forest type fringes open grass and shrubland with occasional isolated trees. Due to fire and cultivation it is decreasing at the present time. Type K occurs in the Navua-Singatoka coastal strip where it covers 2 859 ha (7 065 ac), mostly at the western end, near the Singatoka River. Smaller areas occur in the Wainikoroiluva and Nambukelevu South-East catchments.

Type KF: Low-stocked blocks of forest in grassland

Airphoto appearance This forest type is a mosaic of forest on the ridges so intricately mixed with shrubs or grass on the hillsides as to defy separation at this scale of mapping. The ridge forest has a dark tone with small crowns discernible and the shrubs and grass have a paler tone and finer texture.

Topography This kind of forest occupies a broad zone of foothills that surround the very steep hills in the Nasekawa catchment.

Species composition 'Others' with a high proportion of *velau* (*Casuarina nodiflora*) has the highest stocking of 4 m^3/ha (539 Hsl ft/ac) with *kaudamu* (*Myristica* spp.). *Ma* (*Dysoxylum* sp.), *sasauwira* (*Dysoxylum richii*), *yasiyasi* (Myrtaceae) and *bau* (Sapotaceae) having stockings of 1 to 2 m^3/ha (135-270 Hsl ft/ac). The overall stocking of trees over 35 cm d.b.h. is 20 m^3/ha (2 695 Hsl ft/ac).

Structure and height On the ridges the closed canopy forest has a height of 12 to 17 m 39-56 ft) with the light-crowned *velau* standing above the forest trees. On the hillsides the canopy is open with a dense tangle of shrubs and creepers.

Location and extent The enumerated area of this forest type is 1 431 ha (3 536 ac) in the Nasekawa catchment on the south central coast of Vanua Levu.

Type P: Low-stocked old orchard *dawa-ivi* forest

Airphoto appearance The type appears on the aerial photographs as dark grey, coarse-grained extensive strips of almost continuous cover with occasional white patches or circles around individual crowns.

Topography It occurs on gentle to moderate slopes beside rivers and near villages and old village sites.

Species composition Trees with edible fruit predominate such as *dawa* (*Pometia pinnata*) with a stocking of 3 to 10 m^3/ha (404-1 348 Hsl ft/ac) and species booked as 'Others' such as *ivi* (*Inocarpus fagiferus*), *wi* (*Spondias cytherea*) and *kavika* (*Syzygium malaccense*). *Sasauwira* (*Dysoxylum* sp.) and *koka* (*Bischofia javanica*) have stockings of about 3 m^3/ha (404 Hsl ft/ac). The merchantable species are rare or absent. Stocking of trees over 35 cm d.b.h. ranges from 25 to 50 m^3/ha (3 369-6 738 Hsl ft/ac).

Structure and height The canopy is open with large-crowned trees reaching a height of 12 m (39 ft). There is no regeneration on the ground, which is usually covered with grass or creepers.

Location and extent The type has been enumerated in Vanua Levu where it is restricted to the vicinity of past or present village sites, particularly in the Ndreketi catchment and north-west tip of the island.

Type RT: Raintree woodland

Airphoto appearance Raintrees appear on the aerial photographs as fluffy dark grey crowns usually occurring at the forest margin.

Topography The type occurs on flat low-lying alluvial sites and river valleys, often lying inland from coconut plantations.

Species composition and stocking The woodland consists of pure *raintree* (*Samanea saman*), an introduced species from Hawaii that has become naturalised in Fiji.

Structure and height This has been classified as a woodland because it has one storey only, the trees closing the canopy at a height of between 15 and 20 m (49 and 65 ft). They usually have diameters in excess of 100 cm (39 in), short boles and spreading crowns. The ground is covered with regeneration of the same species.

Location and extent This type is a result of human influence; it occurs near villages and plantations and appears to be propogated by cattle eating the seed. It occurs in north-west Vanua Levu in the drier zones and along the southern shore of the Natewa Peninsula. It has been enumerated in the Ndreketi South Catchment Group.

Type S: Low-stocked open woodland

Airphoto appearance The canopy is open and each tree has a deep crown, resulting in a strongly textured effect on the photographs. Where areas of grass or herb layer occur around the trees, small patches of white can be seen on the photographs, giving a stippled effect of light tone contrasting with the large dark-toned tree crowns.

Topography This forest type occurs on short, moderate or steep slopes, the long, very steep slopes with similar airphoto appearance being classified in type S1. It is frequently to be found at the break in slope between the very steep CS forest and the moderate or steep C1 forest. This is probably due to cultivation in the past of the fertile area at the change in slope.

Species composition and stocking *Kaudamu* (*Myristica* spp.), *kauvula* (*Endospermum macrophyllum*), *sasauwira* (*Dysoxylum richii*) and *koka* (*Bischofia javanica*) have stockings ranging from 2 to 5 m^3/ha (270-674 Hsl ft/ac). 'Others', which includes species like *bo* (*Neonauclea forsteri*), *yaro* (*Premna taitensis*), *tarawau* (*Dysoxylum* sp.), *mako* (*Trichospermum* spp.) and *kuluva* (*Dillenia biflora*), has a variable stocking ranging from 2 to 13 m^3/ha (270-1 752 Hsl ft/ac). Shrubs include *vau* (*Hibiscus tiliaceus*), *sisisi* (*Gironniera celtidifolia*) and *Ficus* spp. as well as tree fern (*Cyathaea lunulata*) and bamboo (*Schyzostachyum glaucifolium*). The overall stocking ranges from 5 to 30 m^3/ha (674-4 043 Hsl ft/ac) of trees over 35 cm d.b.h.

Structure and height The nature of the woodland is illustrated in Plate 3 which shows individual trees reaching to a height of about 17 m (56 ft), draped in creepers with tangles of shrubs and creepers in between. The canopy is partially closed with a canopy closure ranging from $\frac{5}{10}$ to $\frac{9}{10}$. Typical creepers are *Thumbergiana* sp., *wavuka* (*Rubus mollucanus*) and mile-a-minute (*Mikania micrantha*).

Location and extent This partially closed canopy forest occurs in 19 catchments covering an area of 11 283 ha (27 880 ac). It rarely covers large areas and usually occurs in little pockets at the foot of steep hills, near to present villages or at the sites of deserted villages. The correlation of this forest type with old village sites in north-east Vanua Levu is noticeable. In Vanua Levu some of the larger areas of type S should be subdivided so that the steeper parts of the hills go into the S1 protection category. Due to the fact that it is not possible to split the enumeration figures at this stage they have been left as type S.

Discussion This is a seral stage as abandoned plantation reverts to forest. There is a high proportion of species of the families Euphorbiaceae and Meliaceae.

Type V: *Velau* woodland

Airphoto appearance The spreading crowns of *velau* can be recognised on the aerial photographs by a uniform whorled pattern and dark, almost black, tone.

Topography On the dry sides of both main islands *velau* woodland occurs along the forest margin on flat or gently rolling country and extends up the hills on steep country. On the windward side of Viti and Vanua Levu it lies along the low spurs adjacent to the main rivers.

Species composition and stocking *Velau* (*Casuarina nodiflora*), which is coded as 'Others', has a stocking of 7 m^3/ha (943 Hsl ft/ac). *Yasiyasi* (Myrtaceae), *sasauwira* (*Dysoxylum richii*), *Kaudamu* (*Myristica* spp.) and *kauvula* (*Endospermum macrophyllum*) have an average stocking of 2 to 3 m^3/ha (270-404 Hsl ft/ac). Less common are *bau* (Sapotaceae), *dakua makadre* (*Agathis vitiensis*), *sa* (*Parinari insularum*) and *kaunicina* (*Canarium* spp.) with a stocking of about 1 m^3/ha (135 Hsl ft/ac). In the understorey the following trees and shrubs occur: *qumu* (*Acacia richii*), *yaka* (*Dacridium elatum*), *buabua* (*Fagraea gracilipes*), *laubu* (*Garcinia myrtifolia*), *kaukaro* (*Semecarpus vitiensis*), *kuasi* (*Podocarpus neriifolius*), *Brackenridgea nitida*, *Crossostylis pedunculata* and species of the family Sapindaceae. The overall stocking is on average 50 m^3/ha (6 738 Hsl ft/ac), but may be much higher than this. The type is put into the non-commercial category because of the high proportion of *velau* and other species unsuitable for saw timber.

Structure and height *Velau* is characterised by monopodial branching with clusters of foliage at the end of the branches providing a rather open canopy. The trees reach a height of 13 to 17 m (43-56 ft) with 5 to 10 m (16-33 ft) of clear bole. Beneath this open upper canopy there is a dense understorey of trees and shrubs reaching a height of about 10 m (33 ft) except where the *velau* grow so closely together that they preclude an understorey.

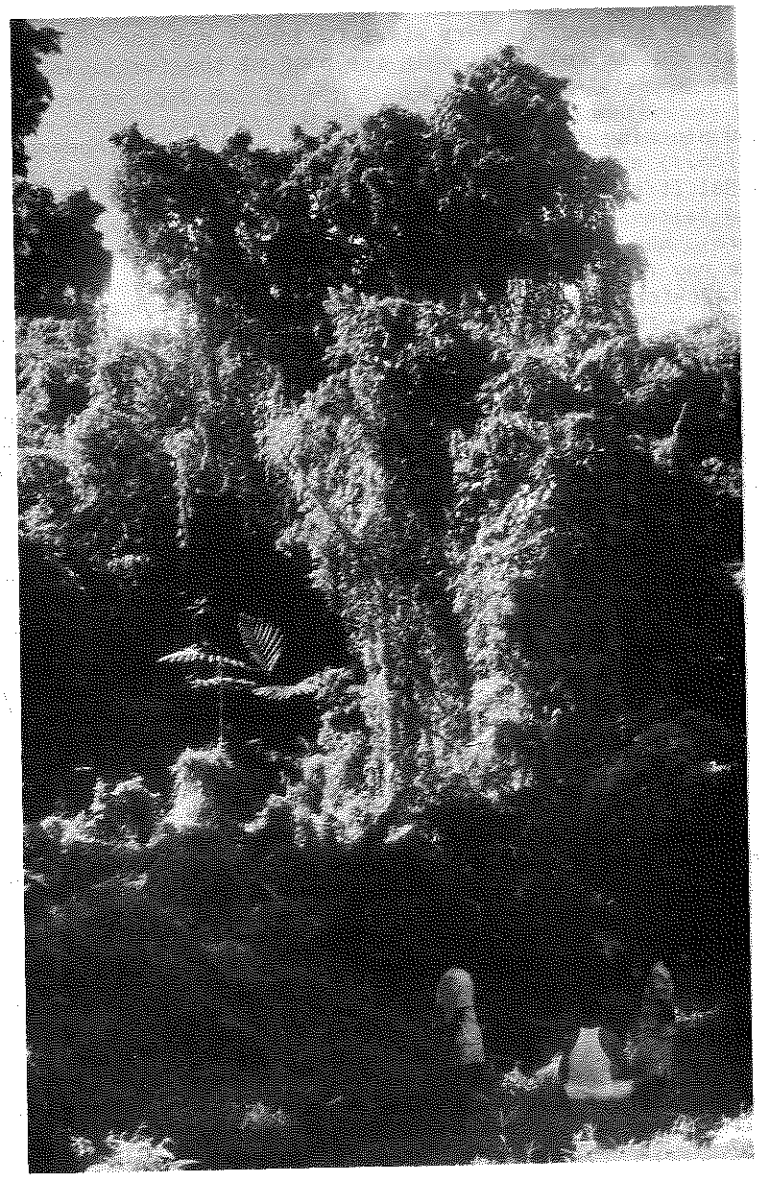


PLATE 3 Forest type S showing *dawa* (*Pometia pinnata*) draped in climbers. Wainimala catchment, Viti Levu

Location and extent *Velau* woodland occurs on the dry side of Vanua Levu where slightly less than 3 000 ha (7 413 ac) have been surveyed. The actual area of this type exceeds this figure because it occurs in areas that have not been surveyed and in areas too small to plot by themselves. It is to be found on the dry side of Viti Levu, notably in the Nausori Highlands, and along the wet sides of the two main islands on low ridges near to large rivers, for example in the Savusavu catchment of Vanua Levu and the Navua-Singatoka coastal strip in Viti Levu.

Discussion *Velau* is associated with soils of low pH and low fertility (Adams, 1968). A tentative suggestion for its present distribution is that it regenerates after fire on dry sites that have suffered from too much cropping with a resultant lowering of fertility. Its presence on the wet side of Vanua Levu and to a small extent Viti Levu is accounted for by the fact that it always occurs on the low-lying ground near the coast where the rainfall is not so high as further inland.

Type VB: Moderately stocked *velau-buabua* forest (Profile Diagram 2)

Airphoto appearance On the aerial photographs this forest type appears light in tone with some almost white patches, and the grain or texture of the tree crowns is very smooth.

Topography This forest, dominated by *velau* and *buabua*, occurs on the gentle and moderate slopes of the Ndreketi basin.

Species composition and stocking The predominant species is *velau* (*Casuarina nodiflora*) which occurs with *buabua* (*Fagraea gracilipes*) and *sasauwira* (*Dysoxylum richii*). Other species are: *yasiyasi* (Myrtaceae), *vesi* (*Intsia bijuga*), *sa* (*Parinari insularum*), *yaka* (*Dacridium elatum*), *mako* (*Trichospermum* spp.) and *kuasi* (*Podocarpus neriifolius*).

Structure and height The *velau* does not form a closed canopy, as it does in type CV, but occurs as isolated trees with a dense canopy of *buabua* and other trees forming a canopy at about 12 m (39 ft). Many of the trees are below 35 cm d.b.h. and have clean boles of only 7 m (23 ft) height.

Location and extent This forest type occurs on the dry side of Vanua Levu in the Ndreketi basin and catchments that lie to the west such as Naimbulu and Mbua. In these catchments the dry season is severe with 5 months having less than 152 mm (6 in) of rainfall per month.

Type VF: Low-stocked *velau-vesi* forest

Airphoto appearance On the ridges tufts of *velau* crowns can be recognised. On the middle and lower slopes there is either partially closed canopy showing patches of white or tightly knit small-sized crowns.

Topography This type occurs on gentle or moderate slopes with low relief,

Species composition and stocking *Velau* (*Casuarina nodiflora*) is common, growing with *vesi* (*Intsia bijuga*), *sa* (*Parinari insularum*) and *kaunicina* (*Canarium* sp.). The overall stocking of trees over 35 cm d.b.h. is 23 m^3/ha (3 099 Hsl ft/ac).

Structure and height The vegetation is dominated by low closed-canopy *velau* at a height of 12 to 17 m (39-56 ft). On the sides of the slopes the canopy is partially closed with a regrowth of shrubs such as *yaqoyaqona* (*Piper* spp.), tree fern (*Cyathea lunulate*) and *Macaranga* spp.

Location and extent This type is confined to the Ndrawa catchment where the enumeration covered 592 ha (1 463 ac).

PRODUCTION FOREST TYPES

Type C1: Well stocked mixed forest on moderate to steep short slopes (Profile Diagram 3)

Airphoto appearance Emergent crowns ranging in diameter from 15 to 25 m (49-82 ft) can be seen on the aerial photographs. This gives a characteristic 'textured' appearance in contrast to the fine crowns of the poorly and moderately stocked forest. This forest covers the foothills immediately below the very steep forest type CS that usually covers the watershed.

Topography The slopes are moderate (10-20°) or steep (20-30°). An analysis of the slopes in this forest type in one Vanua Levu catchment showed 16% very steep, 30% steep, 42% moderate and 12% gentle slopes. The length of the slope from the secondary spur to the streambed is short (100-150 m 328-490 ft) compared with type CS where it is 300-400 m (984-1 310 ft).

Species composition and stocking This is the best-stocked forest, containing a mixture of the best timber species in Fiji, including some of the softwood species such as *dakua makadre* (*Agathis vitiensis*), but made up mostly of the so-called hardwoods, such as *damanu* (*Calophyllum vitiense*), *yasiyasi* (Myrtaceae), *kaudamu* (*Myristica castaniifolia, M. chartacea* and *M. gillespieana*) and *kauvula* (*Endospermum macrophyllum*). Species that are usually present but never in great quantity are: *kaunicina* (*Canarium* spp.), *bauvudi* and *bau* (Sapotaceae), *sa* (*Parinari insularum*), *rogi* (*Heritiera ornithocephala*) and *sacau* (*Palaquium hornei*). *Koka* (*Bischofia javanica*) and *sasauwira* (*Dysoxylum richii*), which are prominent in the secondary forest and on very steep slopes, have stockings of less than 1 m^3/ha (135 Hsl ft/ac). Table 8 gives an idea of the range of stockings of the species in a representative set of catchments.

TABLE 8 The stocking of type C1 in 5 catchments: volume of trees over 35 cm d.b.h. in m^3/ha

Tree name	Nambukelevu	Sovi	Mbutha	Vunivia	Wainunu
Damanu	22.2	8.0	6.2	15.1	14.0
Yasiyasi	11.8	9.3	11.6	14.0	11.3
Others	10.9	3.2	14.7	14.2	13.4
Kaudamu	12.0	7.5	13.5	3.9	10.3
Dakua makadre	10.0	5.7	15.4	3.5	8.9
Kauvula	14.2	20.5	0.5	4.3	2.1
Kaunicina	3.3	1.8	5.0	13.1	6.3
Sa	3.6	3.3	1.5	8.4	9.6
Bauvudi	1.4	0.5	6.6	6.6	8.8
Rogi	2.7	4.3	3.8	2.1	4.9
Sacau	4.7	3.8	5.3	0.3	2.8
Bau	0.2	0.7	3.0	5.1	5.1

Note: In this and subsequent tables comparing the stockings of species they are listed in descending order of volume.

Shrubs in the understorey include the following species: *sisisi* (*Gironniera celtidifolia*), *makita* (*Parinari glaberrima*), *Psychotria* spp., *Couthovia corynocarpa, kuluva* (*Dillenia biflora*) and *Aglaia* spp. Common climbers are *Freycinetia* spp., *Flagellaria gigantea, Entada phaseoloides, Smilax vitiensis* and *Jasminum* sp.

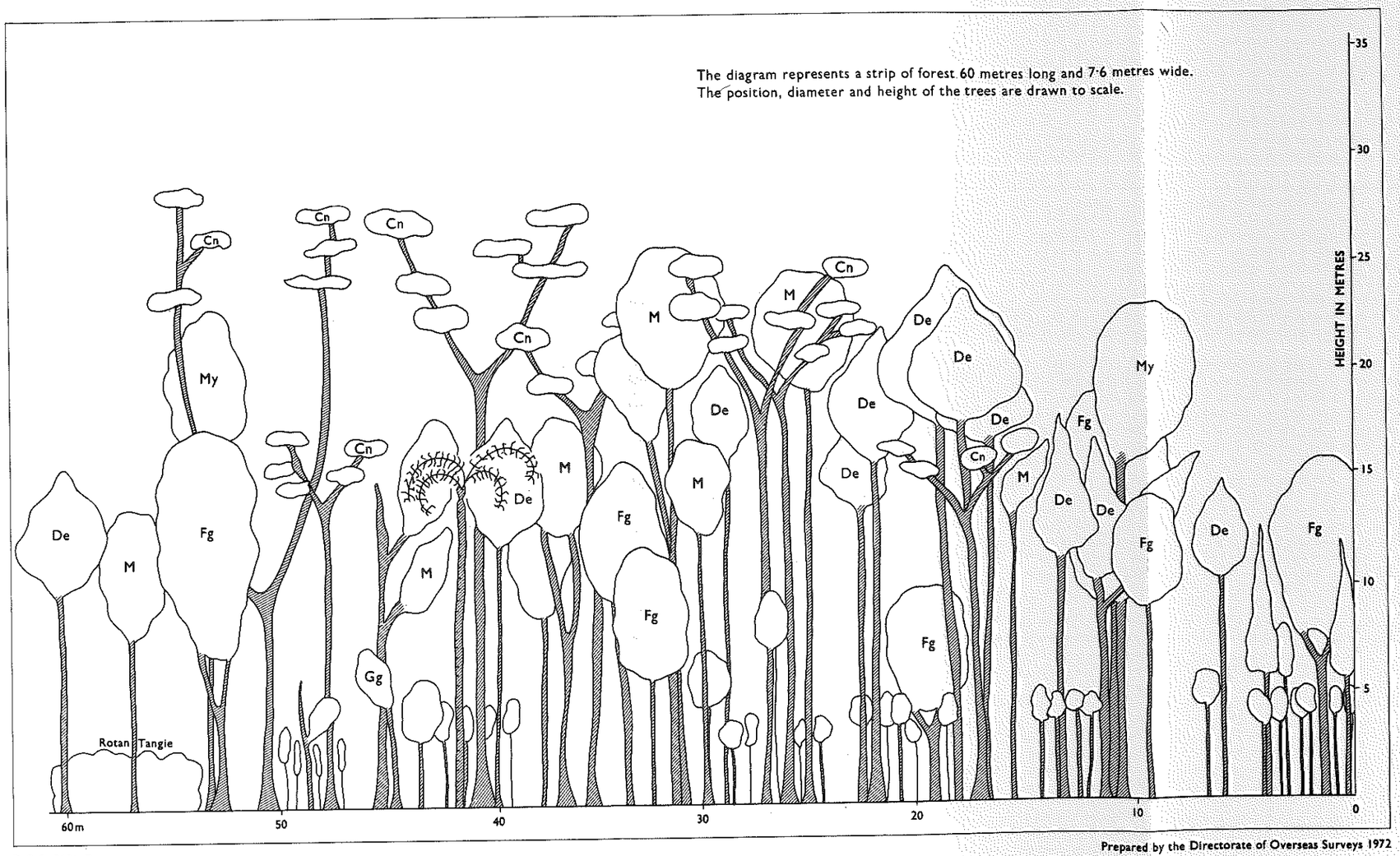
Structure and height The forest has 3 storeys with the main storey having a closed canopy (see Plate 4). Emergent trees reach a top height of 25 m (82 ft) while the main-storey trees have heights of around 20 m (65 ft). Profile Diagram 3 shows emergent *damanu* and *bauvudi*. The lower storey consists of a dense canopy of small trees which do not reach 35 cm d.b.h. Their canopy height is about 15 m (49 ft).

Location and extent Type C1 covers a total area of 82 000 ha (202 600 ac) of which 70% occurs in Viti Levu and 30% in Vanua Levu. In Viti Levu it lies along the south side of the island, particularly in the Navua Catchment Group. In the Rewa Catchment Group it covers a small area, nowhere occurring in such big blocks as it does in the Navua. In Vanua Levu it covers wide areas in the Mbutha and Vunivia catchments but is virtually absent from the forest cover down the main spine of the island until the south-west end of the island is reached (Yanawai, Wainunu and Sarowangga catchments). On Kandavu it covers 1 200 ha (2 965 ac) on the eastern part of the island.

Profile Diagram 2

Forest type VB. Moderately stocked Velau-buabua forest.

The diagram represents a strip of forest 60 metres long and 7·6 metres wide.
The position, diameter and height of the trees are drawn to scale.



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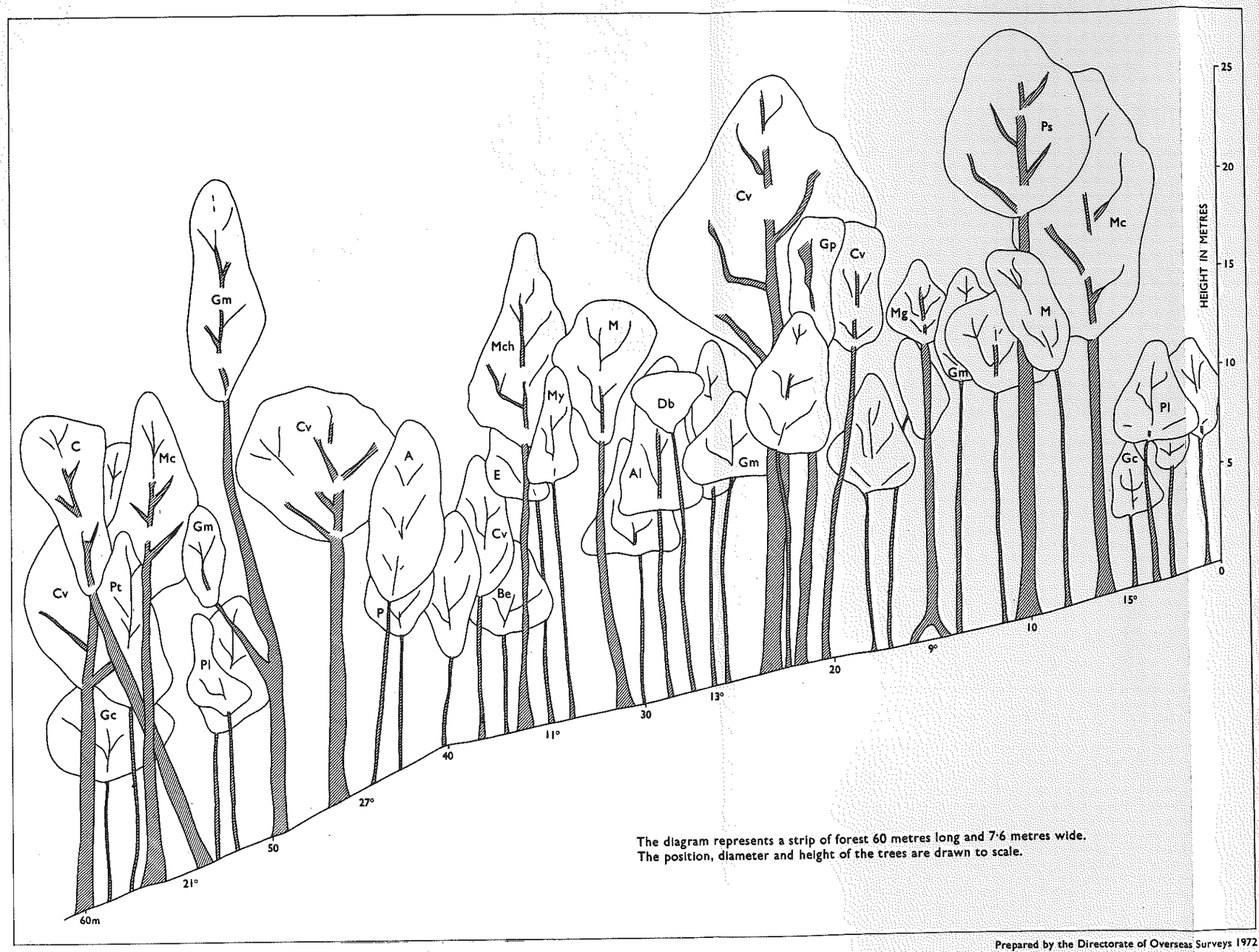
EXPLANATION

	SCIENTIFIC NAME	FIJIAN NAME
A	Annonaceae	qereqaqa
Ag	Aglaia sp.	
Al	Alphitonia sp.	doi
Av	Alstonia vitiensis var. vitiensis	
Be	Barringtonia edulis	vutu
Bi	Bischofia javanica	koka
C	Canarium sp.	
Cn	Casuarina nodiflora	velau
Cv	Calophyllum vitiense	damanu
Db	Dillenia biflora	kuluva
De	Dacridium elatum	yaka
Dy	Dysoxylum richii	sasauwira
E	Endiandra sp.	damabi
Fg	Fagraea gracilipes	buabua
Fl	Ficus sp.	
Gc	Gironniera celtidifolia	sisisi
Gg	Gnetum gnemon	sikau
Gm	Garcinia myrtifolia	laubu
Gp	Gonystylus punctatus	mavota
La	Laportea harveyi	salato
M	Myrtaceae	yasiyasi
Ma	Maniltoa sp.	moivi
Mc	Myristica castaniifolia	kaudamu
Mch	Myristica chartacea	kaudamu
Mg	Myristica gillespieana	kaudamu
My	Myristica spp.	kaudamu
P	Pandanus spp.	
Pg	Parinari glaberrima	makita
Ph	Palaquium hornei	sacau
Ps	Palaquium stehlinii	bauvudi
Pi	Parinari insularum	sa
Pl	Plerandra sp.	
Pt	Pagiantha thurstonii	vasa
Xp	Xylopia pacifica	dulewa



The diagram represents a strip of forest 60 metres long and 7·6 metres wide.
The position, diameter and height of the trees are drawn to scale.

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Profile Diagram 3

Forest type C1. Well stocked mixed forest on moderate to steep, short slopes.

EXPLANATION

	SCIENTIFIC NAME	FIJIAN NAME
A	Annonaceae	qereqaqa
Ag	Aglaia sp.	
Al	Alphitonia sp.	doi
Av	Alstonia vitiensis var. vitiensis	
Be	Barringtonia edulis	vutu
Bj	Bischofia javanica	koka
C	Canarium sp.	
Cn	Casuarina nodiflora	velau
Cv	Calophyllum vitiense	damanu
Db	Dillenia biflora	kuluva
De	Dacridium elatum	yaka
Dy	Dysoxylum richii	sasauwira
E	Endiandra sp.	damabi
Fg	Fagraea gracilipes	buabua
Fi	Ficus sp.	
Gc	Gironniera celtidifolia	sisisi
Gg	Gnetum gnemon	sikau
Gm	Garcinia myrtifolia	laubu
Gp	Gonystylus punctatus	mavota
La	Laportea harveyi	salato
M	Myrtaceae	yasiyasi
Ma	Maniltoa sp.	molvi
Mc	Myristica castanifolia	kaudamu
Mch	Myristica chartacea	kaudamu
Mg	Myristica gillespieana	kaudamu
My	Myristica spp.	kaudamu
P	Pandanus spp.	
Pg	Parinari glaberrima	makita
Ph	Palaquium hornei	sacau
Ps	Palaquium stehlinii	bauvudi
Pi	Parinari insularum	sa
Pl	Plerandra sp.	
Pt	Pagiantha thurstonii	vasa
Xp	Xylopia pacifica	dulewa

PLATE 4 Forest type C1 on the watershed between the Suva-Navua coastal strip and Wainikovu catchment

Type C1(L): Moderately stocked, logged mixed forest on moderate to steep short slopes

Airphoto appearance The aerial photographs show a smoother texture than is found in type C1. This is due to the removal of some emergents which, however is insufficient to show anything but rare gaps in the canopy. Roads and logging tracks are prominent but infrequent due to light selective logging.

Topography The slopes are moderate or steep, the topography being similar to that described in type C1.

Species composition and stocking The valuable commercial species such as *dakua makadre* (*Agathis vitiensis*) and *damanu* (*Calophyllum vitiense*) have been removed leaving stockings of 2 and 3 m /ha (270 and 404 Hsl ft/ac) respectively. *Kaudamu* (*Myristica* spp.), *Kauvula* (*Endospermum macrophyllum*) and *yasiyasi* (Myrtaceae) have higher stockings of 15, 9 and 12 m^3/ha (2 021, 1 213 and 1 617 Hsl ft/ac) respectively.

The overall stocking of trees over 35 cm d.b.h. is 78 m^3/ha (10 511 Hsl ft/ac) in the Navua-Singatoka coastal strip, the only catchment where this forest type covers extensive areas.

Structure and height The canopy is closed at a height of 25 to 30 m (82-98 ft) with rare gaps where emergents have been removed. The upper canopy and understorey are for the most part undamaged by this light intensity of logging, usually with bullock extraction.

Location and extent This type occurs within type C1 alongside sawmill roads penetrating into previously unworked forest. It covers over 1 000 ha (2 471 ac) in the Navua-Singatoka coastal strip on the Viti Levu south coast and occurs to a small extent in the Nambukelevu South-East catchment.

Type C2: Well stocked mixed forest on flat to gentle slopes

Airphoto appearance The aerial photographs show uniform-sized emergents giving the canopy a tightly knit even appearance, more uniform than type C1.

Topography The topography is flat or gently undulating, slopes ranging from 0 to 20°. This forest type occurs on horizontally bedded rock strata or dissected plateau surfaces. The primary difference between this type and type C1 is in the topography rather than the appearance of the tree crowns.

Species composition and stocking *Kauvula* (*Endospermum macrophyllum*) is the commonest tree with consistently high stockings of 23, 33 and 36 m^3/ha (3 099, 4 447 and 4 851 Hsl ft/ac) in the Navua Catchment Group. *Kaudamu* (*Myristica* spp.) has a stocking of about 8 m^3/ha (1 078 Hsl ft/ac) and *damanu* (*Calophyllum vitiense*), *mavota* (*Gonystylus punctatus*), *yasiyasi* (Myrtaceae), *tivi* (*Terminalia vitiensis*) and *sa* (*Parinari insularum*) have stockings ranging from 2 to 16 m^3/ha (270-2 156 Hsl ft/ac). The stocking of 'Others' ranges from 6 to 16 m^3/ha (809-2 156 Hsl ft/ac). The overall stocking ranges from 80 to 120 m^3/ha (10 781-16 171 Hsl ft/ac) and averages 100 m /ha (13 476 Hsl ft/ac, trees over 35 cm d.b.h.) in the Navua catchments.

Structure and height The top height of the trees is about 22 m (72 ft) with a closed canopy. The structure is similar to that of type C1 except that there is less height distinction between the emergent and main-storey trees.

Location and extent This type covers an area of 4 600 ha (11 367 ac), most of which occurs in the Navua Catchment Group, on horizontally bedded Navua mudstones adjacent to the Navua River and over plutonic rocks on the north-west watershed.

Type CDK: Well stocked *dakua makadre* forest on flat to gentle slopes

Airphoto appearance On the aerial photographs the emergent crowns of the *dakua makadre* can be recognised in a fine-textured matrix.

Topography The ground is flat except for the widely separated streams, which have steep valley sides. This forest type confined to the Navonu River valley occurs on the remains of an uplifted mature river system.

Species composition and stocking *Dakua makadre* (*Agathis vitiensis*) has a volume of 18 m^3/ha (2 426 Hsl ft/ac) with *kaudamu* (*Myristica* spp.) 16 m^3/ha, *yasiyasi* (Myrtaceae) 11 m^3/ha, and 'Others', which includes a high proportion of *velau* (*Casuarina nodiflora*) having a volume of 10 m^3/ha (2 156, 1 482 and 1 348 Hsl ft/ac respectively). Common species with stockings of 2 to 5 m3/ha (270-674 Hsl ft/ac) are *vesi* (*Intsia bijuga*), *dakua salusalu* (*Podocarpus vitiensis*), *bau* (Sapotaceae), *roĝi* (*Hertiera ornithocephala*), *sacau* (*Palaquium hornei*), *kaunicina* (*Canarium* spp.), *sa* (*Parinari insularum*), *bauvudi* (*Palaquium* sp.) and *damabi* (*Endiandra* sp.). The overall stocking is 102 m^3/ha (13 746 Hsl ft/ac) of trees over 35 cm d.b.h.

Structure and height The forest consists of an open upper canopy of huge trees of *dakua makadre*, *dakua salusalu* and overmature stag-headed *yasiyasi*, which reach a top height of about 25 m (82 ft). Some of the forest is well stocked with a closed canopy dominated by *kaudamu*. Open-canopied patches occur on slight rises, where the vegetation is open and short with *velau*, *kuasi* (*Podocarpus neriifolius*) and shrub growth.

Location and extent This forest type is confined to an area of 770 ha (1 903 ac) in the Navonu catchment on the Natewa Peninsula, Vanua Levu. It has affinities with gymnosperm forest types in the Wainunu catchment but is unusual in the *Agathis-Myristica* mixture and in occurring at such a low elevation (below 152 m, 500 ft).

Discussion With a view to the creation of oil palm plantations, the Navonu basin has been the subject of a soil survey report by Adams (1968). In the uplifted, mature river system in situ weathering and leaching have continued for a very long period of time giving rise to a deep, infertile soil profile. The soil is a deep, red-brown clay, structureless or with a weak granular structure. Mechanical analysis showed an increase of the clay and silt fractions with depth. Chemical analysis indicated that these soils are infertile and pH levels, total P_2O_5 and available P_2O_5, are very low. Available potash is very low and base saturation is low. It seems that the *dakua* flourishes on the infertile soils that are too infertile for the broadleaved or angiosperm forest.

Type CY: Well stocked *sacau* forest (Profile Diagram 4)

Airphoto appearance This type has a smooth texture and pale tone on the photographs similar to type B. In this case it is not confined to the tops of ridges but spreads over larger areas of dissected plateaux. The smooth texture is caused by the tightly packed narrow crowns of the *sacau*.

Topography *Sacau* forest occurs on the upper slopes and ridges of dissected plateau surfaces that are undergoing a further erosion cycle. The middle and lower slopes have well stocked forest.

Species composition and stockings The dominant species is *sacau* (*Palaquium hornei*) associated with *damanu* (*Calophyllum vitiense*), *dakua makadre* (*Agathis vitiensis*), *kauvula* (*Endospermum* spp.), *kaudamu* (*Myristica* spp.), *yasiyasi* (Myrtaceae) and *rogi* (*Hertiera ornithocephala*). The gymnosperms are present with occasional *dakua salusalu* (*Podocarpus vitiensis*) in the upper storey and *kuasi* (*Podocarpus neriifolius*) and *yaka* (*Dacrydium elatum*) in the understorey. Common species in the understorey are *laubu* (*Garcinia myrtifolia*), *kaunicina* (*Burseraceae*) and yasiyasi (Myrtaceae). Species composition in 2 catchments in Viti Levu and 1 in Vavua Levu is given in Table 9.

TABLE 9 The stocking of type CY in 3 catchments: volume of trees over 35 cm d.b.h. in m^3/ha

Tree name	Waindina	Nambukelevu North-East	Wainunu
Sacau	20.1	28.7	26.3
Damanu	17.7	27.4	8.6
Dakua makadre	16.1	10.3	14.6
Kauvula	18.7	16.8	1.4
Kaudamu	10.5	11.3	8.0
Yasiyasi	8.0	11.6	8.1
Rogi	7.9	5.7	9.9
Others	2.2	6.6	12.9
Laubu	2.2	1.6	1.3
Dakua salusalu	1.1	2.0	1.2

The stocking is high ranging from 60 to 150 m^3/ha (8 086-20 214 Hsl ft/ac) of trees over 35 cm d.b.h. The average for the 9 catchments with this type is 115 m^3/ha (15 497 Hsl ft/ac).

Structure and height The canopy is closed with the dominant *sacau* reaching a height of 25 m (82 ft). There are no emergents. The understorey reaches a height of 10 to 15 m (33-49 ft) consisting of small trees and poles that do not reach 35 cm d.b.h.

Location and extent This type covers 12 658 ha (31 278 ac) of the enumerated forest in the Rewa and Navua Catchment Groups of Viti Levu and in the western part of Vanua Levu, particularly in the Wainunu catchment.

Type DK: Moderately stocked *dakua-yaka* forest on undulating country

Airphoto appearance On the aerial photographs this type has a grey smooth appearance with rare emergents and a more coarse-grained appearance in river valleys.

Topography This forest type occurs on flat or gently undulating high ground, formed either by horizontal lava flows or on old erosion surfaces at an elevation of 457 m (1 500 ft) in Vanua Levu and 914 m (3 000 ft) on the Nandrau Plateau in Viti Levu.

Species composition *Dakua madadre* (*Agathis vitiensis*) has a stocking of 9 m^3/ha (1 213 Hsl ft/ac) associated with *damanu* (*Calophyllum* sp.) and *yasiyasi* (Myrtaceae) with stockings of 5 and 4 m^3/ha (674 and 539 Hsl ft/ac) respectively. Other species with stockings of 1 to 3 m /ha (135-404 Hsl ft/ac) are *kaudamu* (*Myristica* spp.), *yaka* (*Dacrydium elatum*), *vuga* (*Metrosideros collina*), *sa* (*Parinari insularum*), *rogi* (*Heretiera ornithocephala*) and 'Others'.

The overall stocking is 35 m^3/ha (4 717 Hsl ft/ac) in the Wainunu catchment where 667 ha (1 648 ac) were sampled but tends to be higher where the sampled area is smaller.

Structure and height A closed canopy of pole-sized trees reaches a height of 10 to 15 m 33-49 ft) with occasional isolated emergents with short boles standing out of the forest with heights of 20 m (65 ft).

Location and extent This kind of forest occurs in the Mbua North and Coastal Central Catchment Groups in Vanua Levu where the enumerated area is 1 661 ha (4 104 ac) and on the Nandrau Plateau in central Viti Levu where it was not enumerated.

Type DM: Well stocked *dakua makadre* forest at high elevation on steep slopes

Airphoto appearance Emergent crowns of *dakua makadre* have a characteristic appearance on aerial photographs and can be recognised easily. They stand in a matrix of small-crowned trees that have a fine-textured appearance on the photographs.

Topography This type occurs at elevations of 914 m (3 000 ft) on steeply dissected country to the east of Mt Victoria and on the watershed between the Nanuku and Nandarivatu catchments on less steep terrain.

Species composition *Dakua makadre* (*Agathis vitiensis*) has a stocking of 17 and 39 m^3/ha (2 291 and 5 256 Hsl ft/ac) in the Nanuku and Nandarivatu catchments. Associated species are *damanu* (*Calophyllum* sp), *kauvula* (*Endospermum* sp.), *sa* (*Parinari insularum*) and *vuga* (*Metrosideros collina*). The overall stocking of trees over 35 cm d.b.h. is 35 and 62 m^3/ha (4 717 and 8 220 Hsl ft/ac) for the Nanuku and Nandarivatu catchments respectively.

Structure and height The dense lower canopy reaches a height of 15 m (49 ft) with the large emergent trees, mostly *dakua makadre*, developing their crowns above the surrounding forest. The crowns, which are invariably eccentric on the trunk, have diameters of 15 to 20 m (49-65 ft).

Location and extent The enumerated area of this type is 695 ha (1 717 ac) in the Nanuku and Nandarivatu catchments of central Viti Levu.

Type DS: Well stocked *dakua makadre* and *salusalu* forest on steep slopes

Airphoto appearance The tone on the aerial photographs is light grey, the canopy appearing smooth and homogeneous with very few large crowned emergents (although there are a few small ones).

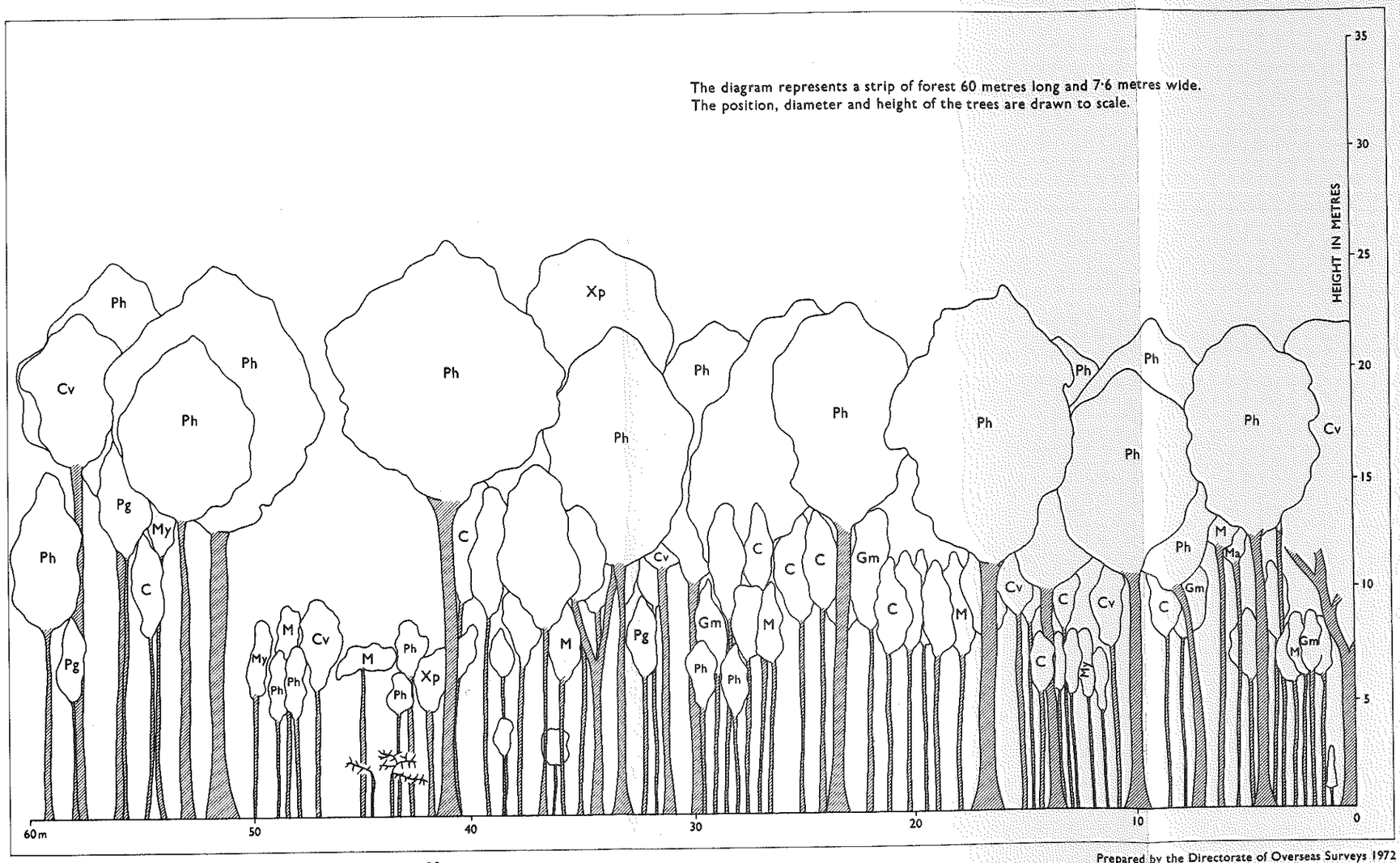
Topography The slopes are short but steep with low relief; the general landform has the appearance of a dissected plateau surface.

Species composition and stocking Diagnostic species for the type are *dakua salusalu* (*Podocarpus vitiensis*) and *dakua makadre* (*Agathis vitiensis*). Other common trees are: *damanu* (*Calophyllum vitiense*), *yasiyasi* (Myrtaceae), *kaudamu* (*Myristica* spp.), *sa* (*Parinari insularum*), *rogi* (*Heretiera ornithocephala*) and 'Others'. Stockings in 4 Vanua Levu catchments where this type is common are given in Table 10.

Profile Diagram 4

Forest type CY.
Well stocked Sacau-forest.

The diagram represents a strip of forest 60 metres long and 7·6 metres wide.
The position, diameter and height of the trees are drawn to scale.



EXPLANATION

	SCIENTIFIC NAME	FIJIAN NAME
A	Annonaceae	qereqaqa
Ag	Aglaia sp.	
Al	Alphitonia sp.	doi
Av	Alstonia vitiensis var. vitiensis	
Be	Barringtonia edulis	vutu
Bi	Bischofia javanica	koka
C	Canarium sp.	
Cn	Casuarina nodiflora	velau
Cv	Calophyllum vitiense	damanu
Db	Dillenia biflora	kuluva
De	Dacridium elatum	yaka
Dy	Dysoxylum richii	sasauwira
E	Endiandra sp.	damabi
Fg	Fagraea gracilipes	buabua
Fl	Ficus sp.	
Gc	Gironniera celtidifolia	sisisi
Gg	Gnetum gnemon	sikau
Gm	Garcinia myrtifolia	laubu
Gp	Gonystylus punctatus	mavota
La	Laportea harveyi	salato
M	Myrtaceae	yasiyasi
Ma	Maniltoa sp.	moivi
Mc	Myristica castaniifolia	kaudamu
Mch	Myristica chartacea	kaudamu
Mg	Myristica gillespieana	kaudamu
My	Myristica spp.	kaudamu
P	Pandanus spp.	
Pg	Parinari glaberrima	makita
Ph	Palaquium hornei	sacau
Ps	Palaquium stehlinii	bauvudi
Pi	Parinari insularum	sa
Pl	Plerandra sp.	
Pt	Pagiantha thurstonii	vasa
Xp	Xylopia pacifica	dulewa

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TABLE 10 The stocking of type DS in 4 catchments: volume of trees over 35 cm d.b.h. in m^3/ha

Tree name	Wainunu	Narailangi	Nanenivunda	Wailevu
Dakua salusalu	7.6	6.4	6.3	12.4
Dakua makadre	8.2	4.8	2.9	5.9
Damanu	14.4	9.8	11.8	13.7
Yasiyasi	7.3	8.5	8.6	10.3
Kaudamu	7.6	8.7	8.9	8.5
Others	15.9	7.1	12.5	0.2
Sa	7.8	5.4	7.5	3.9
Rogi	5.3	5.6	7.1	6.2
Bauvudi	7.3	1.2	10.4	4.5
Kaunicina	5.0	4.4	6.3	5.4
Kauvula	1.8	1.9	3.4	0.8
Yaka	1.6	0.2	0.3	0.3

The overall stocking of trees over 35 cm d.b.h. ranges from 80 to 110 m^3/ha (10 916-14 824 Hsl ft/ac) in Vanua Levu. In Viti Levu, where only small areas of the type were sampled, the stocking is more erratic ranging from 40 to over 100 m^3/ha (5 390-13 476 Hsl ft/ac).

Structure and height The canopy is even, standing at a height of about 20 m (65 ft) with occasional large *dakua* standing higher. *Kaudamu*, *damanu* and *yasiyasi* form a tightly closed canopy but have short boles of 10 to 12 m (33-39 ft) compared with the longer lengths found in type C1.

Location and extent Type DS occurs in the west-central and south-west part of Vanua Levu, covering large areas on both sides of the central watershed, spreading from Nalomate and Wainunu in the west as far as Nasekawa in the east and north of the watershed to Ndrawa, Narailangi and Seangangga. In Viti Levu this type has been mapped north of the Nandarivatu Plateau (Tawa catchment) and on the Nakorotumbu Hills which form the north-eastern coastal range.

Type DS2: Moderately stocked *dakua makedre* and *salusalu* forest on gentle to moderate slopes

This type is similar to the one just described but it has a lower stocking, usually about 40 m^3/ha (5 390 Hsl ft/ac), and occurs on flatter land. It is confined to the Wainunu and Seangangga catchments where it covers an area of enumerated forest of 609 ha (1 505 ac).

Type E: Moderately stocked mixed forest on flat to gentle slopes

Airphoto appearance The type is recognised on the photographs by the appearance of small crowns coalescing into a single canopy.

Topography Slopes are gentle or flat. In the Navonu catchment the forest type coincides with an area of alluvial soil.

Species composition and stocking Species composition is very variable because only small areas have been sampled in the 6 catchments that have this type. Species such as *kaudamu* (*Myristica* spp.), *damanu* (*Calophyllum vitiense*), *sa* (*Parinari insularum*) and *dakua makadre* (*Agathis vitiensis*) are common to all the sampled catchments, but with widely varying stockings. There is always a high proportion of 'Others' ranging from 7 to 15 m^3/ha (943-2 021 Hsl ft/ac). The overall stocking ranges from 50 to 80 m^3/ha (6 738-10 781 Hsl ft/ac).

Structure and height The upper storey trees reach a height of 15 to 20 m (49-65 ft) with a uniform closed canopy and few emergents.

Location and extent Flat or gently undulating land other than riverside alluvium usually has an infertile soil and a specialised forest cover, with coniferous species or *sacau* (*Palaquium hornei*) dominant. These have been mapped separately with the result that moderately stocked mixed forest is comparatively rare, covering an area of only 1 402 ha (3 464 ac) in the enumeration. It occurs in the Waimanu catchment and in 3 of the 8 catchments of the Navua Catchment Group.

Type G: Moderately stocked mixed forest on moderate to steep short slopes

Airphoto appearance On the aerial photographs the pattern of crowns is intermediate between the minute dots of poorly stocked fringe forest (type J) and the coarse texture of well stocked forest (type C1).

Topography Type G often occupies a broad belt of forest either side of the main river of the catchment on short, moderate to steep slopes.

Species composition and stocking The biggest contributions to the stocking are from 'Others', *kauvula* (*Endospermum macrophyllum*) and *sa* (*Parinari insularum*), compared with type C1 where the biggest contributions are from *damanu* (*Calophyllum vitiense*), *yasiyasi* (Myrtaceae) and *kaudamu* (*Myristica* spp.). A comparison of Tables 8 and 11 shows how much the same species occur in type G, but they have a lower stocking. Species included in 'Others' are: *vavaloa* (*Degeneria vitiensis*), *mako* (*Trichospermum* spp.), *bo* (*Neonauclea forsteri*), *yaro* (*Premna taitensis*) and *waciwaci* (*Sterculia vitiensis*). The stocking of trees over 35 cm d.b.h. ranges from 40 to 80 m^3/ha (5 390-10 781 Hsl ft/ac) with an average of about 60 m^3/ha (8 086 Hsl ft/ac).

TABLE 11 The stocking of type G in 6 catchments: volume of trees over 35 cm d.b.h. in m^3/ha

Tree name	Waimunu	Wainimala	Londoni	Nambukelevu South-West	Wainunu	Nasavu
Others	4.9	6.1	4.2	7.6	18.2	7.8
Kauvula	9.2	8.1	17.4	6.5	1.5	4.5
Sa	4.5	1.9	7.9	2.5	6.9	11.7
Kaudamu	7.4	4.4	4.3	7.1	6.1	5.3
Yasiyasi	3.7	3.8	3.3	5.7	7.5	5.5
Damanu	2.7	3.6	0.1	7.1	4.3	3.0
Sacau	10.8	2.6	0	1.7	0.1	0.1
Mavota	5.1	2.2	0.1	5.4	0	0
Kaunicina	2.1	0.9	0.7	1.9	4.1	2.6
Bauvudi	1.5	1.5	1.0	0.4	5.1	2.0
Bau	1.2	2.4	0.9	0	3.7	3.3
Sasauwira	0.5	0.7	0.2	5.1	2.0	1.7

Structure and height The trees reach a height of 15 to 20 m (49-65 ft) with a closed rather even canopy and few emergents. The average length of merchantable bole is 12 m (39 ft). There are on average 50 trees/ha falling in roughly equal proportions into the 35 to 39, 40 to 49 and >50 cm d.b.h. classes. The size of the tree crowns is small compared with those oftype C1.

Location and extent The type is widespread in Viti and Vanua Levu, covering an enumerated area of 55 269 ha (136 570 ac) in 49 of the 62 enumerated catchments. In some catchments it occupies a broad belt either side of the main river with C1 forest developed towards the watershed (eg Waimanu, Viti Levu and Nasavu, Vanua Levu).

Discussion This type often parallels the species composition of the C1 forest that lies adjacent to it. In spite of this there does not seem to be enough evidence to support the view that this is a seral stage towards type C1. Such evidence would be the higher proportion of light-demanding colonizing species such as *kauvula*, *sasauwira* (*Dysoxylum* sp.) and *koka* (*Bischofia* sp.) in type G, which is not the case. It may represent a stage of forest development induced by a combination of factors such as climate, past interference, and soil.

Type GB: Moderately stocked *buabua* forest

Airphoto appearance The tone on the aerial photographs is light grey with a number of isolated light spots giving a general bright pale grey tone.

Topography The slopes are moderate or gentle, this type occurring in country of low relief.

Species composition and stocking This type has a mixed species stocking similar to type G, associated with *buabua* (*Fagraea gracilipes*). Thus *kaudamu* (*Myristica* spp.) and *yasiyasi* (Myrtaceae) both have stockings of 15 to 20 m^3/ha (2 021-2 695 Hsl ft/ac). *Buabua* has a stocking of about 4 m^3/ha (539 Hsl ft/ac), with species such as *bau* (Sapotaceae), *sa* (*Parinari insularum*) and *sasauwira* (*Dysoxylum richii*) having about the same level of stocking as the *buabua*.

The overall stocking of trees over 35 cm d.b.h. ranges from 75 to 130 m^3/ha (8 759- 17 519 Hsl ft/ac). But this figure is misleading because 25% of the trees are between 35 and 40 cm d.b.h.

Structure and height This is a forest type with a closely packed canopy of even height. The trees are small, reaching an average height of 18 m (59 ft) and a top height of 20 m (65 ft). Many have small diameters and the high volume per hectare is achieved because they are packed closely together.

Location and extent Like type VB this type occurs in the dry side of the western half of Vanua Levu on the gently sloping hills there. The enumeration covers areas in Mbua, Narailangi, Vunimako and Seangganga catchments in the Ndreketi basin.

Type GB(L): Moderately stocked, logged *buabua* forest

Near the roads the moderately stocked *buabua* forest has been logged selectively for *buabua* (*Fagraea gracilipes*). This has occurred in the Narailangi catchment of the Ndreketi basin, where the enumeration covered a very small area of this type. The quantity of *yasiyasi* (Myrtaceae) and *kaudamu* (*Myristica* spp.) have been reduced as well as the *buabua* providing an overall stocking of 58 m^3/ha (7 816 Hsl ft/ac) (trees over 35 cm d.b.h.).

Type GDK: Moderately stocked *dakua makadre* forest on steep slopes at high elevations

Airphoto appearance The aerial photographs show a fine-textured matrix similar to type G with occasional dark-crowned emergents of *dakua makadre* often occurring in clusters on the upper slopes and crests of the ridges.

Topography The elevation ranges from 459 to 612 m (1 500-2 000 ft) in Vanua Levu and from 762 to 914 m (2 500-3 000 ft) in Viti Levu. The slopes are short and moderate or steep.

Species composition and stocking *Dakua makadre* (*Agathis vitiensis*) has a stocking of 14 to 15 m^3/ha (1 887-2 021 Hsl ft/ac) followed by *kauvula* (*Endospermum macrophyllum*) and *yasiyasi* (Myrtaceae) which have stockings of 5 to 8 m^3/ha (674-1 078) and 3 to 9 m^3/ha (404-1 213 Hsl ft/ac) respectively. *Kaudamu* (*Myristica* spp.) has a high stocking (9 m^3/ha) (1 213 Hsl ft/ac) in Lambasa catchment but has a stocking of less than 1 m^3/ha (135 Hsl ft/ac) in the Nanuku catchment on the Nandarivatu Plateau, which suggests that it may disappear at high elevations above 610 m (2 000 ft). Other species with a stocking of more than 1 m^3/ha (135 Hsl ft/ac) are *dakua salusalu* (*Podocarpus vitiensis*), *bauvudi* (*Palaquium* sp.), *sasauwira* (*Dysoxylum richii*), *damanu* (*Calophyllum* spp.), *kaunicina* (*Canarium* spp.), *sa* (*Parinari insularum*) and *yaka* (*Dacridium elatum*). 'Others' make a comparatively small contribution to the stocking of from 2 to 7 m^3/ha (270-943 Hsl ft/ac).

The overall stocking of trees over 35 cm d.b.h. is 50 m^3/ha (6 738 Hsl ft/ac) in Viti Levu but nearly 80 m^3/ha (10 781 Hsl ft/ac) in Vanua Levu.

Structure and height The *dakua* reach a height of 25 to 27 m (82-89 ft) with crown diameters of 10 to 18 m (33-59 ft) emerging from the surrounding forest. The broadleaved forest reaches a height of 20 m (65 ft) with a closed canopy.

Location and extent This forest type occurs in the Lambasa catchment on Vanua Levu where it covers an area of 1 862 ha (4 600 ac) and on the Nandarivatu Plateau in Viti Levu in the Nanuku catchment where it covers an area of 2 041 ha (5 050 ac). It also occurs at high elevations where the *Agathis* and *Podocarpus* species seem to be able to regenerate, whereas the shade-bearing species such as *kaudamu* do not do so well.

Type GV: Moderately stocked *kaudamu-velau* forest on moderate to steep short slopes

Airphoto appearance On the photographs small emergent crowns at varying heights can be seen on the sides of the slopes in contrast with the smooth even-textured appearance of the darker toned *velau* on the ridge tops and upper slopes.

Topography Slopes are rounded, moderate or steep, but usually less steep than those found in type G. Generally the landscape is more undulating and less dissected than occurs in type G (see plate 5).

Species composition and stocking The common species are *kaudamu* (*Myristica* spp.), *sa* (*Parinari insularum*), *dakua makadre* (*Agathis vitiensis*), *yasiyasi* (Myrtaceae), *damanu* (*Calophyllum vitiense*) and *kauvula* (*Endospermum* spp.). Less common are *kaunicina* (*Canarium* spp.), *vesi* (*Intsia bijuga*), *sasauwira* (*Dysoxylum richii*), *bauvudi* (*Palaquium* sp.) and *bau* (Sapotaceae). 'Others', which includes a lot of *velau* (*Casuarina nodiflora*) and some *dulewa* (*Xylopia pacifica*), contributes more than any of the individual species. The stocking of *damanu* is variable but tends to be low in the catchments on the dry side of the island. (See Table 12).

The overall stocking of trees over 35 cm d.b.h. ranges from 40 to 80 m^3/ha (5 390-10 781 Hsl ft/ac), averages approximately 60 m^3/ha (8 086 Hsl ft/ac).

TABLE 12 The stocking of type GV in 4 catchments: volume of trees over 35 cm d.b.h. in m^3/ha

Tree name	Mbua	Wainunu	Nanenivunda	Wainikoro
Others	3.3	26.5	10.4	19.3
Kaudamu	6.3	3.6	7.4	4.7
Sa	4.4	4.2	3.6	6.6
Kauvula	3.2	1.3	0.5	6.8
Damanu	0.6	6.4	1.7	0
Kaunicina	2.0	1.1	3.2	0.3
Sasauwira	1.2	0.9	1.8	1.8
Vesi	3.1	0.6	1.6	0.2
Dakua makadre	0	2.3	2.2	0.8

Structure and height Closed-canopy *velau* occurs along the ridges and upper slopes reaching a height of 17 to 20 m (56-65 ft). On either side of the ridges a mixed broadleaved forest is found with a closed-canopy and light understorey. Large trees are rare and the length of merchantable bole is about 12 m (39 ft). (See Plate 5).

Location and extent Forest type GV is located in the intermediate and dry climatic zones occurring to a limited extent near Singatoka but mostly in Vanua Levu. It covers extensive areas in the rolling country of the Ndreketi North and South Catchment Groups and the catchments that run north-westwards to the sea on the dry side of the central spine of hills.

The enumerated area of type GV is 20 000 ha (49 500 ac).

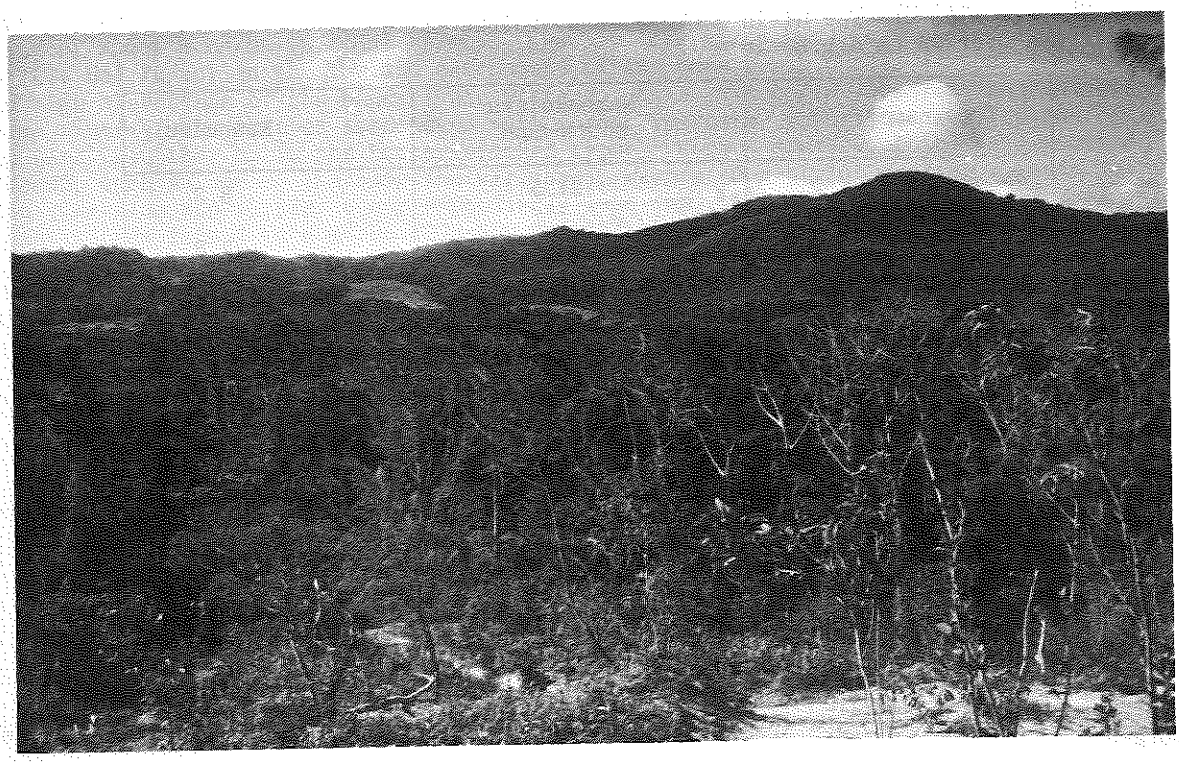


PLATE 5 Typical forest type GV landform in the background. Note *velau* (*Casuarina nodiflora*) trees in the foreground at the forest margin

Type GV(L): Moderately stocked *kaudamu-velau* forest on river valleys

This variant on type GV occurs on the lower slopes near to the main creeks. It differs in species composition in having a high volume of *vesi* (*Intsia bijuga*) (12 m^3/ha, 1 617 Hsl ft/ac). It occurs in the Ndreketi North and South Catchment Groups and in the Wainunu and Kumbulau catchments.

Type GV(H): Moderately stocked *kaudamu-velau* forest on hillsides and ridges

This forest type is a variation of type GV that occurs on the hillsides and ridges. It has a similar structure and airphoto appearance and differs from type GV in its stocking of *damanu* (*Calophyllum* sp.) of about 5 m^3/ha (674 Hsl ft/ac) and the high level of *vesi* (*Intsia bijuga*). The type is limited to the Vunimako and Ndrawa catchments in Ndreketi and to the Kumbulau catchment, all in Vanua Levu.

Type GY: Moderately stocked *sacau* forest

Airphoto appearance The appearance on the aerial photography is similar to type CY but the crowns are smaller and more even, giving a fine-textured appearance and pale tone to the photograph.

Topography This type occurs on land with gentle slopes at a higher elevation than that of type CY.

Species composition and stocking *Sacau* (*Palaquium hornei*) predominates, associated with *yasiyasi* (Myrtaceae), *damanu* (*Calophyllum* spp.), *dakua makadre* (*Agathis vitiensis*), *kauvula* (*Endospermum* spp.) and *kaudamu* (*Myristica* spp.). The stocking rates vary considerably, particularly between Viti and Vanua Levu. (See Table 13).

TABLE 13 The stocking of type GY in 2 catchments: volume of trees over 35 cm d.b.h. in m^3/ha

Tree name	Nambukelevu South-East	Kumbulau
Sacau	21.5	8.3
Damanu	12.1	3.8
Yasiyasi	3.6	6.4
Others	5.3	6.6
Dakua makadre	3.7	2.7
Kauvula	3.0	1.2
Kaudamu	2.6	2.9
Tivi	2.1	1.6
Sa	3.7	1.9

The overall stocking of trees over 35 cm d.b.h. is 70 m^3/ha (9 433 Hsl ft/ac).

Structure and height The canopy is closed with *sacau* reaching a height of 15 to 20 m. There are no emergents.

Location and extent The distribution of this type is limited, occurring in 2 catchments in Viti Levu and in 4 in western Vanua Levu but covering an area of only 1 060 ha (2 619 ac).

Type KD: Moderately stocked *kaudamu* forest

Airphoto appearance On the aerial photographs this type has a dark tone and fine appearance similar to type GV. The canopy is closed and small-sized emergents can be seen under the X3-stereoscope binoculars.

Topography The type occurs on gentle and moderate slopes.

Species composition and stocking This is an almost pure *kaudamu* (*Myristica* spp.) forest with a stocking of 60 m /ha (8 086 Hsl ft/ac). Other species are: *yasiyasi* (Myrtaceae), *bau* (Sapotaceae), *kaunicina* (*Canarium* spp.) and *tabadamu* (*Elaeocarpus* spp.).

The overall stocking is 141 m^3/ha (19 001 Hsl ft/ac) (trees over 35 cm d.b.h. species group 1 to 5), but a high proportion of the trees are between 35 and 40 cm d.b.h. This remarkably high stocking figure is the result of sampling only a small area (187 ha, 463 ac).

Structure and height The forest has a dense closed canopy reaching a height of about 20 m (65 ft).

Location and extent This type covers a limited area in the Mbua catchment, where it occurs north of the main road in the north-east corner of this catchment.

Type KV: Moderately stocked *kauvula-sa* forest

Airphoto appearance In this open-canopied forest the flat crowns of the *kauvula* can be recognised on the photographs by their pale tone. On the Nandarivatu Plateau the emergent *kauvula* are widely spaced and the crowns can be seen clearly, whereas in the lowlands the canopy is partially closed (shown by contrasts of dark and light on the photographs) compared with the more closely-knit C1 type.

Topography This type occurs on gentle to moderate slopes in the Nandarivatu Plateau and in the Wainimbuka catchment, but in the rest of the Rewa catchment it is found on short steep slopes in country with low relief.

Species composition and stocking The stocking of *kauvula* (*Endospermum macrophyllum*) and *sa* (*Parinari insularum*) accounts for 50% of the total volume, that of *kauvula* being about 17 m^3/ha (2 291 Hsl ft/ac) whereas *sa* ranges from 2 to 30 m^3/ha (270-4 043 Hsl ft/ac). 'Others', including a high proportion of *mako* (*Trichospermum* spp.) and *vavaloa* (*Degeneria vitiensis*), has a stocking of about 5 m^3/ha (674 Hsl ft/ac). *Kaudamu* (*Myristica* spp.) has a stocking of about 5 m^3/ha (674 Hsl ft/ac) in the lowland catchments of the Rewa Group but is virtually absent from the high elevations of the Nandarivatu Plateau. *Koka* (*Bischofia javanica*) and *sasauwira* (*Dysoxylum richii*), two species associated with forest regrowth, contribute more to the stocking here than they do in the better-stocked types. Common species of the well stocked mixed forest, such as *damanu* (*Calophyllum vitiense*), *mavota* (*Gonystylus punctatus*) and *kaunicina* (*Canarium* spp.), play a correspondingly less important role in this type. *Yasiyasi* (Myrtaceae) ranges from 2 to 6 m^3/ha (270-809 Hsl ft/ac) having a relatively high stocking. (See Table 14).

Overall stocking ranges from 30 to 70 m^3/ha (4 043-9 433) (trees over 35 cm d.b.h.) and is usually 50 m^3/ha (6 738 Hsl ft/ac).

TABLE 14 The stocking of type KV in 8 catchments: volume of trees over 35 cm d.b.h. in m^3/ha

Tree name	Waindina	Sovi	Lomaivuna	Wainimbuka	Wainivandu	Waimbula	Nanuku	Nandarivatu
Kauvula	18.8	20.8	22.1	8.2	26.9	11.6	7.9	24.4
Sa	3.6	2.6	19.6	3.5	1.6	10.0	2.2	2.7
Others	4.7	5.1	2.7	7.4	3.9	4.7	1.7	8.9
Kaudamu	5.8	4.8	7.8	0.9	0.9	8.3	0.2	0.7
Yasiyasi	5.9	3.4	4.0	2.1	2.6	5.2	1.6	4.8
Koka	1.2	0.6	0	5.3	3.0	0.9	1.3	6.7
Sasauwira	0.9	0.8	0.1	3.4	0	0.3	1.8	7.4
Damanu	1.8	3.0	0	1.2	2.3	0.6	1.5	0.9
Mavota	2.9	2.3	1.8	0	0	1.4	0	0
Dakua makadre	1.8	0.1	0	0	0	0.1	3.3	2.3
Bau	0.1	0.8	0.2	0.7	0.2	1.8	0.8	1.5
Kaunicina	0.9	1.3	0	0.8	0.7	0.5	0.1	0.3

Structure and height On the Nandarivatu Plateau the *kauvula* reach a height of 12 to 18 m (39-60 ft) standing above a dense understorey of shrubs such as *yaqoyaqona* (*Piper* sp.), tree fern, *yaro* (*Premna taitensis*), *Alpinia* sp., *Macaranga* spp., *kuluva* (*Dillenia biflora*), *sisisi* (*Gironniera celtidifolia*) and *vau* (*Hibiscus tiliaceus*) (see Plate 6). In the Rewa Catchment Group the canopy is more closed with the trees reaching a height of about 20 m (65 ft).

Location and extent The type is confined to Viti Levu where it occurs in the Rewa and east coast Catchment Groups and also on the Nandarivatu Plateau. It covers an area of 10 293 ha (25 434 ac).

Discussion In the Rewa and Tailevu Catchment Groups this forest type almost certainly represents a seral stage from farm clearing to mature forest. This is indicated by the essentially 2-storeyed structure and the presence of light-demanding pioneer species of the families Euphorbiaceae and Meliaceae. On the Nandarivatu Plateau the type occurs over compacted clays and may represent an edaphic climax.

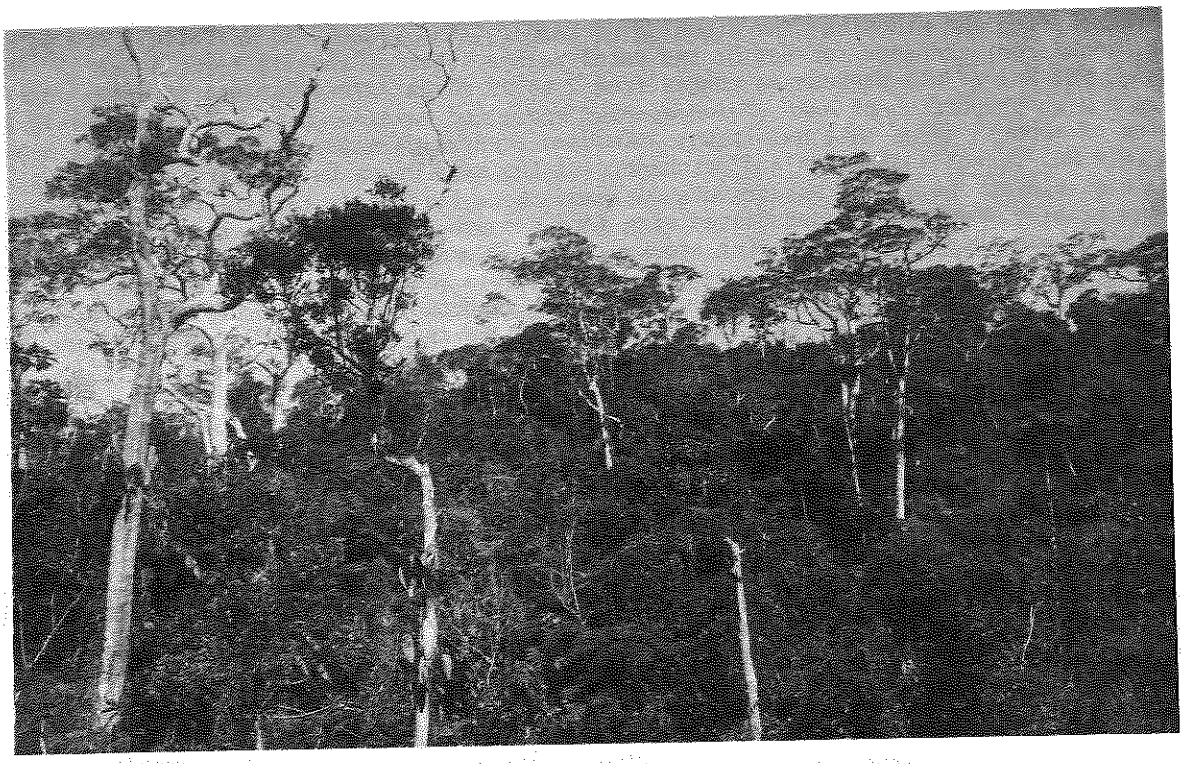


PLATE 6 Forest type KV showing the open nature of the forest on Nandarivatu Plateau. The white-barked trees with flat crowns are *kauvula* (*Endospermum macrophyllum*)

Type SK: Moderately to well stocked *sacau-yaka* forest

Airphoto appearance In the Vanua Levu catchments the aerial photographs show a fine-textured appearance caused by the many small crowns with occasional pale specks that may be emergent *sacau*. In the Wainimala catchment the fine texture is confined to the ridges and upper slopes with emergent crowns showing clearly on the middle and lower slopes. Earth slips recognised as small triangular white patches are another distinctive feature in this catchment.

Topography In the Vanua Levu catchments and the Sovi basin the type occurs near the headwaters of the streams on moderate slopes in country of low relief. In the Wainimala catchment slopes are steep or very steep and the type occurs in one block spreading across the topography.

Species composition and stocking From Table 15 it can be seen that there is a high stocking of *dakua makadre* (*Agathis vitiensis*) and *sacau* (*Palaquium hornei*). *Yaka* (*Dacrydium elatum*) is included in the type name because of its high stocking, particularly in the Vanua Levu catchments, and because it is noticeable on the ground. The species computed as 'Others' have a variable stocking ranging from 1 to 13 m^3/ha (135 - 1 752 Hsl ft/ac). Included in this group are *mako* (*Trichospermum richii* and *T. calyculatum*), *vavaloa* (*Degeneria vitiensis*), *bo* (*Neonauclea forsteri*) and *yaro* (*Premna taitensis*). Common species are *damanu* (*Calophyllym vitiense*), *rogi* (*Heritiera ornithocephala*), *yasiyasi* (*Myrtaceae*), *kaudamu* (*Myristica* spp.) and *kaunicina* (*Canarium* spp.). *Kauvula* (*Endospermum macrophyllum*) plays a minor role in this forest, particularly in Vanua Levu.

The stocking ranges from 40 to 100 m^3/ha (5 390 - 13 476 Hsl ft/ac) (trees over 35 cm d.b.h.). It averages 70 m^3/ha (9 433 Hsl ft/ac) in Vanua Levu and 50 m^3/ha (6 738 Hsl ft/ac) in Viti Levu.

TABLE 15 The stocking of type SK in 6 catchments: volume of trees over 35 cm d.b.h. in m^3/ha

Tree name	Waindrandra	Wainimala	Wainunu	Yanawai	Kumbulau	Wailevu
Dakua makadre	2.7	13.1	15.9	13.6	18.3	10.0
Sacau	7.1	15.7	13.7	14.9	8.7	11.2
Yaka	2.1	1.6	7.7	9.3	4.2	4.3
Others	2.5	5.0	4.0	0.9	12.6	5.3
Damanu	3.8	4.9	3.7	5.0	7.5	3.6
Rogi	1.8	3.2	2.0	2.1	7.3	7.1
Yasiyasi	2.4	2.4	3.2	4.3	7.1	3.5
Kaudamu	3.6	4.3	3.6	2.4	5.3	2.9
Kaunicina	1.4	1.3	1.5	2.9	6.8	3.6
Sa	1.3	1.0	2.8	1.1	2.5	2.2
Bauvudi	0.7	0	3.8	1.4	2.4	1.8
Kauvula	4.7	2.6	0.9	0.3	3.3	1.7
Dakua salusalu	0.1	0	1.1	1.4	3.1	1.3
Bau	0.3	1.2	1.3	0.6	2.8	0.5

Structure and height The structure of the forest, with large-crowned emergent *dakau makadre* in a matrix of smaller trees, is shown in Plate 7. The *dakua* reach a height of 30 m (98 ft) with spreading crowns having diameters ranging from 12 to 25 m (39 - 82 ft). The canopy of the main storey is low (20 m, 65 ft) and closed.

Location and extent The distribution of this forest type is limited to 4 catchments in the south-east end of Vanua Levu where it covers 4 700 ha (11 600 ac), and the Rewa Catchment group in Viti Levu where it covers 3 200 ha (7 900 ac).

Type SV: Low-stocked *sacau-velau* forest

Airphoto appearance Light grey fine-textured crowns are the identifying features of this type on the aerial photographs.

Topography This forest type is confined to the moderate sloping foothills just inland from the coast in the Wailevu catchment.

Species composition and stocking *Sacau* (*Palaquium hornei*) predominates with a stocking of 13 m^3/ha (1 752 Hsl ft/ac) associated with *velau* (*Casuarina nodiflora*). Other common species with stockings of 6 m /ha (809 Hsl ft/ac) are *kaudamu* (*Myristica* spp.), *yasiyasi* (*Myrtaceae*) and *kaunicina* (*Canarium* spp.). Softwood species include *dakua makadre* (*Agathis vitiensis*), *yaka* (*Dacridium elatum*) and *amunu* (*Podocarpus imbricatus*) which have stockings of 3, 1.2 and 1 m^3/ha (404 162 and 135 Hsl ft/ac) respectively. The overall stocking of trees over 35 cm d.b.h. is 74 m^3/ha 9 972 Hsl ft/ac).

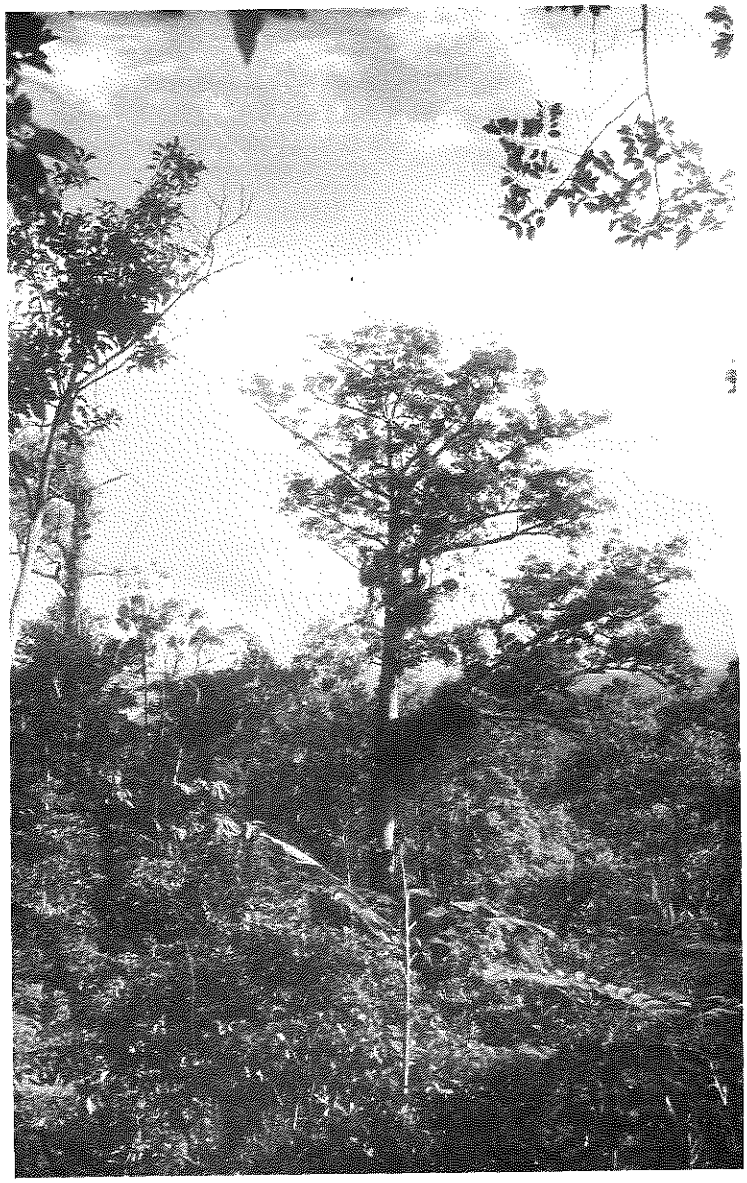


Plate 7 *Dakua makadre* (*Agathis vitiensis*) with its crown developed above the forest in forest type SK. Wainimala catchment, Viti Levu

Structure and height The canopy is closed with the *sacau* and other upper canopy species reaching heights of 15-20 m (49 - 65 ft). The *velau* occurs on the crests of the ridges as a 1-storey woodland.

Location and extent The mixture of *velau* and *sacau* is uncommon. This forest type is confined to the Wailevu catchment on Vanua Levu where it covers an enumerated area of 1 273 ha (3 146 ac).

Type VS: Moderately stocked *vesi* forest

Airphoto appearance The forest has a slightly open canopy which appears on the photographs as a textured pattern of light and dark tones.

Topography This type of forest is confined to the lower slopes in gently undulating country.

Species composition and stocking *Vesi* (*Intsia bijuga*) is the predominant species with a stocking of 25 m^3/ha (3 369 Hsl ft/ac). *Moivi* (*Manilotoa grandiflora*) has a stocking of 11 m^3/ha (1 482 Hsl ft/ac) and 'Others' 7 m^3/ha (943 Hsl ft/ac).

The overall stocking is 46 m^3/ha (6 199 Hsl ft/ac).

Structure and height The trees have a partially closed canopy and a height of 17 m (56 ft). The boles of the *vesi* are short with forked and twisted trunks growing out of the rock boulders.

Location and extent This type has been recorded from only 2 catchments in Ndreketi and Mbua. The enumeration has covered 95 ha (235 ac). The type is widespread but occurs in areas too small to be mapped separately.

PROTECTION FOREST TYPES

Type B: Ridge thicket

Airphoto appearance Along the top of every major ridge there is a narrow strip of pole-size trees. The enumeration lines cross the ridges at right-angles and so it is unusual for a whole plot to fall into this forest type. For this reason the type has not been mapped extensively, but confined to high ridges where the typical ridge vegetation covers an extensive area. The type is recognised on the photographs by the fine texture along the tops of ridges.

Topography The type is confined to the crests of high ridges and occurs along the watersheds and on the peaks of hill ranges.

Species composition and stocking Isolated large trees standing on the ridge, as is shown in Plate 8, are to be found. Species include *dakua makadre* (*Agathis vitiensis*), *damanu* (*Calophyllum vitiense, C. neo-ebudicum*), *kuasi* (*Podocarpus neriifolius*), *yasiyasi* (Myrtaceae) and *vuga* (*Metrosideros collina*). 'Others', which contribute 5-10 m^3/ha (674 - 1 348 Hsl ft/ac) to the volume, include species such as *mako* (*Trichospermum richii*), *baka* (*Ficus* sp.) and *Elaeocarpus* spp. Species of pole-size trees, ranging in size from 10 to 35 cm d.b.h., collected at Nandarivatu and in the Lambasa catchment, have been identified as: *Eleaocarpus lepidus, Endiandra luteola, kuasi* (*Podocarpus neriifolius*), *Decaspermum fruticosum, Dodonaea viscosa, Pandanus* spp., *Soulamea soulameoides, Astronidium confertifolium, vuga* (*Metrosideros collina*), *Palaquium fidjiense, Hedycarya dorstenioides, duvula* (*Hernandia olivacea*) and *Allstonia montana*.

The stocking ranges from 1 to 40 m^3/ha (135 - 5 390 Hsl ft/ac), but these figures are not very meaningful because only small areas have been sampled.

Structure and height The trees form a dense canopy about 7 m (23 ft) high. The thicket is difficult to penetrate unless there is a path along the ridge top. Diameters at breast height rarely exceed 35 cm and are on average 20 cm (8 in).

Location and extent The type is much more widespread than the enumeration area figures indicate but is usually too narrow to plot. It has been demarcated in many catchments in Viti and Vanua Levu, particularly at the crest of the high hill masses in both islands.

Type BS: Low-stocked forest on very steep or precipitous slopes

Airphoto appearance The tree crowns have a cropped appearance due to the large crowns coalescing with each other at an even height. Outcrops of rock are numerous.

Topography The slopes are very steep and in places precipitous. There is no pattern of ridges as is found in type CS but the ground falls away in one plane. Within this type has been grouped all the area that was marked 30^{+o} on the contour maps and therefore not included in the enumerated area. This category proved in the field to mean over 45^o. In both Viti and Vanua Levu the type includes areas of rock face and scree in which the trees are rooted in crevices in the rocks. Along the north-west catchments of Vanua Levu the line between types GDS and BS has been drawn roughly coinciding with the line separating 'strong dry season' from 'no dry season' and an annual rainfall of over 2 540 mm (100 in) on Twyford and Wright's (1965) climate map.

Plate 8 Forest type B, ridge thicket, beside a logging road. Note the large *yasiyasi* (Myrtaceae) in the middle of the picture.

Species composition and stocking Like forest type CS the largest stocking occurs in 'Others' which averages 9 m^3/ha (1 213 Hsl ft/ac). This group includes *salato* (*Laportea harveyi*), *vauceva* (*Firmiana diversifolia*), *mako* (*Trichospermum richii*) and *doi* (*Alphitonia* sp.). Common species are *damanu* (*Calophyllum* spp.), *sasauwira* (*Dysoxylum richii*), *kaudamu* (*Myristica* spp.) and *vesi* (*Intsia bijuga*) which is very common in Vanua Levu but absent from Viti Levu. Species that do not contribute much to the volume figures but are noticeable in the field are *vuga* (*Metrosideros collina*) and *cevua* (*Vavaea amicorum*), particularly the former which may be found growing in pure association on the steepest cliff faces.

Stocking figures of trees (over 35 cm d.b.h.) range from 15 to 50 m^3/ha (2 021 - 6 738 Hsl ft/ac). A common figure for the type is 30 m /ha (4 043 Hsl ft/ac).

Structure and height The upper canopy is at a height of about 20 m (65 ft) and is closed. The forest consists of large short-boled trees with wide spreading crowns. On precipitous slopes the trees are often crooked or branched from the ground.

Location and extent The area of 9 972 ha (24 641 ac) covered in the fieldwork does not represent the total area of the type, which is widespread in both large islands. It includes the peaks of the main hill ranges such as Korombasambasanga and Mendrausuthu and the Nandarivatu Plateau in Viti Levu and the highest points in Vanua Levu as well as the escarpments that often occur around their flanks.

Type CS: Moderately stocked forest on long, very steep slopes (Profile Diagram 5)

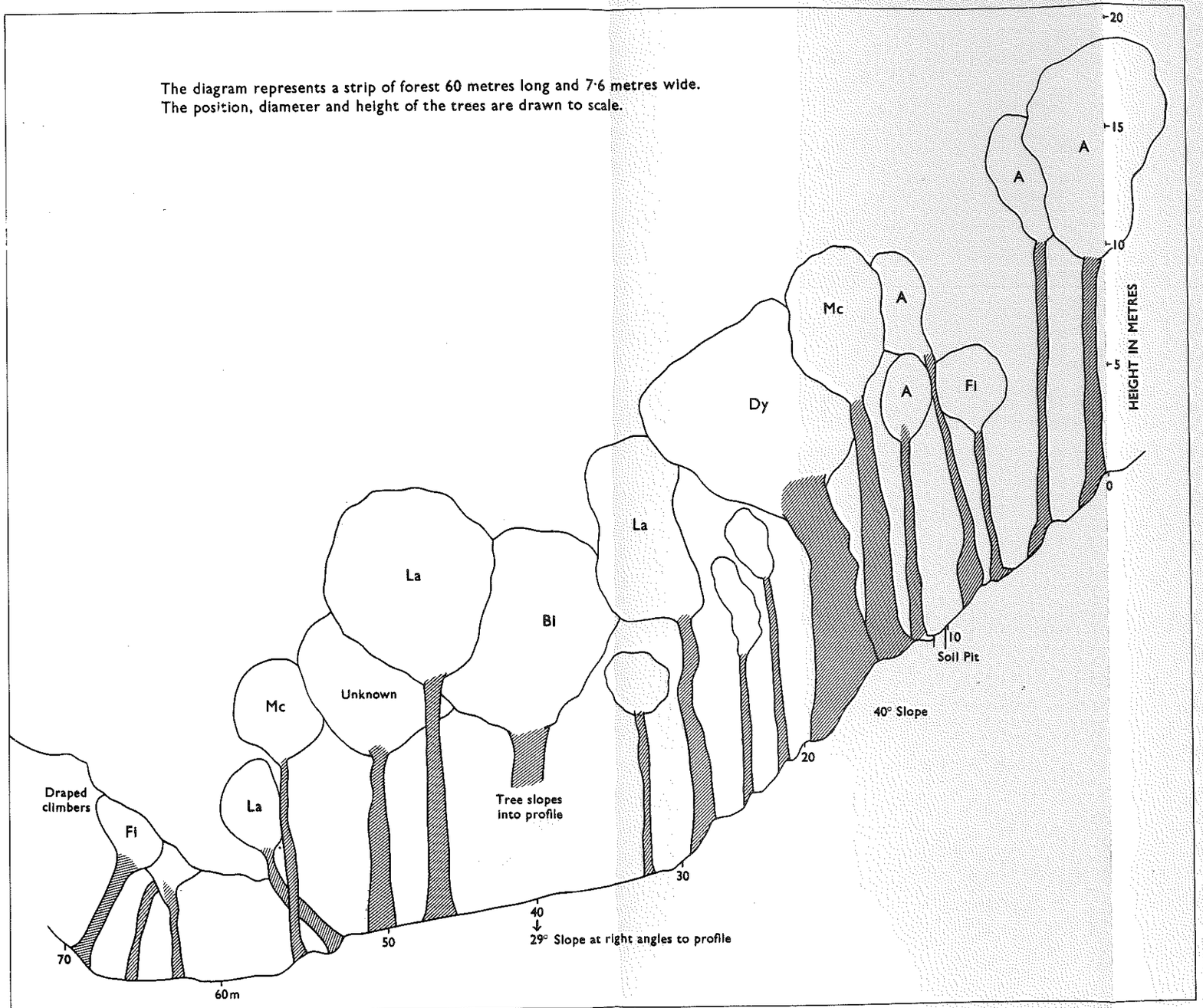
Airphoto appearance The large coalescing tree crowns, which are characteristic of this type, are of secondary importance as a diagnostic feature to the landform and species composition. Large earth slips are often evident, especially along the courses of streams.

Topography The landform is characterised by a pattern of ridges with very steep sides radiating from a high hill mass. The streams flow straight between V-shaped valleys. Slopes are very

Profile Diagram 5

Forest type CS. Moderately stocked forest on long, very steep slopes.

The diagram represents a strip of forest 60 metres long and 7·6 metres wide.
The position, diameter and height of the trees are drawn to scale.



EXPLANATION

	SCIENTIFIC NAME	FIJIAN NAME
A	Annonaceae	qereqaqa
Ag	Aglaia sp.	
Al	Alphitonia sp.	doi
Av	Alstonia vitiensis var. vitiensis	
Be	Barringtonia edulis	vutu
Bi	Bischofia javanica	koka
C	Canarium sp.	
Cn	Casuarina nodiflora	velau
Cv	Calophyllum vitiense	damanu
Db	Dillenia biflora	kuluva
De	Dacridium elatum	yaka
Dy	Dysoxylum richii	sasauwira
E	Endiandra sp.	damabi
Fg	Fagraea gracilipes	buabua
Fl	Ficus sp.	
Gc	Gironniera celtidifolia	sisisi
Gg	Gnetum gnemon	sikau
Gm	Garcinia myrtifolia	laubu
Gp	Gonystylus punctatus	mavota
La	Laportea harveyi	salato
M	Myrtaceae	yasiyasi
Ma	Maniltoa sp.	moivi
Mc	Myristica castanlifolia	kaudamu
Mch	Myristica chartacea	kaudamu
Mg	Myristica gillespieana	kaudamu
My	Myristica spp.	kaudamu
P	Pandanus spp.	
Pg	Parinari glaberrima	makita
Ph	Palaquium hornei	sacau
Ps	Palaquium stehlinii	bauvudi
Pi	Parinari insularum	sa
Pl	Plerandra sp.	
Pt	Pagiantha thurstonii	vasa
Xp	Xylopia pacifica	dulewa

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steep (30-50) and the length of slope is about 500 m^3 (1 650 ft). In one catchment (Mbutha) 50% of the slopes were very steep (over 30°), 28% were steep (20-30°), 18% moderate (10-20°) and 2% gentle (< 10°).

Species composition and stocking The species composition in 6 typical catchments is given in Table 16. This shows that 'Others' has the highest stocking with an average of 10 m^3/ha (1 348 Hsl ft/ac). Included in this are such species as the poisonous *salato* (*Laportea harveyi*), *vauceva* (*Firmiana diversifolia*, which is a common species on the steep slopes of Vanua Levu), *cibicibi* (Caesalpiniaceae), *vota* (*Geissois ternata*) and *mako* (*Trichospermum richii*). *Damanu*, which is mostly the small-leafed *Calophyllum neo-ebudicum* and not the more common *C. vitiense*, has a stocking ranging from 6 to 13 m^3/ha (809 - 1 752 Hsl ft/ac) and is a characteristic species of this type. Common species are *kaudamu* (*Myristica* spp.), *yasiyasi* (Myrtaceae), *kauvula* (*Endospermum macrophyllum*) and *dakua makadre* (*Agathis vitiensis*). *Koka* (*Bischofia javanica*) and *sasauwira* (*Disoxylum richii*) are indicators of the type and grow with *salato*, *mako* and *vauceva* on the steepest scree slopes. They contribute a smaller proportion to the timber volume than might be expected from their abundance on the ground, due to their poor form and short boles.

Stocking of trees (over 35 cm d.b.h.) ranges from 30 to 100 m^3/ha (4 043 - 13 476 Hsl ft/ac) with an average figure in the order of 60 m^3/ha (8 086 Hsl ft/ac).

TABLE 16 The stocking of type CS in 6 catchments: volume of trees over 35 cm d.b.h. in m^3/ha

Tree name	Waindina	Waionamoli	Wailevu	Lambosa	Nasavu	Mbutha
Others	3.9	12.8	9.9	12.8	10.2	12.2
Damanu	5.8	12.8	22.7	5.8	6.1	11.2
Kaudamu	3.1	2.4	4.2	11.8	6.6	10.3
Yasiyasi	6.2	6.4	8.0	4.0	3.5	10.1
Kauvula	17.1	5.1	0.2	3.7	3.2	0.2
Dakua makadre	8.9	5.9	3.2	5.4	0.7	2.6
Koka	2.9	3.8	3.5	1.6	2.5	2.2
Kaunicina	1.8	1.8	1.7	2.9	0.8	4.9
Sasauwira	0.4	7.3	0.4	0.8	2.1	1.8

Structure and height Profile Diagram 5, depicting typical CS forest in Kandavu, shows the wide crowns and short boles of the trees. The top canopy height is 20 m (65 ft) but on the scree slope the canopy is low (12 m, 39 ft) and open, with species such as *koka* and *salato* growing.

Location and extent Type CS occurs in 38 of the 62 catchments enumerated, covering an area of 44 641 ha. (110 308 ac). The area is divided equally between Viti Levu and Vanua Levu. It is the forest type with the third biggest enumerated area, being exceeded only by C1 and G.

Discussion Under this forest type the soil usually consists of 15 cm (6 in) of very dark greyish brown clay, free of coarse material, on a horizon that is a mixture of rock rubble and soil which merges into rock at about 45 cm (18 in). Tree roots extend into the C horizon in gaps between the rocks. A noticeable feature of the trees on these slopes is the way in which earth piles up on the upper side of the tree making a small patch of level ground whereas, on the lower side, the soil wastes away leaving the tree roots exposed like stilt roots. This illustrates how unstable the soil is and the important part the trees play in stabilising it.

Type GDS: Low-stocked dry-zone forest on long, very steep slopes

Airphoto appearance The very steep hills that run out to the sea along the north-east coast of Vanua Levu have a dark-toned forest cover on the photographs, in which the crowns of the trees form a fine pattern. The boundary of the type has been decided on slope rather than on stocking or species composition.

Topography The slopes are very steep (over 30^{o}) and long, not usually broken up into short spurs and ridges.

Species composition and stocking 'Others' comprise the highest stocking, being made up largely of *velau* (*Casuarina nodiflora*), *Yasiyasi* (Myrtaceae), *dakua makadre* (*Agathis vitiensis*) and *damanu* (*Calophyllum* sp.) have stockings ranging from 2 to 19 m^3/ha (270 - 2 560 Hsl ft/ac). Common species are *kaunicina* (*Canarium* sp.), *sa* (*Parinari insularum*), *bauvudi* (*Palaquium* sp.), *bau* (Sapotaceae) and *kaudamu* (*Myristica* spp.), *Vaivai-ni-veikau* (*Serianthes myriadenia*), *vesi* (*Intsia bijuga*), *yaka* (*Dacridium elatum*) and *buabua* (*Fagraea gracilipes*) are common locally but do not appear to be present consistently.

The stocking of trees over 35 cm d.b.h. ranges from 20 to 70 m^3/ha (2 695 - 9 433 Hsl ft/ac) depending very much on whether there has been any logging.

Structure and height Due to human interference the forest is variable in stocking and appearance. The inland hills lying far from cleared land and villages, such as can be found in the Numbu catchment, have an almost untouched forest, but usally the forest is 1-storeyed and about 17 m (56 ft) high. Climbing the hill, the trees become lower until on the top a thin canopy of *velau* or *nokonoko* (*Casuarina equisetifolia*) is the only cover. (See Plate 9.)

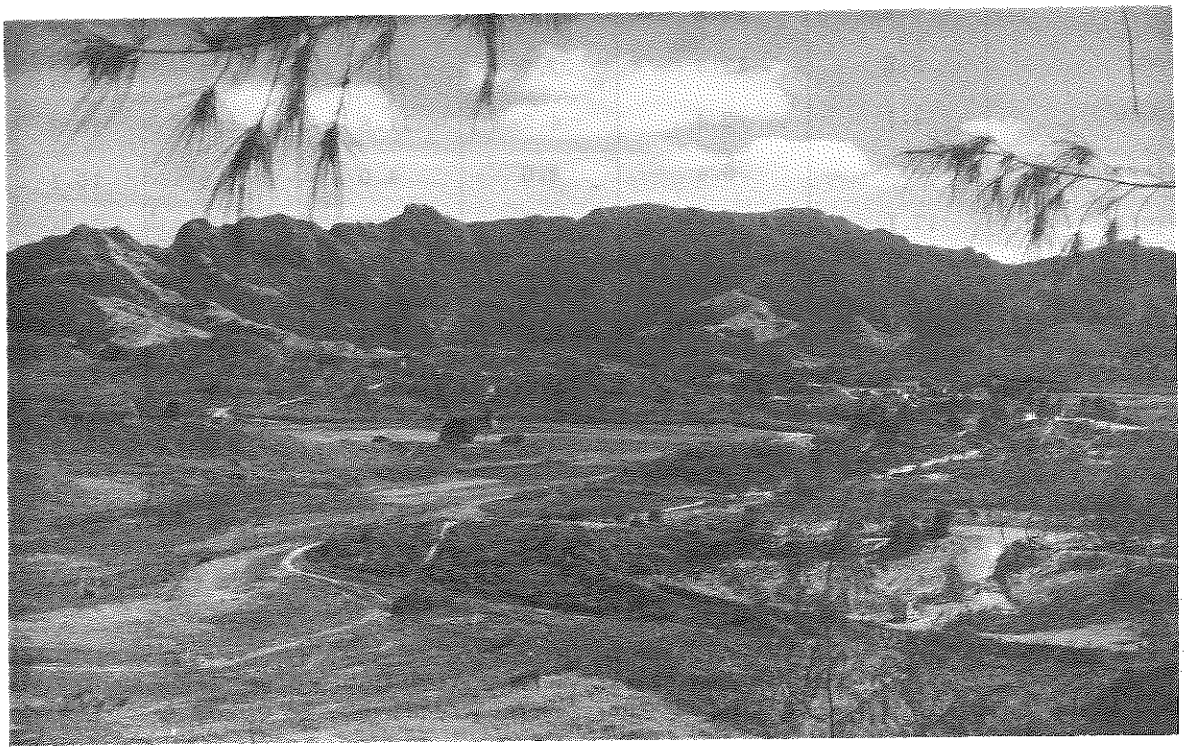

Plate 9 Forest type GDS on steep hills on the north-west side of Vanua Levu. The tree at top foreground is *nokonoko* (*Casuarina equisetifolia*).

Location and extent Down the north-east side of Vanua Levu a series of steeply rising hills jut out, separating the flat alluvial plains of the Wainikoro, Mbuthaisau, Nggawa and Lambasa Rivers. The forest cover on these very steep hills has been included in this type so the type covers a wide area although it has not been sampled extensively. The area of this type covered by the enumeration is 2 890 ha (7 141 ac).

Discussion The forest on the steep slopes adjacent to the cane lands is under constant exploitation by local inhabitants seeking timber and poles for house building and firewood, as well as grazing for their bullocks and cows.

Type GS: Low-stocked forest on short, very steep slopes

Airphoto appearance The ridge crests have a dark grey medium- to coarse-grained texture and appear rounded by the canopy of trees, contrasting with the steep hillsides which have a fine-grained texture.

Topography Dissected long spurs in a herring-bone pattern characterise this type. The slopes are very steep but short. Some landslips can be recognised on the photographs as white triangles of bare earth and rock scree.

Species composition and stocking The ridge crests carry the better species such as *yasiyasi* (Myrtaceae), *damanu* (*Calophyllum* sp.), *kaudamu* (*Myristica* spp.) and *dakua makadre* (*Agathis vitiensis*), whereas the very steep sides carry the species associated with scree slopes such as *sasauwira* (*Dysoxylum* sp.), *koka* (*Bischofia javanica*), *salato* (*Laportea harveyi*), *mako* (*Trichospermum* sp.) and many more, as well as the last two booked as 'Others'. In Vanua Levu the forest is of better quality containing more *kaudamu* and some *dakua salusalu* (*Podocarpus vitiensis*). The species composition for 3 typical catchments is given in Table 17.

TABLE 17 The stocking of type GS in 3 catchments: volume of trees over 35 cm d.b.h. in m^3/ha

Tree name	Waini-koroiluva	Nambukelevu North-East	Wailevu
Others	8.7	12.8	12.3
Yasiyasi	6.8	8.0	7.5
Damanu	2.9	5.4	6.9
Kauvula	6.1	7.0	0.4
Sasauwira	4.1	5.2	3.6
Koka	2.7	6.7	2.8
Kaudamu	0.9	3.4	5.2
Dakua makadre	0.4	1.5	0.8

The stocking of trees over 35 cm d.b.h. ranges from 20 to 50 m^3/ha (2 695 - 6 738 Hsl ft/ac) in Viti Levu whereas in Vanua Levu it tends to be higher; 3 catchments with areas of over 1 000 ha (2 470 ac) sampled there have stockings of over 60 m^3/ha (8 086 Hsl ft/ac).

Structure and height The tops of the ridges have a closed upper canopy with a height of from 20 to 25 m (65 - 82 ft) whereas on the sides of the hills the canopy is often open with large short-boled trees growing in a matrix of poles.

Location and extent This forest type is widespread in Viti Levu and Vanua Levu covering a total enumerated area of 13 983 ha (34 552 ac). In Viti Levu it covers extensive areas in the rugged inland catchments which include Wainikoroiluva and the Korombasambasanga hills (Wainikoroiluva, Nambukelevu North-East and Mavuvu catchments). In Vanua Levu it occurs in the south-west and north-west, particularly in the Ndrawa, Yanawai and Wailevu catchments.

Type S1: Low-stocked open canopy woodland on very steep slopes

Airphoto appearance A stippled effect of light and dark tones is characteristic of this type, the dark tone of the trees contrasting with the light tone of the exposed herb layer. In some places the canopy is nearly closed, in which case the type is recognised by the dark shadows surrounding the individual tree crowns.

Topography The type occurs on long, very steep slopes of over 30° which have a shallow soil cover of only a few centimetres over rock scree.

Species composition and stocking Most of the trees over 35 cm d.b.h. are in 'Others', which may have a volume as high as 10 m^3/ha (1 348 Hsl ft/ac). Typical species are: *tarawau* (*Dysoxylum* spp.), *makosoi* (*Cananga odorate*), *doi* (*Alphitonia* sp.), *vota* (*Geissois ternata*), *salato* (*Laportea harveyi*) and *yaro* (*Premna taitensis*). *Kauvula* (*Endospermum macrophyllum*) and *koka* (*Bischofia javanica*) are common with stockings ranging from 1 to 4 m^3/ha (135 - 539 Hsl ft/ac). Other species that are common to the closed-canopy forest, but here only have a volume of less than 1 m^3/ha (< 135 Hsl ft/ac), are *sa* (*Parinari insularum*), *sasauwira* (*Dysoxylum richii*), *yasiyasi* (Myrtaceae) *kaunicina* (*Canarium* spp.), *kaudamu* (*Myristica* spp.) and *damanu* (*Calophyllum vitiense*). Many trees do not reach timber size but grow with wide crowns branching from the ground. A common species is *rote* (*Macaranga* spp.), which, like *kauvula* and *koka*, is a member of the family Euphorbiaceae, *Allstonia vitiensis var. vitiensis*, tree fern (*Cyathaea lunulata*), the hill bamboo (*Schizostachyum glaucifolium*) and *vau* (*Hibiscus tiliaceus*).

The stocking of trees over 35 cm d.b.h. ranges from 7 to 50 m^3/ha (943 - 6 738 Hsl ft/ac) with an average of 30 m^3/ha (4 043 Hsl ft/ac).

Structure and height The trees reach a height of 7 to 14 m (23 - 46 ft) with a canopy closure ranging from $\frac{5}{10}$ to $\frac{9}{10}$. The crowns are deep and the merchantable bole in consequence is short. Climbers abound, draping the low trees and shrubs. Patches of *gasau* (*Myscanthus*) occur between the trees.

Location and extent This type occurs in half the catchments enumerated and covers an area of 17 176 ha (42 442 ac). It is widespread on the sides of the Nandarivatu Plateau and on the south side of the chain of hills that run north-east from Ndelainakoro.

Discussion This present vegetation cover is probably due to the clearing of the original forest for farming in the past. Some soil erosion may have taken place, but not necessarily so, as type CS, a well stocked forest on long, very steep slopes, occurs over similar soils.

PART 4. REFERENCES AND RELEVANT WORKS

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APPENDIXES 1 - 4

APPENDIX 1. NOTE ON FIJIAN SPELLING

In this report phonetic spelling has been used for Fijian place names in order to conform to the spelling on the base maps. The names of trees, on the other hand, have been spelt in Fijian spelling, which uses the following conventions

B is pronounced MB as in number
C is pronounced TH as in that
D is pronounced ND as in end
G is pronounced NG as in sing
Q is pronounced NG as in finger

APPENDIX 2. FORMULA FOR COMPUTING THE VARIANCE OF THE VOLUME ESTIMATE

The sampling error is obtained by taking the square root.

$$\frac{n(N-n)}{N(n-1)} \times \frac{\left(\sum_{i=1}^{N} M_i\right)^2}{\left(\sum_{i=1}^{n} M_i\right)^2} \left\{ \sum_{i=1}^{n} \left(\sum_{j=1}^{M_i} x_{ij} \right)^2 - \frac{\left(\sum_{i=1}^{n} \sum_{j=1}^{M_i} x_{ij} \right)^2}{n} - 2 \frac{\sum_{i=1}^{n} \sum_{j=1}^{M_i} x_{ij}}{\sum_{i=1}^{n} M_i} \right.$$

$$\left. \left[\sum_{i=1}^{n} \left(M_i \sum_{j=1}^{M_i} x_{ij} \right) - \frac{\sum_{i=1}^{n} M_i \sum_{i=1}^{n} \sum_{j=1}^{M_i} x_{ij}}{n} \right] + \frac{\left(\sum_{i=1}^{n} \sum_{j=1}^{M_i} x_{ij} \right)^2}{\left(\sum_{i=1}^{n} M_i \right)^2} \left[\sum_{i=1}^{n} (M_i)^2 - \frac{\left(\sum_{i=1}^{n} M_i \right)^2}{n} \right] \right\}$$

where N = total number of possible lines

n = number of lines sampled

M_i = total number of possible plots in the i^{th} line

x_{ij} = volume on j^{th} plot in i^{th} line

APPENDIX 3a. VOLUME TABLE: ALL SPECIES -

Diameter at breast height (cm)	Height of merchant-						
	4	5	6	7	8	9	10
35	0.34	0.40	0.46	0.52	0.58	0.64	0.70
37.5	0.38	0.45	0.52	0.59	0.66	0.73	0.79
40	0.42	0.50	0.58	0.65	0.73	0.81	0.89
42.5	0.46	0.55	0.64	0.72	0.81	0.90	0.99
45	0.50	0.60	0.70	0.80	0.90	1.00	1.10
47.5	0.55	0.66	0.77	0.88	0.99	1.10	1.21
50	0.59	0.72	0.84	0.96	1.09	1.21	1.33
52.5	0.64	0.78	0.92	1.05	1.19	1.32	1.46
55	0.70	0.85	0.99	1.14	1.29	1.44	1.59
57.5	0.75	0.92	1.08	1.24	1.40	1.56	1.73
60	0.81	0.99	1.16	1.34	1.52	1.69	1.87
62.5	0.87	1.06	1.25	1.45	1.64	1.83	2.02
65	0.93	1.14	1.35	1.56	1.76	1.97	2.18
67.5	1.00	1.22	1.45	1.67	1.89	2.12	2.34
70	1.07	1.31	1.55	1.79	2.03	2.27	2.51
72.5	1.14	1.39	1.65	1.91	2.17	2.43	2.68
75	1.21	1.48	1.76	2.04	2.31	2.59	2.86
77.5	1.28	1.58	1.87	2.17	2.46	2.76	3.05
80	1.36	1.67	1.99	2.30	2.62	2.93	3.24
82.5	1.44	1.77	2.11	2.44	2.78	3.11	3.44
85	1.52	1.88	2.23	2.59	2.94	3.29	3.65
87.5	1.61	1.98	2.36	2.73	3.11	3.49	3.86
90	1.69	2.09	2.49	2.89	3.28	3.68	4.08

$y = 0.104 + 0.00004908\ D^2H$

coefficient of determination $r^2 = 0.9074$

coefficient of linear correlation = $r = \sqrt{0.9074} = 0.9526$

VITI LEVU (VOLUME IN CUBIC METRES OVER BARK)

able bole (metres)									
11	12	13	14	15	16	17	18	19	20
0.77	0.83	0.89	0.95	1.01	1.07	1.13	1.19	1.25	1.31
0.86	0.93	1.00	1.07	1.14	1.21	1.28	1.35	1.42	1.48
0.97	1.05	1.12	1.20	1.28	1.36	1.44	1.52	1.60	1.67
1.08	1.17	1.26	1.34	1.43	1.52	1.61	1.70	1.79	1.88
1.20	1.30	1.40	1.50	1.59	1.69	1.79	1.89	1.99	2.09
1.32	1.43	1.54	1.65	1.76	1.88	1.99	2.10	2.21	2.32
1.45	1.58	1.70	1.82	1.94	2.07	2.19	2.31	2.44	2.56
1.59	1.73	1.86	2.00	2.13	2.27	2.40	2.54	2.67	2.81
1.74	1.89	2.03	2.18	2.33	2.48	2.63	2.78	2.92	3.07
1.89	2.05	2.21	2.38	2.54	2.70	2.86	3.02	3.19	3.35
2.05	2.22	2.40	2.58	2.75	2.93	3.11	3.28	3.46	3.64
2.21	2.40	2.60	2.79	2.98	3.17	3.36	3.55	3.75	3.94
2.38	2.59	2.80	3.01	3.21	3.42	3.63	3.84	4.04	4.25
2.56	2.79	3.01	3.23	3.46	3.68	3.90	4.13	4.35	4.58
2.75	2.99	3.23	3.47	3.71	3.95	4.19	4.43	4.67	4.91
2.94	3.20	3.46	3.72	3.97	4.23	4.49	4.75	5.01	5.26
3.14	3.42	3.69	3.97	4.25	4.52	4.80	5.07	5.35	5.63
3.35	3.64	3.94	4.23	4.52	4.82	5.11	5.41	5.70	6.00
3.56	3.87	4.19	4.50	4.82	5.13	5.44	5.76	6.07	6.39
3.78	4.11	4.45	4.78	5.11	5.45	5.78	6.12	6.45	6.78
4.00	4.36	4.71	5.07	5.42	5.78	6.13	6.49	6.84	7.19
4.24	4.61	4.99	5.36	5.74	6.12	6.49	6.87	7.24	7.62
4.48	4.87	5.27	5.67	6.07	6.46	6.86	7.26	7.66	8.05

Confidence limits for estimation of y from observations of x:

standard error at mean = 0.45 m^3

confidence limits at mean = $\pm$ 0.88 m^3

APPENDIX 3b. VOLUME TABLE: DAKUA MAKADRE IN NANDARIVATU AND

Diameter at breast height (cm)	Height of merchant-					
	8	9	10	11	12	13
35	0.71	.78	.85	.92	.98	1.05
37.5	0.79	.87	.95	1.02	1.10	1.18
40	0.88	.97	1.05	1.14	1.23	1.32
42.5	0.97	1.07	1.17	1.27	1.37	1.46
45	1.06	1.18	1.29	1.40	1.51	1.62
47.5	1.17	1.29	1.41	1.54	1.66	1.79
50	1.27	1.41	1.55	1.69	1.82	1.96
52.5	1.39	1.54	1.69	1.84	1.99	2.14
55	1.50	1.67	1.84	2.00	2.17	2.34
57.5	1.63	1.81	1.99	2.17	2.35	2.54
60	1.76	1.95	2.15	2.35	2.55	2.75
62.5	1.89	2.11	2.33	2.54	2.75	2.96
65	2.03	2.36	2.50	2.73	2.96	3.19
67.5	2.18	2.43	2.68	2.93	3.18	3.43
70	2.33	2.60	2.87	3.14	3.41	3.67
72.5	2.49	2.77	3.06	3.35	3.64	3.93
75	2.65	2.96	3.27	3.57	3.88	4.19
77.5	2.18	3.14	3.47	3.80	4.13	4.46
80	2.99	3.34	3.69	4.84	4.39	4.75
82.5	3.17	3.54	3.91	4.29	4.66	5.04
85	3.35	3.75	4.14	4.54	4.94	5.34
87.5	3.54	3.96	4.38	4.80	5.22	5.64
90	3.74	4.18	4.63	5.07	5.52	5.96
92.5	3.14	4.41	4.88	5.35	5.82	6.29
95	4.14	4.64	1.13	5.63	6.12	6.62
97.5	4.35	4.88	5.40	5.92	6.44	6.96
100	4.57	5.12	5.67	6.22	6.77	7.32
102.5	4.79	5.27	5.95	6.52	7.10	7.68
105	5.82	5.63	6.23	6.84	7.44	8.05
107.5	5.25	5.89	6.52	7.16	7.79	8.43
110	5.49	6.16	6.82	7.49	8.15	8.82
112.5	5.74	6.43	7.13	7.82	8.52	9.21

WAINIMALA CATCHMENTS, VITI LEVU (VOLUME IN CUBIC METRES OVER BARK)

able bole (metres)					
14	15	16	17	18	
1.12	1.18	1.25	1.32	1.39	
1.26	1.33	1.41	1.49	1.57	
1.41	1.49	1.58	1.67	1.76	
1.56	1.66	1.76	1.86	1.96	
1.73	1.84	1.95	2.07	2.18	
1.91	2.03	2.16	2.28	2.41	
2.10	2.24	2.37	2.51	2.65	
2.29	2.45	2.60	2.75	2.90	
2.50	2.67	2.83	3.00	3.17	
2.72	2.90	3.08	3.26	3.44	
2.94	3.14	3.34	3.54	3.74	
3.18	3.39	3.61	3.82	4.04	
3.42	3.66	3.89	4.12	4.35	
3.68	3.93	4.18	4.43	4.68	$Y = 0.1749 + 0.00005494\ D^2H$
3.94	4.21	4.48	4.75	5.02	coefficient of determination $r^2 = 0.9188$
4.22	4.51	4.80	5.08	5.37	coefficient of linear correlation $r = 0.9585$
4.50	4.81	5.12	5.43	5.74	
4.80	5.12	5.45	5.78	6.11	Confidence limits for estimation of y from observations of x:
5.10	5.45	5.80	6.15	6.50	standard error at mean = 0.76
5.41	5.78	6.16	6.53	6.91	confidence limits at mean $\pm$ 1.49
5.73	6.13	6.53	6.92	7.32	
6.06	6.18	6.91	7.32	7.75	
6.41	6.85	7.30	7.74	8.19	
6.76	7.23	7.70	8.17	8.64	
7.12	7.61	8.11	8.60	9.10	
7.49	8.01	8.53	9.05	9.58	
7.87	8.42	8.97	9.51	10.06	
8.26	8.83	9.41	9.99	10.56	
8.65	9.26	9.87	10.47	11.08	
9.06	9.70	10.33	10.97	11.60	
9.48	10.15	10.81	11.48	12.14	
9.91	10.60	11.30	12.00	12.69	

APPENDIX 4. BOTANICAL AND LOCAL NAMES OF COMMON TREES AND SHRUBS

BOTANICAL NAME	*LOCAL NAME*
PINACEAE	
Agathis vitiensis	dakua makadre
TAXACEAE	
Dacrydium elatum	yaka
Dacrydium nausoriense	yaka drau lailai
Podocarpus neriifolius var. *neriifolius*	kuasi
Podocarpus neriifolius var. *degeneri*	kuasi
Podocarpus imbricatus	amunu
Podocarpus vitiensis	dakua salusalu
DEGENERIACEAE	
Degeneria vitiensis	masiratu, vavaloa
ANNONACEAE	
Cananga odorata	makosoi
Cyathocalyx insularis	
Xylopia pacifica	dulewa
Cyathocalyx suaveolens	tubu-ni-makosoi
LAURACEAE	
Cinnamomum fitianum	makosoi-ni-veikau
Cryptocarya parinariodes	nacou
Endiandra reticulata	damabi
Endiandra elaeocarpa	damabi
Endiandra gillespiei	damabi
Endiandra luteola	damabi
Endiandra monticola	damabi
Litsea mellifera	lidi
HERNANDIACEAE	
Gyrocarpus americanus	wiriwiri
Hernandia olivacea	duvula
Hernandia peltata	evuevu
MYRISTICACEAE	
Myristica castaniifolia	kaudamu
Myristica chartacea	kaudamu-drau-lalai
Myristica gillespieana	kaudamu, male, kaudamu-drau-levi
Myristica grandifolia	kaudamu
DILLENIACEAE	
Dillenia biflora	kuluva
ROSACEAE	
Parinari insularum	sa
Parinari glaberrima	makita
CAESALPINIACEAE	
Cynometra insularis	cibicibi
Intsia bijuga	vesi
Inocarpus fagiferus	ivi
Maniltoa floribunda	moivi
Maniltoa minor	moivi
Maniltoa grandiflora	moivi
Maniltoa brevipes	moivi
Storckiella vitiensis	marasa
Kingiodendron platycarpum	cibicibi
MIMOSACEAE	
Acacia richii	qumu
Samanea saman	raintree
Serianthes myriadenia	vaivai-ni-veikau
PAPILIONACEAE	
Erythrina variegata var. *orientalis*	drala
Pongamia pinnata	vesivai
CUNONIACEAE	
Geissois ternata var. *glabrior*	vota
Geissois ternata var. *ternata*	vota
ARALIACEAE	
Plerandra insolita	sole
Schefflera seemanniana	sole
CASUARINACEAE	
Casuarina nodiflora	velau
Casuarina equisitifolia	nokonoko

*This list was compiled during the period of fieldwork (1967-69) with the assistance of the Director of the Herbarium, Suva and the scientific binomials given were in current use and were believed to be correct at that time.

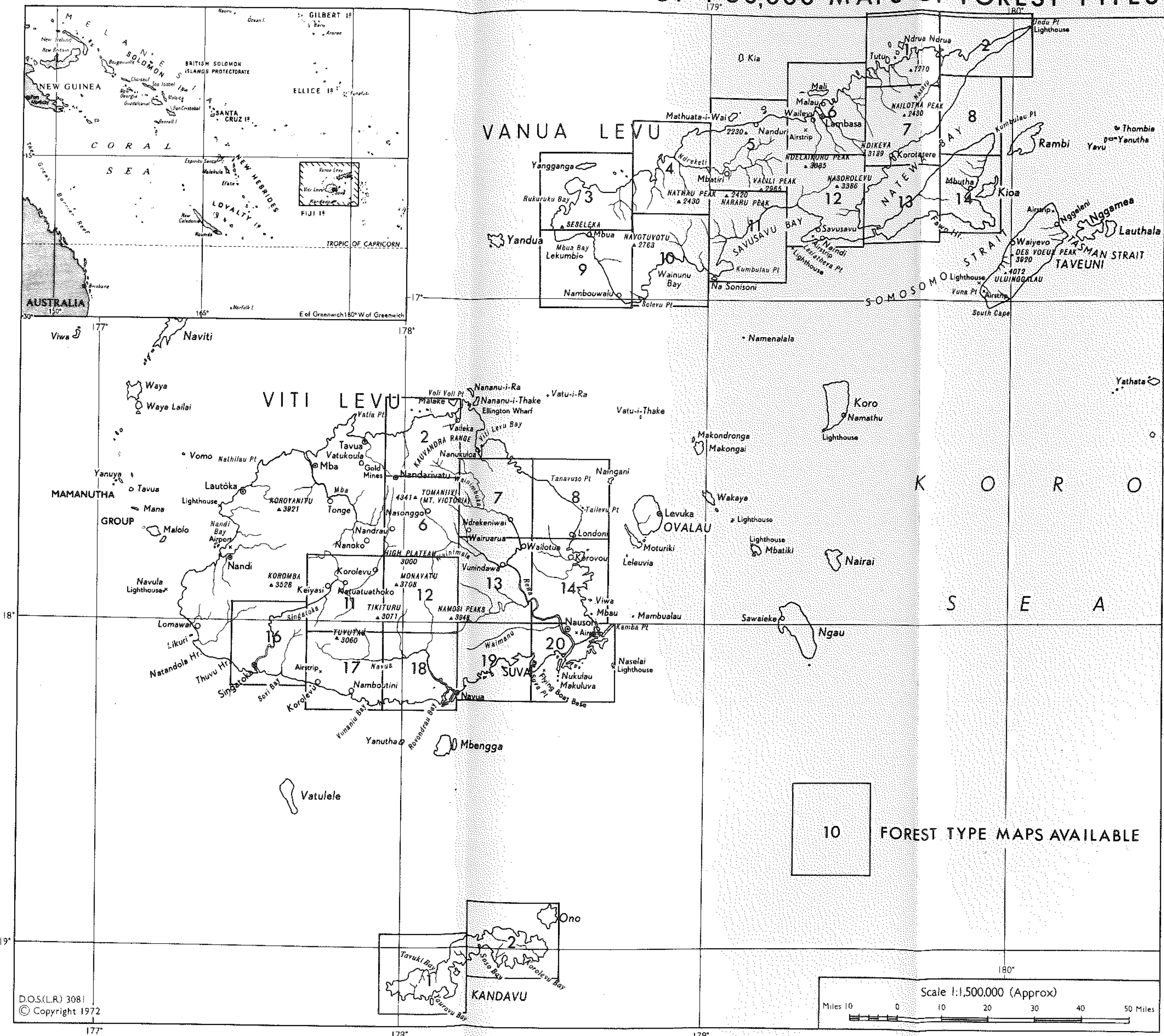
BOTANICAL NAME	LOCAL NAME
ULMACEAE	
Girronniera celtidifolia	sisisi
MORACEAE	
Ficus begoniifolia	
Ficus vitiensis	lolo
URTICACEAE	
Laportea harveyi	salato
GONYSTILACEAE	
Gonystylus punctatus	mavota
PROTEACEAE	
Kermedecia ferruginea	kauceutidrau-damu
Kermedecia vitiensis	kauceuti
TILIACEAE	
Berrya pacifica	tivivula
Elaeocarpus cassinoides	tabadamu
Elaeocarpus chelonimorphus	tabadamu
Elaeocarpus graeffei	tabadamu
Elaeocarpus kambi	tabadamu (kabi)
Elaeocarpus lepidus	tabadamu
Elaeocarpus storckii	tabadamu
Elaeocarpus subcapitatus	tabadamu
Trichosperum calyculatum	makoloa
Trichospermum richii	mako
STERCULIACEAE	
Commersonia bartramia	sama
Heritiera ornithocephala	rogi
Heritiera littoralis	kedraivi
Pterocymbium oceanicum	ma
Firmiana diversifolia	vauceva
Sterculia vitiensis	waciwaci
EUPHORBIACEAE	
Aleurites moluccana	lauci
Bischofia javanica	koka
Endospermum macrophyllum	kauvula
Endospermum robbieanum	vulavula
Macaranga graeffeana var. *graeffeana*	davo, gadoa
Macaranga seemanni var. *seemanni*	davo, gadoa
Glochidion seemanni	molau
OCHNACEAE	
Brackenridgea nitida	

BOTANICAL NAME	LOCAL NAME
CLUSIACEAE	
Calophyllum inophyllum	dilo
Calophyllum vitiense	damanu
Calophyllum neo-ebudicum	damanu drau-lalai
Calophyllum cerasiferum	damanu dilodilo
Garcinia myrtifolia	laubu
Garcinia pseudoguttifera	bulumaga
Garcinia sessilis	buluwai
Garcinia vitiensis	bulu
Mammea odorata	vetau
MYRTACEAE	
Cleistocalyx eugenioides	yasiyasi
Cleistocalyx ellipticus	yasiyasi
Cleistocalyx longiflorus	yasiyasi
Cleistocalyx myrtoides	yasiyasi
Cleistocalyx seemanni	yasiyasi
Cleistocalyx sp. nov.	yasimoli
Metrosideros collina (3 varieties)	vuga
Piliocalyx wagapensis	yasiyasi
Syzygium brackenridgei	yasiyasi
Syzygium confertiflorum	yasiyasi
Syzygium corynocarpum	yasiyasi
Syzygium curvistylum var. *curvistylum*	yasiyasi
Syzygium diffusum var. *diffusum*	yasiyasi
Syzygium diffusum var. *purpureum*	yasiyasi
Syzygium effusum	yasiyasi
Syzygium fijiense	yasiyasi
Syzygium gracilipes	yasiyasi
Syzygium leucanthum	yasiyasi
Syzygium malaccense	yasiyasi
Syzygium nidie	yasiyasi
Syzygium oblongifolium	yasiyasi
Syzygium quadrangulatum	yasiyasi
Syzygium rubescens var. *rubescens*	yasiyasi
Syzygium seemannianum	yasiyasi
LECYTHIDACEAE	
Barringtonia asiatica	vutuwai
Barringtonia edulis	vutukana
Barringtonia petiolata	vutu
Barringtonia racemosa	vutu
RHIZOPHORACEAE	
Crossostylis seemannii	Tirivanua
COMBRETACEAE	
Terminalia catappa	tavola
Terminalia litoralis	tavola
Terminalia pterocarpa	tivi
Terminalia vitiensis	tivi

BOTANICAL NAME	*LOCAL NAME*
SANTALACEAE	
Santalum yasi	yasiboi
RHAMNACEAE	
Alphitonia franguloides	doidamu
Alphitonia zizyphoides	doi
Colubrina micropetala	temanu
SAPOTACEAE	
Burckella brachypoda	bauvudi
Burckella multinervis	bauloa, bau
Burckella thurstonii	bauloa, bau
Manilkara multinerois	bausogali
Palaquium fidjiense	bauvudi
Palaquium hornei	sacau
Palaquium stehlinii	bauvudi
Palaquium vitilevuense	bauvudi, bulubau,
Planchonella costata var. *smithii*	bauloa, bau
Planchonella costata var. *vitiensis*	bausa, bau
Planchonella linggensis var. *linggensis*	sarosaro
Planchonella linggensis var. *garberi*	sarosaro
Planchonella membranacea	sarosaro
Planchonella pyrulifera	sarosaro
Planchonella vitiensis	sarosaro
Planchonella spec. nov.	- (Coastal sites)
RUTACEAE	
Fagara gillespiana	totowiwi
SIMAROUBACEAE	
Amaroria soulameoides	seleqa
BURSERACEAE	
Canarium harveyi var. *harveyi*	kaunicina
Canarium vitiense	kaunicina
Canarium vanikoroense	kaunicina
Haplolobus floribundus	kaunigai
MELIACEAE	
Aglaia archboldiana	-
Aglaia axiplaris	-
Aglaia elegans	-
Aglaia gracilis	-
Aglaia greenwoodii	waicavucavu, maladamu
Aglaia vitiensis var. *minor*	-
Aglaia vitiensis var. *vitiensis*	-
Dysoxylum gillespieanum	mala
Dysoxylum lenticellare	mala
Dysoxylum myriandrum	mala
Dysoxylum quercifolium	tarawau-kei-rakaka
Dysoxylum richii	sasauwira
Dysoxylum sp. nov.	sorovulu
Vavaea amicorum	cevua
SAPINDACEAE	
Aryterya brackenridgei	-
Cupaniopsis induta	-
Dodonaea viscosa	-
Elattostachys falcata	drausasa
Koelreuteria elegans	manawi
Pometia pinnata	dawa
ANACARDIACEAE	
Buchanania attenuata	kaukaro
Dracontomelon vitiense	tarawau
Rhus simarubaefolia	manawi
Semecarpus vitiensis	kaukaro
Pleiogynium timoriense	totowiwi
Spondias cytherea	wi
POTALIACEAE	
Fagraea gracilipes	buabua
STRYCHNACEAE	
Couthovia corynocarpa	bo
APOCINACEAE	
Alstonia montana	-
Alstonia vitiensis var. *vitiensis*	sorua
Alstonia reineckeana	sorua, drega
Cerbera odollam	vasa
Pagiantha thurstonii	tadalo
RUBIACEAE	
Neonauclea forsteri	bo
Mastixiodendron flavidum	kauloa
Mastixiodendron sp. nov.	kauloa
Timonius affinis var. *affinis*	tirivanua
VERBENACEAE	
Gmelina vitiensis	rosawa
Premna taitensis	yaro
Vitex quinata	

FIJI ISLANDS

COVERAGE OF 1:50,000 MAPS OF FOREST TYPES



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PUBLICATIONS OF THE LAND RESOURCES DIVISION

These publications have a restricted distribution and are not available to booksellers. The Division makes a report on each completed project. The report is published as a *Land Resource Study* or *Technical Bulletin* only with the consent of the government concerned. The abbreviated titles of the reports in the style of the 'World List of Scientific Periodicals' are *Land Resour. Stud.* and *Tech. Bull. Land Resour. Div. overseas Dev. Admin.*

BAWDEN M G and LANGDALE-BROWN I	1961	An aerial photographic reconnaissance of the present and possible land use in the Bamenda Area, Southern Cameroons.*
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* Out of print.

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Land Resource Study

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Foreign and Commonwealth Office

Fiji Forest Inventory

Volume 2

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Foreign and Commonwealth Office
Overseas Development Administration

Fiji Forest Inventory
Volume 2
Catchment Groups of Viti Levu and Kandavu

by

M J Berry and W J Howard

Land Resource Study No. 12

Land Resources Division, Tolworth Tower,
Surbiton, Surrey, England
1973

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The Navua Catchment Group

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PART 1. THE REWA CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The Rewa is by far the biggest river in Fiji and its catchment area occupies the eastern half of Viti Levu. For the purposes of the forest inventory this area has been designated a Catchment Group, comprising the following 8 catchments listed below, each of which has been allocated a computer code number. (See Text Map 6.)

59/1	Waimanu	59/5	Lomaivuna
59/2	Waindina	59/7	Wainimala
59/3	Sovi	59/10	Wainimbuka
59/4	Waindrandra	59/11	Wainivandu

The 2 catchments Wailoa and Tawa on the Nandarivatu Plateau which have forest are described under that heading. The Catchment Group is bounded in the north and north-east by the Kauvandra and Nakorotumbu hills and in the west by the Korombasambasanga range. In the south the coastal hill range lies between the Catchment Group and the sea. Administratively it lies mainly in Naitasiri Province but touches on Namosi in the west and Tailevu in the north-east.

CLIMATE

The Rewa Catchment Group lies mostly in the climatic zone F (see Volume 1) which has a high mean annual rainfall of more than 3 800 mm (150 in) and a very weak dry season or none at all. The Wainimbuka catchment on the east side of the group falls in zone E, which has a slightly lower mean annual rainfall of 3 050 - 3 800 mm (120-150 in) and a weak dry season of 1 to 2 months duration.

The average annual rainfall increases progressively from 2 650 mm (104 in) in the north to about 4 300 mm (170 in) in the south. Light easterly winds prevail throughout most of the drier season (April-September) so that rain clouds reach this part of the island directly from the sea.

Table 1 gives mean monthly rainfall figures for 4 stations, arranged in a north-to-south list from Dombuilevu to Tholo-i-Suva, on the southern limit of the area. The drier months occur from May to October, the more northern stations having less rain in this period than the southern ones.

TABLE 1 Mean monthly rainfall figures in millimetres and inches

Location	Jan.	Feb.	Mar.	Apr.	May.	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
mm													
Dombuilevu	356	407	393	336	113	104	54	125	138	133	204	276	2 639
Nayavu	419	376	419	489	211	130	86	175	264	186	339	379	3 478
Vunindawa	482	456	533	534	276	142	97	206	241	241	345	378	3 931
Tholo-i-Suva	432	426	447	538	384	240	207	241	334	343	386	369	4 347
in													
Dombuilevu	14.00	16.01	15.48	13.23	4.45	4.08	2.13	4.92	5.44	5.25	8.03	10.87	103.88
Nayavu	16.51	14.79	16.49	19.26	8.29	5.12	3.38	6.90	10.41	7.51	13.33	14.93	136.93
Vunindawa	18.99	17.94	20.98	21.02	10.86	5.61	3.84	8.11	9.51	9.51	13.58	14.88	154.75
Tholo-i-Suva	17.03	16.79	17.59	21.17	13.12	9.45	8.14	9.51	13.14	13.51	15.19	14.56	169.19

The mean monthly relative humidity at 0900 h ranges from 73 to 92% with mean annual averages of 81% at Dombuilevu, 87% at Lomaivuna and 84% at Tholo-i-Suva.

Temperature readings from 3 stations indicate that at the time of heaviest rain in January, February and March the mean monthly maximum temperature is about 29°C (84°F). It falls in June, July and August to 26°C (79°F) and rises gradually in October, November and December to the January temperature. The mean monthly minimum follows the same pattern but is from 4 to 7 degC (7-13 degF).

The north of the area is subject to greater extremes of temperature than the south. At all the stations the temperature falls in the dry months.

GEOLOGY

Lower Tertiary volcanic and sedimentary rocks of the Wainimala Group are exposed in an east-west band running across the middle of the Catchment Group. They consist of basic to acidic volcanic rocks and overlie sedimentary strata which have been intruded by stocks of gabbro-diorite and tonalitegranodiorite. The mid-Tertiary andesites and sedimentary rocks of the Mendrausuthu Andesitic Group form the dramatic hills of the Korombasambasanga and Mendrausuthu ranges as well as the low-lying Waindina sandstones. Sandstone of Pleistocene age underlies the Rewa basin.

In the north of the Catchment Group Upper Pliocene and Pleistocene volcanic and sedimentary rocks (Mba Group) overlie the Wainimala Group. Major rocks are Vatukoro greywacke formed from basaltic detritus deposited partly under marine conditions, and Nakorotunbu basalt underlying the hills of the same name.

LANDFORM AND SOILS

Hill ranges of a mountainous character occur in the south-west corner of the Catchment Group (Korombasambasanga and Mendrausuthu) and in the north-east (Nakorotumbu). Much of the forested land occurs in immature dissected country where the streams flow in deep valleys, separated by knife-edge ridges. All the catchments have this kind of landform, with the exception of Waindrandra and Lomaivuna. These two occur on the Rewa plain where erosion of the nearly horizontally bedded sandstones has given rise to a series of short, steep-sided, rounded hills and narrow winding valleys. All the ridge tops are nearly level at the same elevation, which is less than 152 m (500 ft).

The very steep sides of the high hill ranges are covered by lithosols, which consists of about 15 cm (6 in) of dark brown clay, free of coarse material, above a horizon of soil mixed with a rubble of parent material which may comprise soft decomposing rock to a depth to 45 cm (18 in).

Most of the forest-covered immature dissected country is underlain by soils of the Visa soil set (number 83 of Twyford and Wright, 1965). These are defined as Steepland soils related to humic latosols, developed from intermediate or basic parent materials in a climate that is wet and has no appreciable dry season. Nailoca steepland bouldery clay (83e) and Serua steepland clay and bouldery clay (83g) are widespread soil types. A typical profile of the latter shows 5 cm (2 in) of dark brown clay with a strong, medium subangular blocky structure on 68 cm (27 in) of red clay of moderate, fine subangular blocky structure. The C horizon occurs at a depth of 90 cm (35 in); it contains very many strongly weathered angular stones and is structureless.

Red-yellow podsolic soils are developed over the intrusive diorite rocks. This development has occurred over most of the Sovi catchment and in a narrow band along the Waingga River in the Wainimala catchment. The soil type has been mapped by Twyford and Wright as Narayawa stony sandy clay (90a). It has a topsoil of dark yellowish brown sandy clay loam on brown clay loam to a depth of 24 cm (9 in). Below this the colour becomes pale and the texture loam down to a depth of 86 cm (34 in), where decomposing rock is found.

Soils in the Rewa plain have been classified as Sote and related soils (27) under 'Humic latosols developed on undulating rolling and moderately hilly terrain'. The forest areas are underlain by Sote clay (27f) which typically shows 13 cm (5 in) of brownish red friable clay on 75-90 cm (29-35 in) of red friable clay on weathered tuff or marl.

A small area of limestone (Waindalithi conglomerate) at the southern edge of the Wainimbuka catchment has given rise to a nigrescent soil, Wailotua steepland bouldery clay (64). The profile has a dark brown colour, clay loam texture in the topsoil and clay in the subsoil. Structure grade is strong, usually angular blocky. The soil is shallow with limestone outcrops and a soil depth of about 106 cm (42 in).

VEGETATION

Closed-canopy tropical rain forest covers the more inaccessible catchments such as Waimanu, Sovi and parts of Wainimala. On the Rewa plain and near to the main rivers, such as Waindina and Wainimala, the vegetation consists of a mosaic of cultivated land, mixed shrubs and grass.

The forest ranges in height from 15 to 25 m (49-82 ft) with an average of 50 trees/ha over 35 cm d.b.h. Stocking ranges from 15 to 100 m^3/ha (2 021-13 476 Hsl ft/ac). Common species are *kaudamu, damanu, yasiyasi, kauvula, dakua makadre* and *sacau*. Well stocked forest occurs in the Waimanu and Sovi catchments while the Waindina, Wainimala and Wainimbuka catchments have moderate or poorly stocked forest and some partially-closed canopy woodland, particularly on the very steep hills.

In the Wainimbuka catchment grass and mixed shrub occur on the western side, extending in a tongue down the Wainimbuka River as far as Nambouva. Bamboo and mixed shrub occur on the Rewa plain and in the Wainimala catchment either side of the Wainimala and near the Waithakene River (east of Wairuarua).

POPULATION AND LAND TENURE

The population of the area under consideration is 18 000 persons of whom 14 000 are Fijian and 5 000 are Indian (Zwart, 1968). The Fijians live in villages close to the lines of communication, such as roads and rivers. There are about 100 Fijian villages in the area, usually with a population of less than 100 people in each except for a few big villages such as Nakorosule, Lutu, Naivuthini and Vunindawa which have populations of over 300. The Indians are concentrated along the Rewa River below Vunindawa, where they are engaged in tending cows for milk production and some arable agriculture. The Waimanu, Sovi and Wainivandu catchments have no villages in them.

In the two well forested catchments, Waimanu and Sovi, the unpopulated, forest-covered hill land is under Fijian ownership but is not a native reserve.

Freehold land lies along the lower Rewa below Nangavungavu village where the sugar cane farming used to be, with a small block to the east of Vunindawa.

Small blocks of Crown land are scattered through the area in among the population centres, along the Sawani-Serea road, around Vunindawa and a large block in the upper Wainimbuka either side of Rokovuaka village. Native reserve land occurs in odd-shaped blocks all the way down the Waindina River, covering the alluvial plains and adjacent hills. The same pattern occurs up the Wainimala and its tributary the Waisomo as far as Wairuarua village. In the same way native reserve land lies either side of the Wainimbuka River with sections spreading from 2 to 3 Km (1-2 mi) either side of the road.

PRESENT LAND USE

The Fijians raise crops of cassava, taro, bananas, *yaqona* and yam for their own consumption, and sell some bananas, taro and *yaqona*. The cultivation occurs along the river flats and in isolated clearings in the forest often a few kilometres away from the village.

Banana and, to a small extent, cocoa are grown as cash crops in the Waindina and Wainimbuka catchments. The Lomaivuna Settlement Scheme, where bananas were grown on a commerical scale, is now converted to the cultivation of a variety of root crops.

Grazing of cattle for milk production is confined to the banks of the major rivers such as the Rewa, Waindina and Wainimala, where it has become a well organised industry involving milk collection in outboard-motored canoes.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

No enumerations have taken place in the survey area but reconnaissances were carried out in the 1950s in the Waimanu, Sovi and western Wainimala catchments. These took the form of 'walkabouts' with comments upon the quality of the forest viewed from peaks and ridges.

EXPLOITATION PAST AND PRESENT

There are no major concession areas within the Catchment Group but exploitation has been allowed under annual licences relating to small blocks of forest. The Waimanu catchment has been felled over at its eastern end and along the slopes facing the river for as far as the river is navigable by logs. Here, and throughout the Catchment Group, extraction has been done with bullocks. The result is that the felling consists of a partial exploitation of the forest in which the areas near the main road or river are completely felled over, but an increasing number of useful trees are left standing as the extraction distance lengthens.

SAWMILLS

There are no sawmills in the area. The logs are taken to the many small sawmills that are situated at Nausori and Suva.

PLANTATION SPECIES AND AGE CLASS

Part of the Tailevu Mahogany Plantation extends into the Lomaivuna catchment 5 km (3 mi) to the west of Kasavu village, following the north bank of the Rewa River. The species is mahogany (*Swietenia macrophylla*), the trees having been planted in lines 10 m (33 ft) apart and at intervals of 1.8 m (6 ft) within the lines. Planting was started in 1960.

EXISTING ACCESS ROUTES

The main road from Suva, called the Kings Road, runs northwards along the east coast and turns inland at Korovou. It serves the area from Natokalau northwards where it follows the bank of the Wainimbuka River. A branch off this road connects Nasau with Wailotua. Another branch road serves the village of Soa. A branch road connects Vunindawa with the Kings Road at Natokalau, but there is a passenger-ferry only at Vunindawa, so there is no connection with the Sawani-Serea road. The latter provides access to the Rewa basin; with a new branch road from Nanggali to Nambukaluka and Wainawangga it serves the lower Waindina River as well. The road that serves the Tailevu Mahogany Plantation leaves the Kings Road past Namulomulo and runs along the catchment boundary between the Rewa and the Tailevu Catchment Groups.

In this area it is river transport that links the Fijian villages that lie along the main rivers. The means of transport is a narrow flat-bottomed boat, propelled by an outboard motor which is sufficiently powerful to make headway against the flow of the river.

The Waimanu River is navigable by outboard motorboat for 8 km (5 mi) above Vatuvula to just above the Waingganake creek. The Waindina is navigable as far as Nasirotu. The Wainimala River is navigable as far as Laselevu at the main junction of the Wailoa and Wainimala Rivers. The Waisomo which flows into the Wainimala at Ndraunindakua is navigable as far as Wairuarua. The Wainimbuka River is navigable for as far as there is forest near it, that is to Wailotua. Because the river is paralleled by a road the river is not the sole means of communication in the area.

Paths through the forest follow either the creeks or ridges. They usually keep to the line of their intended direction and are well graded. They range from wide tracks (used by pack horses and maintained, until recently, at government expense) to ephemeral tracks used for hunting wild pig. The people of the upper Waindina valley prefer to carry their market produce to Suva over the hills to the Queens Road near Kalokolevu rather than use the circuitous river route and motorboat carrier. The path from Nasirotu heads south-east, crosses the Waimanu near the Waimbue

creek and joins the Queens Road beside Joske's Thumb on the Naikorokoro feeder road. There is a path from Nasirotu that follows the Waindina River as far as Namosi. Access to the Sovi catchment is hindered by the Mendrausuthu range, which renders the river unnavigable. There is a footpath beside the Sovi River. A branch of this path follows the Wainavambo River southwards and then crosses the watershed to Naseuvou in the Waindina valley; a northern branch links the upper Sovi River with Naivuthini in the Wainimala catchment. An important track suitable for pack horses links the upper Wainimala catchment with the Nandarivatu Plateau. This track, which is well graded, goes from Wairuarua to Numbumakita and then to Nasonggo and Navai. In the Wainimbuka catchment the forest on the Nakorotumbu hills is reached by following a path north from Soa along the Wailou creek.

THE ENUMERATION

LAYOUT OF SURVEY

The Waimanu was the first catchment sampled and the layout of lines is slightly different from that used in sampling the other catchments. In this case the catchment was divided into 1 000 m (3 281 ft) sections along the base line (the river) and the choice as to whether the offset line for each section should fall north or south of the river was decided by three tosses of a coin. This produced the same effect as dividing it into 2 000 m (6 560 ft) sections and having a line on both sides of the river, as described under 'Method' in Volume 1. The layout employed here was discontinued because it could have resulted in an uneven coverage of sample lines, which would have been undesirable as the lines were also used as a guide for mapping the forest types.

In the Waindina catchment one set of lines lay to the south-east of the river and another to the north-west. This was due to the hilly nature of the terrain and discontinuous forest cover.

The Sovi catchment had one set of lines right across the basin at right angles to a base line running in the direction of the main drainage rather than following the Sovi River.

In the Wainimala the base line was chosen along the line of the lower Wainimala River. Airphoto cover indicated that much of the area had a vegetation cover of only poor forest or shrubs. This accounts for the rather fragmented appearance of the sample layout.

Like the Wainimala, the Wainimbuka catchment has only a partial cover of forest. At the southern end the lines ran right across the main road but in the north they sampled the forest on the Nakorotumbu hills.

In the Lomaivuna catchment the base line followed the general line of the Rewa River.

In the Waindrandra catchment the base line ran east-west and the lines crossed small patches of forest at the southern fringe and in the middle of the area.

TIMBER VOLUMES

Enumerated areas for the different forest types are given by catchment in Table 2. The volume of timber in each catchment under the 3 management headings - non-commercial, production and protection forest - are given in Table 3. Table 4 shows the volumes by forest type. The enumerated area covers the production forest. There are areas of forest type J in the Wainimala catchment and other areas of non-commercial forest that have not been enumerated.

DESCRIPTION OF FOREST TYPES

Forest types J, C1, G, CS and S1 account for 85% of the enumerated area.

Type J: Low-stocked fringe forest

This occurs in the Waimanu, Lomaivuna, Wainimala and Wainimbuka catchments covering 7 513 ha (18 565 ac) or 12% of the total enumerated area.

TABLE 2 Enumerated areas of forest types in the Rewa Catchment Group (ha)

Forest type	Waimanu	Waindina	Sovi	Waindrandra	Lomaivuna	Wainimala	Wainimbuka	Wainivandu	Total enumerated area		% of enumerated forest
									ha	ac	
H	1 259	-	-	-	-	-	-	-	1 259	3 111	2
J	244	-	-	-	1 280	5 513	476	-	7 513	18 565	13
S	-	-	-	191	-	131	208	-	530	1 310	1
Non-commercial	1 503	-	-	191	1 280	5 644	684	-	9 302	22 985	16
C1	5 609	906	1 563	835	613	1 930	-	246	11 702	28 916	19
C2	296	-	-	-	-	-	-	-	296	731	1
CY	-	567	947	-	-	-	-	-	1 514	3 741	2
DK	-	-	-	-	-	-	8	-	8	20	<1
DS	-	-	-	-	-	-	302	-	302	746	1
E	385	-	-	-	-	-	-	-	385	951	1
G	2 818	1 212	2 260	740	1 912	3 849	2 454	230	15 475	38 239	26
GY	-	116	-	-	-	-	-	-	116	287	1
KV	-	1 745	1 848	-	825	-	1 863	208	6 489	16 034	11
SK	-	27	1 631	-	-	1 558	-	-	3 216	7 947	5
Production	9 108	4 573	8 249	1 575	3 350	7 337	4 627	684	39 503	97 611	67
B	87	-	-	-	-	-	-	-	87	215	<1
CS	2 754	507	314	-	-	1 134	578	60	5 347	13 212	9
GS	-	-	69	-	-	-	1 086	-	1 155	2 854	2
S1	-	-	1 595	-	-	142	2 544	97	4 378	10 818	7
Protection	2 841	507	1 978	-	-	1 276	4 208	157	10 967	27 099	18
Total									59 772	147 697	

TABLE 3 Volume of timber from trees over 40 cm d.b.h., species group 1-4, reliable minimum estimate, and percentage error by catchment and management category, Rewa Catchment Group ('000 m^3)

Management and catchment	Volume >40 cm s.g. 1-4	Sampling error >40 cm s.g. 1-4	Degrees of freedom	Confidence limit P <0.05	r.m.e. P <0.025	% error	Volume >40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Waimanu	23	3	5	8	15	35	8
Waindrandra	1	-	-	-	-	-	0
Lomaivuna	10	1	5	3	7	30	3
Wainimala	58	10	10	22	36	38	19
Wainimbuka	3	<1	3	1	2	33	1
Total	95				60		31
Production							
Waimanu	518	23	34	47	471	9	172
Waindina	197	10	34	20	177	10	65
Sovi	305	17	23	35	270	11	101
Waindrandra	44	6	8	14	30	32	15
Lomaivuna	128	8	10	18	110	14	43
Wainimala	269	13	13	28	241	10	90
Wainimbuka	116	7	10	17	99	17	39
Wainivandu	32	2	3	6	26	23	11
Total	1 609				1 424		536
Protection							
Waimanu	114	10	14	21	93	19	38
Waindina	23	6	1	76	0	>100	8
Sovi	31	2	8	5	26	17	10
Wainimala	24	3	6	7	17	29	8
Wainimbuka	41	4	9	9	32	22	14
Wainivandu	3	-	-	-	0	-	1
Total	236				168		79

TABLE 4 Total volumes and sampling errors of orest types in the Rewa Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
Waimanu							
J	9	7	5	-	2	21	Non-
H	40	30	18	3	6	14	commercial
Subtotal			23	3	8	15	
C1	625	478	380	19	126	68	Production
C2	29	22	18	-	6	61	
E	3	2	2	0	1	5	
G	198	148	118	13	39	42	
Subtotal			518	23	172	57	
B	2	2	1	-	0	11	Protection
CS	182	144	113	10	38	41	
Subtotal			114	10	38	40	
Waindina							
C1	67	54	48	5	16	53	Production
CY	68	53	49	3	19	86	
G	53	42	34	3	11	28	
GY	4	2	2	1	1	17	
KV	94	75	63	7	21	36	
SK	2	1	1	-	0	37	
Subtotal			197	10	68	43	
CS	31	26	23	6	8	45	Protection
Sovi							
C1	132	104	93	13	31	60	Production
CY	61	47	41	5	14	43	
G	99	79	56	7	19	25	
KV	106	84	71	6	24	38	
SK	67	53	44	4	15	27	
Subtotal			305	17	103	37	
Sovi							
CS	22	18	15	1	5	48	Protection
GS	2	1	1	-	0	14	
S1	41	31	15	2	5	9	
Subtotal			31	2	10	16	

TABLE 4 (continued)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(1) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
Waindrandra							
S	3	3	1	0	0	5	Non-commercial
C1	50	38	31	6	10	37	Production
G	27	22	13	1	4	18	
Subtotal			44	6	14	28	
Lomaivuna							
J	22	17	10	1	3	8	Non-commercial
C1	62	50	33	2	11	54	
G	122	97	62	6	21	32	
KV	61	53	33	4	11	40	Production
Subtotal			128	8	43	38	
Wainimala							
J	121	92	57	10	19	10	Non-commercial
S	1	1	1	0	0	8	
Subtotal			58	10	19	10	
C1	139	115	97	11	32	50	Production
SK	100	81	73	5	24	47	
G	169	133	99	6	33	26	
Subtotal			269	13	89	37	
GS	40	32	23	3	8	20	Protection
S1	2	2	1	0	0	7	
Subtotal			24	3	8	19	
Wainimbuka							
J	6	4	2	0	1	4	Non-commercial
S	2	1	0	0	0	0	
Subtotal			3	0	1	4	

TABLE 4 continued)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(1) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
G	105	84	62	6	21	25	Production
DK	1	1	1	0	0	125	
DS	16	12	10	1	3	33	
KV	74	64	44	4	15	24	
Subtotal			116	7	39	25	
GS	36	32	19	4	6	17	Protection
CS	20	15	10	2	3	17	
S1	38	24	12	1	4	5	
Subtotal			41	4	13	10	
Wainivandu							
C1	22	19	16	2	5	65	Production
G	10	8	8	1	3	35	
KV	11	9	8	0	3	38	
Subtotal			32	2	11	47	
CS	2	2	2	0	1	33	Protection
S1	2	2	1	0	0	10	
Subtotal			3	0	1	19	

In the Lomaivuna, Wainimala and Wainimbuka catchments this type represents typical secondary forest growth with a high proportion of *kauvula*, *kaudamu*, *koka*, *sa* and 'Others'. In the Waimanu catchment *kauvula* and *koka* are not in evidence, the forest being dominated by *sacau* and *kaudamu*. This type occurs on an old landform with very infertile soils.

Type C1: Well stocked mixed forest on moderate to steep short slopes

This type occurs in all the catchments of the Group, except for Wainimbuka. It covers 11 702 ha (28 916 ac) or 20% of the enumerated area.

In all the catchments except Lomaivuna and Wainimala the commonest species are *kauvula* and *kaudamu*. In Waindina, the high *kauvula* stocking is coupled with a high stocking of *dakua makadre* and low stocking of *damanu*, *yasiyasi* and 'Others'. In Lomaivuna *sa*, *kauvula*, *kaudamu* and *mavota* are the common species, *damanu* contributing less than 1 m^3/ha (135 Hsl ft/ac) to the stocking. Wainimala, in contrast to this, has a high stocking of *damanu* as well as *kaudamu*, *kauvula*, 'Others', *yasiyasi*, *sacau*, *rogi* and *dakua makadre*.

The stocking of trees over 40 cm d.b.h. ranges from 46 to 85 m^3/ha (6 199-11 455 Hsl ft/ac) In the Wainimala catchment the block of C1 forest north-east of the river has affinities with the forest type SK that adjoins it.

Type G: Moderately stocked mixed forest on moderate to steep short slopes

This type covers 15 475 ha (38 239 ac) or 25% of the total enumerated area. It occurs in all the catchments covering extensive areas. In Wainimala and Winimbuka most of the forest is type G, with high proportions of *kauvula* and *kaudamu*. In the Sovi and Waindina catchments it occurs amongst the other types with a tendency in the Sovi basin to occur around the edge of the catchment immediately below the steeply rising hills. *Kauvula* and *kaudamu* are once again the predominant species. The Waimanu catchment which was surveyed first, has a high proportion of *sacau* in type G. In the light of subsequent experience type G might have been broken down into the *sacau*-rich forest CY or GY.

Stocking in all these catchments is in the order of 35 m^3/ha (4 717 Hsl ft/ac) (trees over 40 cm d.b.h.).

Type KV: Moderately stocked *kauvula-sa* forest

This type covers an area of 6 489 ha (16 034 ac) or 11% of the total enumerated area. It occurs in 5 catchments, Waindina, Sovi, Lomaivuna, Wainimbuka and Wainivandu.

The main difference between this and type G is that here the *kauvula* stocking is in the order of 20 m^3/ha (2 695 Hsl ft/ac) (compared with 7 m^3/ha (943 Hsl ft/ac) in G). The more or less valueless tree *sa* is more in evidence in this type. *Koka* is present, particularly in catchments in which *kaudamu* is low, such as Wainimbuka and Wainivandu.

Type SK: Moderately to well stocked *sacau-yaka* forest

This distinct type covers an area of 3 216 ha (7 947 ac) occurring in the Waindina, Sovi and Wainimala catchments. In the Sovi catchment the stocking of *dakua makadre* is low, whereas in the Wainimala catchment the stocking of *yaka* is low compared with this type in Vanua Levu.

Type CS: Moderately stocked forest on long, very steep slopes

This type is defined in terms of its physiography rather than its species composition. It occurs along the edges of the catchment where the ground rises up to the watershed. Thus it occurs in the catchments that are steep and hilly, such as Waimanu, Waindina, Sovi, Wainimala and Wainimbuka. It covers an area of 5 347 ha (13 212 ac) or 9% of the enumerated area. The species composition consists of 'Others' and *kauvula*, with *kaudamu*, *koka* and *dakua makadre* contributing smaller volumes. Stocking of trees over 40 cm d.b.h. ranges from 27 to 58 m^3/ha (3 639-7 816 Hsl ft/ac).

Type SI: Low-stocked open canopy woodland on very steep slopes

This type occurs on very steep hills, similar to those associated with type CS. Partially closed canopy woodland on very steep hills covers extensive areas in only 2 catchments, Sovi and Wainimbuka. In Sovi the predominant species are *koka* and *kauvula* and in Wainimbuka they are 'Others', *kauvula* and *sa*.

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

The Waimanu and Sovi catchments have sufficiently large volumes in the production forest categories to make them viable units for sawmills. The production forest in the south-east portion of the Wainimala catchment should be added to the adjacent block in the Wainimbuka catchment to provide sufficient volume to supply one medium-size sawmill. The production forest in the other catchments has too low a volume and is too fragmented to be worth exploiting by a large-scale sawmilling concern, but it can be logged by licencees who carry the logs to Suva or Nausori.

PROPOSED ACCESS ROUTES

Waimanu A road from the Queens Road at Naikorokoro could gain access to upper Waimanu following the route of the track to Nasirotu (described above under Existing Access Routes). Access to the middle section of Waimanu could be gained by cutting a road from the Sawani-Nanggali-Nambukaluka road, along the line of the path from Nambukaluka crossing the Waingganake stream to the Waimanu River (see Sheet 19). This road would tap a large area of well stocked forest on both sides of the Waimanu River.

Sovi Access to the Sovi basin is blocked by the Mendrausuthu range of hills. The best line of approach would be from the Waindina valley to the south, following the track that goes from Naseuvou on the Waindina River beside the Wainavambo River to meet the Sovi River at the foot of the Mendrausuthu hills.

Wainimala and Wainimbuka Access to the forest that lies between the confluence of the Wainimala and Wainimbuka Rivers is best approached from Vunindawa. Two possibilities exist from Vunindawa: either a route due north up the catchment boundary, or one following the Wainimala River on the east bank as far as Navuniyasi. To approach this forest from the Kings Road, running beside the Wainimbuka River would not be easy because this river has cut downwards during a period of uplift leaving the forest land at a higher elevation, separated from the river by some very steep slopes.

PROPOSED TREATMENT OF FOREST TYPES

Non-commercial forest 16% of the enumerated area falls within this category which includes types J, H and S, although most of it is J. This type is common in the Wainimala catchment outside the enumerated area.

Type H in the Waimanu catchment should be replanted or some natural regeneration silvicultural operations carried out. The forest is degraded particularly on the ridge tops where the remaining trees are dying and grass is invading.

It seems likely that type J is a seral stage from cleared land to mature forest. If this is the case it will be many years, possibly centuries, before the forest has grown to maturity. The only forest management that might be done on an experimental basis is to release the crowns of desirable species and poison unwanted species.

Analysed soil samples from this type, taken from the Wainimala catchment, showed low fertility. It may be that the forest type is stagnated at this level of stocking, either by the depletion of soil fertility through cropping, or by climatic influences. If either is the case, planting of mahogany or the incurring of any capital expenditure would be unwise.

Production forest Forest capable of timber production covers 39 503 ha (97 612 ac) and would yield a timber volume of 1 355 600 m^3 (451 million Hsl ft). The data on forest types, either by inference or directly, provide information for forest management on species composition, topography, and, to a limited extent, on site conditions for artificial regeneration. The mixed species types are C1, C2, G and E, whereas CY and GY are rich in *sacau*, a heavy hardwood with a limited market. The conifers occur in types DS and SK of which only SK is of any importance here. Type KV is rich in *kauvula*, which is a timber much used in Fiji for banana boxes, match-making and coffins.

For artificial regeneration it would be unwise to plant in any of the forest types that have a specialised species composition until more is known about the site. Soil sampling in type SK in Wainimala indicated that the *dakua-sacau* forest was growing on an infertile soil.

Protection forest The actual area of protection forest exceeds the enumerated area of 10 967 ha (27 099 ac) because much of the very steep hills were not included in the sampling layout. Areas not included are parts of the Korombasambasanga and Mendrausuthu ranges that fall in this Catchment Group, as well as the steep hills on the eastern side (Nakorotumbu hills).

For the reasons that have been given in the general description of type CS in Volume 1, it is recommended that there is no felling in the protection category forest. It is felt that the timber resources of Fiji are large enough to forego this small portion, where soil erosion and flooding might be the consequences of exploitation.

PART 2. THE TAILEVU CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The area consists of four catchments on the east coast of Viti Levu:

60/1 Naitaleira	60/3 Londoni
60/2 Ndawasamu	60/4 Waimbula

They run from Viti Levu Bay in the north to Korovou village in the south and are bounded on the western side by the Nakorotumbu hills.

The area lies in the tikinas of Nakorotumbu, Sawakasa and part of Verata in Tailevu Province.

CLIMATE

This coast is exposed to the south-east trade winds and comes in climatic zone E, characterised by mean annual rainfall of 3 050-3 800 mm (120-150 in) and a weak dry season with 1 or possibly 2 months having less than 150 mm (6 in) of rainfall.

GEOLOGY

The highland in the Waimbula Catchment is underlain by Wainimbuka trachyte of Miocene age belonging to the Wainimala Group of rocks, the oldest rocks in Fiji. To the north extending up the coast as far as Viti Levu Bay is Nakorotumbu basalt, a basaltic conglomerate of Pleistocene age belonging to the Mba Basaltic Group. On the coast Tova peak is made up of Tova andesite of the same Group. In the south Korovou sandstones belonging to the Verata Sedimentary Group run out to the sea.

LANDFORM AND SOILS

The landform reflects the age and mode of formation of the rocks. The high inland hills of the Waimbula catchment, underlain by the older Wainimala Group rocks are steep but finely dissected, with peaks along the watershed reaching a height of 566 m (1 856 ft). The chain of hills underlain by basalt, on the other hand have small high level plateaux falling away in escarpments on both sides of the range. The elevation of the high peaks along the watershed is 762 m (2 500 ft) falling away northwards to 457 m (1 500 ft). The steep country continues to the coast as far south as Londoni. The landform over the Korovou sandstone consists of short steep slopes with low relief, the rivers flowing on wide, flat valley floors.

The main soils developed over the Wainimala Group of rocks are Seatura steepland stoney and bouldery clay (83d), Nailoca steepland bouldery clay (83e) and Lobau steepland clay (83f). Over the basalt, soils of the Tailevu soil set (84) have developed. Common soil types are Tailevu steepland stony and bouldery clay (84b) and Nacula steepland clay (84c). The former shows 13 cm (5 in) of reddish brown friable clay over 61 cm (2 ft) of red friable stony clay over basalt with many boulders through the profile. Soils developed over the sandstones belong in part to the Sote soil set (27) which are similar to the Visa soils but tend to be deeper.

VEGETATION

In the Naitaleira, Ndawasamu and Londoni catchments forest caps the hills, with open woodland on the slopes and valley bottoms. The hills along the coast are covered with mixed shrub or grass,

which extends up the main river valleys, such as Tavenu, Naimasi and Waivou. The northern part of the Waimbula catchment is forest covered w th tongues of fenced grassland extending up the Waimbula and Wainivesi Rivers. South of the Kings Road the vegetation cover of the Waimbula catchment is poor consisting of mixed shrub and open woodland with isolated blocks of forest.

POPULATION AND LAND TENURE

The population of the area consists of nearly 8 000 Fijians, 1 340 Indians and 200 of other races making a total of 9 540 people. Villages lie along the coast and along the roads. Inland villages are situated on the Ndawasamu River and Rukuruku River in the north of the area. There are two secondary schools on the coast, the Queen Victoria School and Ratu Kandavulevu School at Londoni.

Rectangular blocks of freehold land occur along the coast north of Londoni continuing as far as Ndawasamu. Areas of land in Native Reserve lie along the coast between the freehold land and up the Vatundele creek above Ndawasamu. In the south isolated blocks of Native Reserve occur near Navunisole and Naivithula, but the dairy country on the Waimbula and Wainivesi Rivers is not freehold land or in Native Reserve. The watershed and forested country is under Fijian ownership, but not in Native Reserves.

PRESENT LAND USE

Due to the steep coast line there is no appreciable coastal fringe of flat land north of Ratu Kandavulevu School. Cultivation along the coast is restricted to subsistence agriculture on the small alluvial deltas of the bigger rivers.

Dairy farming is carried on in the extensive areas of lush grass that occur on the valleys of the Waimbula and Wainivesi Rivers. A little rice is grown in the vicinity of Korovou.

The aerial photographs show evidence of past cultivation in this group of catchments and in the area immediately to the east. There are signs of terraces on the slopes beside the rivers.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

In 1953 the Forest Department carried out an enumeration of the catchment of the Waimaro creek, which lies west of Naivithula village and north of the Kings Road. They used a systematic strip sample layout covering 2½% of the area and lower girth limits of 7 ft for *dakua* and 5 ft for other species, roughly equivalent to 68 to 48 cm diameter respectively. Over the whole area of 2 914 ha (7 200 ac) the stocking was found to be 33 m^3/ha (4 500 Hsl ft/ac), but the volume of timber on individual lines varied. The survey figures were used as a guide during the mapping of the forest types in the present survey.

EXPLOITATION PAST AND PRESENT

No commercial logging on a large scale is carried on in this area, but there is a certain amount of small logging conducted on an annual licence basis.

SAWMILLS

No sawmills operate in this area.

PLANTATIONS

Mahogany plantations at Nukurua were started in 1961 and have been added to since.

EXISTING ACCESS ROUTES

The main Kings Road turns west at Korovou to go to Ndakuivuna and then to follow the Wainimbuka valley to Rakiraki. Soon after Korovou a turning to the north follows up the Wainivesi River to Naivithula village. At Korovou the coast road goes to Londoni and north along the coast as far as the Queen Victoria School.

The rivers in this group of catchments are too small to be useful for access.

THE ENUMERATION

LAYOUT OF SURVEY

The Naitaleira and Ndawasamu catchments had the same base line running parallel to the coast with lines cut into the forested part of the hills in a west-south-west direction. The base line for the Londoni catchment followed the coast and the lines went from the forest margin near the road to the watershed. In Waimbula catchment the base line followed the Naivithula road and the lines ran right across the catchment from watershed to watershed.

TIMBER VOLUMES

Enumerated areas of forest types are laid out in Table 5 below. The enumeration covered the production forest, but only partially covered the non-commercial and protection forest. With the exception of Waimbula catchment, the enumerated areas of non-commercial and protection forest are much lower than the total areas under the categories shown in Table 5.

TABLE 5 Enumerated areas of forest types in the Tailevu Catchment Group (ha)

Forest type	Naitaleira	Ndawasamu	Londoni	Waimbula	Total enumerated area		% of enumerated forest
					ha	ac	
J	-	-	-	1 800	1 800	4 448	14
S	-	-	195	-	195	482	2
G2	-	-	2 308	-	2 308	5 703	18
Non-commercial	-	-	2 503	1 800	4 303	10 633	34
C1	144	428	402	1 021	1 995	4 930	15
DS	-	120	114	-	234	578	2
G	86	83	1 145	1 197	2 511	6 205	20
KV	-	-	-	1 703	1 703	4 208	13
Production	230	631	1 661	3 921	6 443	15 921	50
GS	-	231	400	397	1 028	2 540	8
S1	-	-	605	440	1 045	2 582	8
Protection	-	231	1 005	837	2 073	5 122	16
Total					12 819	31 676	

Timber volumes are given in Table 6 below. The production forest contains 272 000 m^3 (91 million Hsl ft) trees over 40 cm d.b.h. species groups 1-4 and a r.m.e. of 219 000 m^3 (73 million Hsl ft). This volume comes from Londoni 77 000 and Waimbula 119 000 m^3 (26 and 40 million Hsl ft respectively). Waimbula contains 14 000 m^3 (5 million Hsl ft) in the non-commercial forest.

Sampling error comes within the prescribed 20% error limit for the production forests of the Londoni and Waimbula catchments. In Ndawasamu the sampling error is 30% and in Naitaleira it was not possible to calculate it, because there were not enough lines. The sampling errors for the non-commercial and protection forest are either very high or not calculated due to insufficient sampling because the value of the timber in these management categories did not justify increasing the sample.

TABLE 6 Volume of timber from trees over 40 cm d.b.h., species group 1-4, reliable minimum estimate, and percentage error by catchment and management category, Tailevu Catchment Group, ('000 m^3)

Management and catchment	Volume >40 cm s.g. 1-4	Sampling error >40 cm s.g. 1-4	Degrees of freedom	Confidence limit P<0.05	r.m.e. P<0.025	% error	Volume >40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Londoni	15	3	5	8	7	47	5
Waimbula	22	3	5	8	14	36	7
Total	37				21		12
Production							
Naitaleira	11	-	-	-	-	-	4
Ndawasamu	33	3	3	10	23	30	11
Londoni	89	5	8	12	77	13	30
Waimbula	139	9	11	20	119	14	46
Total	272				219		91
Protection							
Ndawasamu	13	4	1	51	-	>100	4
Londoni	32	-	-	-	-	-	11
Waimbula	15	-	-	-	-	-	5
Total	60				-		20

DESCRIPTION OF FOREST TYPES

The forest types are listed in Table 7 below. It gives standing volume, sampling error, net stocking and also groups the forest types by management categories.

Type C1: Well stocked mixed forest on moderate to steep, short slopes

This type, which covers nearly 2 000 ha (4 942 ac) in the four catchments, occurs on the high ground below the protection forest. The stocking of usable species is 55 to 70 m^3/ha (7 412-9 433 Hsl ft/ac) that is trees over 40 cm d.b.h. sp groups 1-4, and the predominant species are *kaudamu* and *kauvula*.

Type G: Moderately stocked mixed forest on moderate to steep short slopes

This type occurs in all the catchments, covering over 1 000 ha (2 471 ac) in Londoni and Waimbula. The stocking of useful timber species trees over 40 cm d.b.h. species group 1-4 is low, about 30 m^3/ha (4 043 Hsl ft/ac) In the species composition *damanu* predominates in Ndawasamu, *kauvula* in Londoni and *kauvula* and *kaudamu* in Waimbula.

Type CS: Moderately stocked forest on long, very steep slopes

Protection forest caps the watershed and the slopes immediately below it. The stocking is variable ranging from 30 m^3/ha (4 043 Hsl ft/ac) of 40 cm d.b.h. species groups 1-4 in Waimbula to 75 (10 107 Hsl ft/ac) in Londoni and 57 (7 681 Hsl ft/ac) in Ndawasamu.

TABLE 7 Total volumes and sampling errors of forest types in the Tailevu Catchment Group, ('000 m^3)

Catchment and forest type	Minimum diameter & sp. group			Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management
	(1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4				
Naitaleira							
C1	15	12	10	-	3	69	Production
G	3	2	1	-	0	12	
Subtotal			11	-	3	48	
Ndawasamu							
C1	37	31	26	3	9	61	Production
DS	6	4	4	1	1	33	
G	5	4	3	-	1	36	
Subtotal			33	3	11	52	
CS	19	16	13	4	4	56	Production
Londoni							
S	3	2	2	-	1	10	Non-commercial
G2	28	22	13	3	4	6	
Subtotal			15	3	5	6	
C1	47	41	31	3	10	77	Production
DS	29	28	27	-	9	237	
G	56	45	31	4	10	27	
Subtotal			89	5	29	22	
CS	49	42	30	-	10	75	Protection
S1	5	3	2	2	1	3	
Subtotal			32	-	11	32	
Waimbula							
J	40	33	22	3	7	12	Non-commercial
Subtotal							

TABLE 7 (continued)

Catchment and forest type	Minimum diameter & sp. group			Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
	(1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4				
C1	87	70	58	5	19	55	Production
G	53	41	34	4	11	28	
KV	85	69	47	6	16	28	
Subtotal			139	9	46	35	
CS	20	17	12	-	4	30	Protection
S1	6	5	3	1	1	7	
Subtotal			15	-	5	18	

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

Only the Waimbula catchment with 139 000 m^3 (46 million Hsl ft) of timber on nearly 4 000 ha (9 884 ac) of land represents a viable unit for timber exploitation. In the Londoni catchment and to a greater extent in the other two catchments, the production forest is too scattered and too low in stocking to be worth exploiting by a large sawmilling concern.

PROPOSED ACCESS ROUTES

Access to the Waimbula catchment can be gained by extending the road to Naivithula or by making a road from near Ndakuivuna following the course of the Waimaro creek northwards.

PROPOSED TREATMENT OF FOREST TYPES

The production forest types are all suitable for exploitation although the yield from some of them may be low. Forest type C1 in the Waimbula is suitable for replacement by mahogany plantations, although the ground is steep and soil more shallow than in the Rewa plains. The presence of a certain amount of *sacau* in this forest is a bad sign as regards soil condition.

PART 3. THE NANDARIVATU CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

This Catchment Group comprising high plateaux with an elevation of over 610 m (2 000 ft) lies along a north-south axis in the centre of Viti Levu. It includes the Nandarivatu plateau in the north linked by high ground with the flat country of the Nandrau Plateau in the south where the elevation is over 914 m (3 000 ft). The Rewa, Singatoka and Mba Rivers rise on the slopes of these hills. The following catchments will be considered in this part:

59/6	Nanuku	64/1	Nandarivatu
59/9	Tawa	64/2	Solikana

The Nanuku catchment includes the catchment of the Wailoa River in the north and the source of the Wainimala River in the south. The Nandarivatu catchment includes the source of the Singatoka River which rises to the west of Tomanivi (Mt Victoria). The Tawa creek flows in a north-easterly direction into the Wainimbuka River. The area lies at the junction of the four provinces Nandronga and Navosa, Mba, Ra and Naitasiri.

CLIMATE

Due to the high elevation this area experiences the heaviest rainfall in Fiji.

The Nanuku catchment lies in climatic zone F with more than 3 800 mm (150 in) of rain and a very weak or no dry season. The Nandarivatu catchment lies in zone D and is drier with 2 540-3 300 mm (100-130 in) of rain and a moderate dry season with 3 to 5 months with less than 150 mm (6 in) of rain. Rainfall figures have been collected at the Nandarivatu Government Station, and at Koro-O, Nandrau and Vanualevu. The mean monthly figures for the last ten years for Nandarivatu and Koro-O are quoted in Table 8.

TABLE 8 Mean monthly rainfall figures in millimetres and inches

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
mm													
Nandarivatu	663	840	946	299	130	98	62	108	139	125	259	336	4005
Koro-O	595	740	657	348	121	90	43	136	148	148	190	340	3556
in													
Nandarivatu	26.14	33.07	37.23	11.79	5.12	3.87	2.45	4.27	5.49	4.94	10.21	13.34	157.92
Koro-O	23.42	29.12	25.87	13.69	4.77	3.53	1.69	5.37	5.81	5.82	7.47	13.39	139.95

The drier climate is evidenced on the west of the Nandarivatu catchment by the presence of grass replacing forest on the steep slopes. From May to October the rainfall drops below 150 mm (6 in) per month but only in July is it really dry.

Mean monthly maximum temperatures at Nandarivatu reach a highest value of 25° C (77° F) in December, fall to 22° C (72° F) in July, and rise again gradually towards the end of the year. The minimum figures follow the same pattern, equivalent figures being 17° C (62° F) and 14°C (57° F). It can be seen that Nandarivatu is much colder than the lowland regions.

The mean relative humidity at 0900 hours at Nandarivatu is 89.3% in January, 83.8% in July and 85.8% in December.

GEOLOGY

In the south-east conglomerates, tuffs and keratophyres of the Wainimala Group intruded by Tholo Plutonics underlie the Nanuku catchment. In the east, on the lower Wailoa River, rocks of the Ra Sedimentary Group (Wailo conglomerate) are found. Younger basalts of Pliocene to Pleistocene age have flowed down from the north covering the older rocks with a sequence of volcanic rocks ranging from basaltic conglomerate around Mt Victoria through basalt flows to basalt derived sandstone in the south on the Nandrau plateau. A monzonite sill is intruded along the southern and eastern boundary of the basalt forming an escarpment across the Nanuku catchment.

LANDFORM AND SOILS

Tomanivi (Mt Victoria), the highest peak in Fiji with an elevation of 1 323 m (4 341 ft) lies at the north of the survey area forming the watershed between the Rewa and Singatoka Rivers. The Nandarivatu Plateau, an area of steeply dissected country, lies to the west at an elevation of 760 m (2 500 ft) connected by a narrow bridge of high land called the Rairaimatuku Plateau, with the Nandrau Plateau. This is made up of flat lava flows at an elevation of 915 m (3 000 ft). The high land falls away steeply with escarpments on the west to the Singatoka River and in the east to the tributaries of the Wainimala River. Easier sloping country occurs along the eastern side of the Nanuku catchment but in the south there are steep hills aligned across the main drainage and cut through by the Wailoa and Waikonavono creeks just above their confluence. The forested part of the Tawa catchment lies in a basin at an elevation of about 760 m (2 500 ft) surrounded on all sides by very steep hills.

The soil type that covers the northern part of the area around Nandarivatu is a humic latosol, Monasavu bouldery red-brown clay (95G) classified by Twyford and Wright (1965) as an upland soil developed under conditions of continuous rainfall and no dry season. It is formed from olivine basalt and consists of horizons of red on top of yellowish red friable clay of low base status which is strongly acid. On the flat country particularly in the Nandrau Plateau the soils are classified as Waibici clay (59a) and Nabuesa clay (59b) derived from basic parent material. Waibici clay is a reddish brown friable clay, with stained structural aggregates, overlying reddish yellow clay, with a moderately to strongly developed medium blocky structure. In the Tawa catchment a soil pit dug beneath the *Agathis - Podocarpus* forest showed a dark brown sandy clay loam topsoil over about 70 cm (28 in) of reddish brown clay with a moderate, medium sub-angular blocky structure. The parent material is basalt with occasional huge slabs exposed on the ground. A limited area of gley soil lies either side of the upper Nanuku creek.

VEGETATION

Forest covers the high ground around Mt Victoria and extends east as far as the villages of the upper Wainimbuka and Wainimala catchments, Nggelethimbi, Nasaukamai and Nukulau. Towards the south it gives way to partial forest cover on the very steep escarpment slopes that border the high ground. In the west grassland comes in more or less on a level with the Singatoka river, extending up the valleys of the Nukunuku, Nandala and Navai rivers. In the vicinity of Nandarivatu the grasslands have been planted with pine in recent years.

The low forest cover on the steep slopes of Mt Victoria is sub-montane with good stands of *dakua makadre* occurring to the south on the easier slopes that lie east of Nandrau village. The Nandrau Plateau has a poor forest with isolated *dakua makadre* and a dense understorey. On the east side of the Nanuku catchment mixed shrub and bamboo occur in the vicinity of the villages that lie along the river there.

POPULATION AND LAND TENURE

The almost entirely Fijian population of 1 500 persons live in about 24 villages. Main centres are Nandarivatu at the northern end of the area, Navai on the western forest margin above the Singatoka River, Nanggelewai in the north-east and the villages on the upper Wainimala in the south-east corner.

Three deserted village sites are situated near the source of the Nanuku creek. Four sites lie within a radius of 3.2 km (2 mi) of Vanualevu village. On the upper Wainimala River 4 sites occur between the existing villages and 3 on the Wainisavulevu creek. South of the Nandrau plateau a village site called Naloka lies on the Wainivau creek in very steep country. The site shows on the aerial photographs as a thinning of the forest cover beside the creek. The people

of this village can only have farmed on the nearby very steep slopes. In the east, village sites lie on the Nasonggo and Wailoa Rivers interspersed between the existing ones. A history of shifting village sites would account for the poor vegetation cover on this side of the catchment.

The northern part of the Nandarivatu catchment is Crown-owned freehold land, which has been made into a forest reserve and includes three nature reserves. One lies to the east of Mt Victoria, one lies on the northern escarpment and one small patch of *dakua makadre* forest lies 1 km (½ mi) west of the government station. Extensive blocks of Native Reserve occur on the western side along the Nggaliwana creek and around Nambouwangga and Vanualevu villages. On the eastern side, the cluster of villages on the Nasonggo River is surrounded by Native Reserve. In the south-east the villages along the upper Wainimala River are surrounded by Native Reserve. With the exception of some isolated blocks of Crown land the rest of the land is in Fijian ownership and is not reserved.

PRESENT LAND USE

Pine plantations started in the early 1950s provide a source of income to a considerable labour force on the Nandarivatu Plateau. The plantations lie along the roads that go down the parallel valleys of the Nukunuku, Nandala and Savai creeks. A settlement scheme for growing potatoes in the Nandala area has now been converted to mixed crops. *Arabica* coffee was grown in the past at Nandarivatu and the bushes are now growing wild beside the road. In the past few years tea has been planted in experimental plots beside the road to Nabai. Subsistence crops grown in the area include taro, cassava, *yagona* and yam. Some of these crops are grown for sale at the gold mine at Vatukoula and on the coast, but it is more usual for the men to be employed at Vatukoula leaving old men, women and children in the villages.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

Timber enumeration No. 2 of 1953 covered the middle part of the area under discussion with a 1% survey. Detailed results are not available, but from a summary it appears that the better forest was found towards the north near Nandala with the forest getting poorer towards the south. Timber enumeration No. 2 of 1955 covered the valleys of the Nanggangga, Waithangi, Waisara and Waimongge creeks in the north of the Nanuku catchment. The 1% sample provided a volume of 33 m^3/ha (4 500 Hsl ft/ac) using a 122 cm (4 ft) girth limit. Exploitation was thought to be impractical due to difficulties of access.

EXPLOITATION PAST AND PRESENT

The Nandarivatu area has a long history of exploitation going back to the period before the second world war when the Fiji Kauri Company exploited the hills around Nandarivatu Station, Nandala and Navai.

The concession area of Dijendra Singh is 6.4 km (4 mi) wide lying on both sides of the motor road from Navai to Nandrau from the Forest Reserve boundary in the north to the hill, Tokaravutia, in the south. Coupes have been laid out in the north in the vicinity of the sawmill and so far three of the coupes have been cut over.

SAWMILLS

The sawmill of Dijendra Singh lies 4.8 km (3 mi) south of Navai on the Nandrau road. It is not operating and the logs are carried down to Mba and sawn up in the Mba Sawmill. Derelict sawmills lie at Navai and 1.6 km (1 mi) west of Nandarivatu.

PLANTATION SPECIES AND AGE CLASS

Plantations of *Pinus elliottii* have been established since the early 1950s and now extend down the valleys of the Nukunuku and Nandala creeks. Trial plots and small plantations of pines and *Araucaria* and hardwoods such as *Eucalyptus* and mahogany have been established.

EXISTING ACCESS ROUTES

From Tavua and the north coast a turning off the Kings Road runs south to Waikumbukumbu at the foot of the Nandarivatu escarpment. The road maintained by the Public Works Department goes up the escarpment and is good enough for a daily bus service to be run as far as Navai.

Within the area, roads run down the Nukunuku valley to Lewa, the Nandala valley to Nandala and into the Nggaliwana valley to follow the Singatoka-Nanuku watershed to Nandrau.

The major rivers of Viti Levu have their source in this area but none of them are navigable here. An important track links Navai with the villages of the Upper Wainimala going south-east from Navai to Nasonggo down a well graded route with a few steep sections. From Nasonggo one track goes to Nukulau and Numbumakita and thence to the villages on the Wainimala river. The other branch goes down near the Nasonggo river through Nasiriti and Nanggelewai to Laselevu on the Wainimala. From Nanggelewai a track runs west onto the high plateau by easy gradient joining the road to Nandrau 3.2 km (2 mi) east of the village. From Laselevu the Wainimala river is navigable by flat bottomed boat with an outboard motor. A wide well-used track connects Nasauvere, at the head of the Wainimala valley, to the group of villages Wainimakutu and Naraiyawa at the head of the Wainikoroiluva valley. From Nasauvere a track goes west to Numbuyanita across the steep country at the southern end of the catchment.

THE ENUMERATION

LAYOUT OF SURVEY

The base line for the Nanuku catchment follows the direction of the Nasonggo River with lines running right across the forested part of the Wailoa river catchment and stopping at the escarpment edge in the Nanuku river catchment. The lines were not continued south onto the Nandrau Plateau because of inaccessibility of the area and because the forest looked poor on the aerial photographs.

TIMBER VOLUMES

Enumerated areas under the forest types are given in the table below:

TABLE 9 Enumerated areas of forest types in the Nandarivatu Catchment Group (ha)

Forest type	Nanuku	Tawa	Nandarivatu	Solikana	Total enumerated ha	area ac	% of enumerated forest
G(L)	-	-	224	-	224	554	1
H	110	-	148	-	258	638	2
J	1 049	-	-	-	1 049	2 592	7
S	157	-	-	-	157	388	1
Non-commerical	1 316	-	372	-	1 688	4 171	12
C1	-	-	541	-	541	1 337	4
CI(L)	-	-	80	-	80	198	<1
DM	515	-	180	-	695	1 717	5
DS	-	127	-	-	127	314	1
G	-	-	39	77	116	287	1
GDK	2 041	184	-	-	2 225	5 498	15
KV	1 694	-	407	-	2 101	5 192	14
Production	4 250	311	1 247	77	5 885	14 542	40
CS	3 075	382	374	-	3 831	9 466	26
GS	-		824	240	1 064	2 629	7
S1	1 690		423	-	2 113	5 221	15
Protection	4 765	382	1 621	240	7 008	17 317	48
Total					14 581	36 030	

The enumerated areas cover the production forest except forest type DK on the Nandrau Plateau, but do not cover the protection or non-commercial forest.

The volumes of standing timber in the enumerated forest are summarised in Table 10. Nanuku catchment contains 127 000 m^3 (42 million Hsl ft) and Nandarivatu 67 000 m^3 (22 million Hsl ft), the reliable minimum estimate figures being 109 000 and 49 000 m^3 respectively (36 and 16 million Hsl ft).

TABLE 10 Volume of timber from trees over 40 cm d.b.h., species group 1-4, reliable minimum estimate, and percentage error by catchment and management category, Nandarivatu Catchment Group, ('000 m^3)

Management and catchment	Volume >40 cm s.g 1-4	Sampling error >40 cm s.g. 1-4	Degrees of freedom	Confidence limit P <0.05	r.m.e. P <0.025	% error	Volume >40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Nanuka	19	4	3	13	6	65	6
Nandarivatu	4	1	2	4	0	80	1
Total	23				6		7
Production							
Nanuku	127	8	11	18	109	15	42
Tawa	18	-	1	0	0	> 110	6
Nandarivatu	67	8	9	18	49	27	22
Solikana	2	-	0	-	0	> 100	1
Total	214				158		71
Protection							
Nanuku	56	5	10	11	45	31	19
Tawa	5	2	1	25	0	> 100	2
Nandarivatu	46	7	6	17	29	38	15
Solikana	3	1	1	13	0	-	1
Total	110				74		37

In the Nanuku catchment the percentage error for the production forest is 15% which is satisfactory. In the Nandarivatu catchment, due to the limited amount of production forest and the fragmented nature of the forest types, the percentage error is 27%. The error in both the Tawa and Solikana catchments is high because of the small amount of sampling done. These two catchments are better looked upon as reconnaissance catchments, in which the sampling indicates the nature of the forest but does not provide a reliable estimate of the standing volume.

DESCRIPTION OF FOREST TYPES

In Table 11 below the forest types are shown by management catagories for the catchments and timber volumes, sampling error, area and stocking for each forest type are given.

The forest types of interest that will be discussed here are forest types J, DM, GDK, KV, CS and S1.

J; Low-stocked fringe forest

This type covers an area of 1 049 ha (2 592 ac) in the Nanuku catchment, but does not occur in the enumerated part of the other catchments. It is found on the high ground on moderate or gentle slopes on the eastern side of the high plateau. The high elevation has influenced the stocking in the virtual absence of *kaudamu* and the high stocking of *dakua makadre* of 5 m^3/ha (674 Hsl ft/ac). In the presence of *koka, kauvula* and *sasauwira* the species composition is close to that described in Part 4. Overall stocking is 16 m^3/ha (2 156 Hsl ft/ac) of trees over 40 cm d.b.h.

TABLE 11 Total volumes and sampling errors of forest types in the Nandarivatu Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
Nanuku							
H	4	3	1	-	0	9	Non-
J	19	17	15	4	5	14	commercial
S	3	3	3	-	1	19	
Subtotal			19	4	6	14	
DM	18	17	14	2	5	27	Production
GDK	104	93	79	8	26	39	
KV	46	42	34	2	11	20	
Subtotal			127	8	42	30	
CS	57	50	40	4	13	13	Protection
S1	24	21	16	2	5	9	
Subtotal			56	5	18	12	
Tawa							
DS	12	11	10	-	3	79	Production
GDK	11	10	8	-	3	43	
Subtotal			18	-	6	58	
CS	8	6	5	2	2	13	Protection
Nandarivatu							
G(L)	7	6	4	1	1	18	Non-
H	<1	<1	<1	-	0	5	commercial
Subtotal			4	1	1	11	
C1	43	36	31	5	10	57	Production
C1(L)	5	4	3	-	1	38	
DM	11	10	9	6	3	50	
G	2	2	2	-	1	51	
KV	30	26	22	3	7	54	
Subtotal			67	8	22	54	
CS	20	18	14	3	5	37	Protection
GS	37	33	24	4	8	29	
S1	14	11	8	4	3	19	
Subtotal			46	7	16	28	
Solikana							
G	3	2	2	-	1	26	Production
GS	6	6	3	1	1	13	Protection

This type is poorer in stocking than the forest type DK, which has been mapped over large areas of the Nandrau plateau by photo interpretation. Although there is no field work to support the view, it appears from photo interpretation that the forest type DK will contain more *dakua makadre*.

DM: Well stocked *dakua makadre* forest at high elevation on steep slopes

This type covers a total of 695 ha (1 717 ac) in the Nanuku and Nandarivatu catchments. Its distribution is limited to the valley of the Wambu creek east of Mt. Victoria and to small pockets in the middle and southern part of the Nandarivatu catchment. Species composition consists of *dakua makadre, damanu, kauvula, sa* and *vuga*. The *dakua makadre* has a stocking of 17 and 39 m^3/ha (2 291 and 5 256 Hsl ft/ac) in the Nanuku and Nandarivatu catchments respectively. *Damanu* has a stocking of 3 to 5 m^3/ha (404-674 Hsl ft/ac). *Vuga* with a stocking of 8 m^3/ha (1 078 Hsl ft/ac) is confined to the Nandarivatu catchment. Overall stocking of trees over 40 cm d.b.h. is 32 and 54 m^3/ha (4 312 and 7 277 Hsl ft/ac) for the Nanuku and Nandarivatu catchments respectively.

GDK: Moderately stocked *dakua makadre* forest on steep slopes at high elevation

This type covers 2 041 ha (5 043 ac) in Nanuku and 184 ha (455 ac) in Tawa catchment, making 15% of the enumerated forest. It occurs to the south of the source of the Nanuku creek and on the upper reaches of the Mali and Nakasanga creeks on middle and lower slopes in the Tawa catchment. Species composition is described in Part 4 (page 90), the salient features being a stocking of 14 m^3/ha (1 887 Hsl ft/ac) of *dakua makadre* followed by *kauvula* and *yasiyasi* with stockings of 8 and 3 m^3/ha (1 078 and 404 Hsl ft/ac) respectively. *Kaudamu* has a volume of 1 087 m^3 (361 789 000 Hsl ft) of trees over 35 cm d.b.h. but only 374 m^3 (124 480 000 Hsl ft) of trees over 40 cm leading to the conclusion that, although it can grow at elevations over 914 m (3 000 ft) it does not reach large sizes. Overall stocking is 46 m^3/ha (6 199 Hsl ft/ac) in Nanuku catchment and 53 m^3/ha (7 142 Hsl ft/ac) in Tawa catchment.

KV: Moderately stocked *kauvula-sa* forest

This forest type is widespread in the Nanuku catchment covering 1 694 ha (4 186 ac) and occurs to a lesser extent in the Nandarivatu catchment (407 ha) (1 006 ac). It occurs on the flat country at the source of the Nanuku creek overlying residual clays and older alluvium of Pleistocene to Recent age and on the middle and lower slopes of the same river before it goes over the Monasavu Falls. The species composition is given in Part 4 where a photograph of this type, taken on the Nanggelewai to Nandrau track is also included. The overall stocking in the Nanuku catchment is 25 and in the Nandarivatu catchment is 64 m^3/ha (trees over 40 cm d.b.h., 3 369 and 8 625 Hsl ft/ac respectively).

CS: Moderately stocked forest on long, very steep slopes

This type occurs in all the catchments described here except Solikana and covers an area of 3 831 ha (9 466 ac) or 26% of the enumerated forest. It covers the whole of the Mt Victoria hill mass and the high ground in the southern part of the Nanuku catchment to the west of the Nanuku creek. In the presence of *dakua makadre, kauvula, damanu, yasiyasi* and *sasauwira* the species agree with the composition of this type at lower elevations. However the lines in the Nanuku catchment, particularly those that sampled the Mt Victoria hills, show a very much lower stocking than occurs at lower elevations. Stocking figures for the species listed above are 3, 2, 2, 1 and 2 m^3/ha (404, 270, 270, 135 and 270 Hsl ft/ac) respectively, with a total of 16 m^3/ha (2 156 Hsl ft/ac, trees over 40 cm d.b.h.) for both Nanuku and Tawa catchments. The forest understorey is hung with moss and the canopy is lower with the *dakua makadre* often occurring as emergents. Robbins (1968) has classified this forest as submontane forest.

S1: Low-stocked open canopy woodland on very steep slopes

This type covers an area of 1 690 ha (4 176 ac) in the enumerated forest in Nanuku catchment and 423 ha (1 045 ac) in Nandarivatu catchment. It is the vegetation cover of the escarpment slopes that surround the high central plateau. The species composition of *sasauwira, koka* and *kauvula*, having about 2 m^3/ha (270 Hsl ft/ac) each, agrees with the type description in Part 4. The overall stocking is 12m^3/ha (1 617 Hsl ft/ac) in Nanuku and 26 m^3/ha (3 504 Hsl ft/ac) in Nandarivatu catchment (trees over 40 cm d.b.h.).

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

The production forest is concentrated on the high plateau straddling the watershed of the Nanuku and Nandarivatu catchments lying to the east of Nandrau. It is already included in the concession area of Dijendra Singh. Neither Tawa nor Solikana catchments contain enough production forest to merit inclusion in a felling plan.

PROPOSED ACCESS ROUTES

The production forest described in the preceding paragraph is served by the road, as yet unmetalled for the latter half, that runs from Navai to Nandrau. Access to the Nandrau plateau in the south of the Nanuku catchment could be gained by continuing the road from Nandrau southwards along the watershed. Approach from any other direction is baulked by the escarpment that surrounds the plateau and the fact that no roads have even reached the foothills of this central part of the island.

PROPOSED TREATMENT OF FOREST TYPES

Non - commercial forest The non-commercial forest types cover 12% of the enumerated forest but a larger proportion of the total forest cover. Large areas of forest types S and J lie on the eastern side of the Nanuku catchment. The whole of the northern part of the Nandarivatu catchment has been logged. In an area visited about 1.5 km (1 mi) east and north-east of Navai good natural regeneration was observed in a stand that had been felled about 24 years ago. A pole forest has grown up of *damanu*, *dakua salusalu* and *dakua makadre* with a few *kauvula* and *amunu*. The trees have a maximum height of 7 m (23 ft) and diameters ranging from 10 to 15 cm (4-6 in). It is recommended that the logged forest in this forest reserve is regenerated by natural regeneration on an experimental basis and by artificial regeneration where necessary, so that advantage can be taken of the security of tenure that exists in a forest reserve to put growing stock back on the ground.

Production forest The production forest available in this group of catchments has been enumerated with the exception of forest type DK on the Nandrau plateau. The total enumerated area of 5 885 ha (14 542 ac) has a standing volume of 214 000 m^3 (71 million Hsl ft) and a reliable minimum estimate of 158 000 m^3 (53 million Hsl ft). Of the forest types, DM and GDK are the most valuable with their high content of softwoods.

Protection forest Protection forest covers 7 008 ha (17 317 ac) or 48% of the enumerated forest. The total area is well in excess of this figure due to the large areas of protection forest that lie in the south of the Nanuku catchment and west of the Nandarivatu catchment. The Tawa and Solikana catchments are largely covered by forest or open woodland that should be protected.

At times of heavy rain when flooding is feared in the lower Rewa River, the rainfall at Koro-O is used as an indicator of whether flooding is likely to occur or not. The fact that this rainfall station at Nandarivatu indicates the run off that is likely in the Rewa River shows how important it is to preserve the forest cover on the very steep slopes and escarpments of this catchment group.

PART 4. THE NAVUA CATCHMENT GROUP

ENVIRONMENT

LOCATION

The area consists of 8 catchments as follows:-

65/1	Wainikovu	65/5	Nambukelevu South-East
65/2	Wainikoroiluva	65/6	Mavuvu
65/3	Waionamoli	65/7	Nambukelevu North-West
65/4	Nambukelevu North-East	65/8	Nambukelevu South-West

They are located in the basin of the Navua River and its major tributaries.

The area is limited by the watersheds dividing the Navua from the Singatoka and Rewa River systems.

It covers the major part of the tikinas of Serua and Wainikoroiluva, and part of Namosi, Navosa, and Veivatuloa in the provinces of Nandronga and Navosa, Serua and Namosi.

CLIMATE

The whole area falls within the very weak dry season - high rainfall zone F, where only July may be relatively dry, and the annual rainfall is in excess of 3 810 mm (150 in). The mean annual temperature is 25°C (77°F).

Crests of the main hills and watersheds are exposed to strong winds. Easterly gales are felt in the Navua valley.

GEOLOGY

Undifferentiated rocks of Eocene-Miocene age underlie the Navua catchment. They comprise Numbuonamboto volcanic conglomerate, Tawavatu tuff and Lokalevu keratophyre of the Mount Gordon Sub-group of the Wainimala Group. These have been intruded by tonalite to diorite and a little gabbro of the Tholo Plutonic Group which is exposed in a tongue south of Matokana, in a broad strip across the southern part of Waionamoli, and forms the main part of the Wainikoroiluva hills in the north-west of the catchment of that name. The Navua valley has been infilled with Navua mudstones of the Mendrausuthu Andesitic Group of Mio-Pliocene age. The dramatic range of the Korombasambasanga hills is made up of Namosi andesite of the same group and age (Rodda and Band, 1967).

LANDFORM AND SOILS

The Navua Catchment Group is made up mostly of steep, dissected country. In the south it is separated from the coast by a line of hills that run parallel to the shore and rise to an elevation of 457-610 m (1 500-2 000 ft). The elevation rises steeply northward and high hills surround the catchment on the north-east, north and north-west sides. In the north-east lies the Korombasambasanga hill range with a peak at an elevation of 1 203 m (3 948 ft). In the north protruding into the Wainikoroiluva catchment are the hills of the same name with a peak at 1 152 m (3 781 ft) and Vungandondrolevu at 802 m (2 630 ft). Moving west along the watershed there are peaks at Tikituru 936 m (3 071 ft), Vatunilevaleva 852 m (2 795 ft) and Tuvutau (Mt Gordon) 933 m (3 060 ft) at the north-west corner of the catchment.

The main rivers flow in deep gorges, particularly the Navua, which has kept pace with a period of uplift by cutting down into the soft mudstone rock. Other rivers that flow in gorges are the lower Waionamoli and Veinungga creek.

Dissected plateau surfaces occur either side of the upper Wainikovu River, where there is an infertile soil, on which the forest type HS, low stocked *sacau-yaka* forest has developed. Along the southern watershed of the Nambukelevu South-East catchment there is a dissected plateau surface on which the forest type CY, well stocked *sacau* forest, has developed.

Near the Navua River, from Nambukelevu village eastwards, the horizontally bedded Navua mudstones have given rise to a broad belt of flat or gently sloping land that extends as far as the village of Namuamua. Another area of gently sloping land occurs at the northern end of the Waionamoli catchment in the form of a broad dome underlain by intruded diorite rock, over which red yellow podsolic soil has developed.

The soils are mostly humic latosols classified on grounds of slope into the Visa soil set (83) on the steep slopes and into Sote (27) and related hill soils on undulating rolling and moderately hilly terrain. The most widespread soil type is Serua steepland clay and bouldery clay (83g). This is derived mainly from basic rocks in a climate that is very wet and has no appreciable dry season. It shows 8 cm (3 in) of reddish brown friable clay on 60 cm (2 ft) of red friable clay with a moderately to strongly developed very fine angular fragmental structure; rock is reached at 90 to 120 cm (3-4 ft). The soils are strongly acid with a moderate to low base status. Batiwai clay (27g) is very similar to Serua steepland clay but there is a mottled horizon of saprolite above the parent material and the soil depth is more variable ranging from 90 cm - 5 m (3-16 ft).

Over the intruded plutonic diorite rock red yellow podsolic soils have developed. These have been mapped as Narayawa steepland stony silty clay loam (90a), which have 13 cm (5 in) of dark brown silty clay loam overlying 15 cm (6 in) of pale brown coarse sandy clay, on rubbly coarse sandy loam. These soils differ from humic latosols in the paler colours, lighter texture, crumbling consistence and poorly developed structural grade. They are easily recognisable in the field and augering in the Matokana vicinity, at the top of the Waionamoli catchment, revealed a soil similar to that described above.

VEGETATION

Lowland wet tropical rain forest covers 90% of the area. The forest has a closed canopy reaching a height of about 20-25 m (65 - 80 ft) with 50-70 trees over 35 cm d.b.h. per ha (20-30 per ac). Common species are *damanu (Calophllum* spp.), *kaudamu (Myristica)*spp.)*yasiyasi* (Myrtaceae), *kauvula (Endospermum* sp.) and *mavota (Gonystylus punctatus.)* Some *dakua makadre (Agathis* sp.) occurs on the ridges, increasing in quantity with rising elevation.

Areas of mixed shrub and bamboo occur on the Navua River upstream from Namuamua and in the southern and upper parts of the Wainikoroiluva catchment. A block of partially closed woodland occurs in the northern part of the Waionamoli catchment possibly indicating past cultivation. Pure stands of Sago palm occur beside the Navua river west of Waimbongi.

POPULATION AND LAND TENURE

The population of this area is exclusively Fijian and comprises nearly 1 200 persons. The villages are concentrated on or near the Navua River west of Namuamua extending upstream for about 8 km (5 mi) as far as Waimbongi and on the lower Wainikoroiluva and Wainiyavu rivers. Nambukelevu is isolated on the upper Navua River and villages lie intermittently along the upper Wainikoroiluva. Six new hamlets with less than 4 households each, occur along the Wainiwere and Wainiyavu creeks in the north.

There are 4 deserted village sites, 2 on the upper Navua, both vacated some 50 years ago (coconut palms are still growing there). Wainiakutu has been deserted on the upper Wainikoroiluva. The fourth deserted village, Naiyalayala, is near Wainilotulevu village on the creek of the same name.

All the forested land of the Navua Catchment Group is under Fijian ownership. Native Reserve stretches in a broad belt from Namuamua, up the Wainikoroiluva River, to beyond Wainimakutu. A thin strip of Crown land lies to the west of Nanggarawai.

PRESENT LAND USE

Between Waimbongi and Namuamua bananas are grown as a cash crop on the flats beside the river. A small co-operative cattle-grazing scheme is centred at Wainayasi, run with moderate success. *Yaqona* is produced by the up-river villages for sale in Navua. Apart from these enterprises, subsistence agriculture is the general rule, the main crops being taro, cassava, bananas, coconuts, onions, tobacco and *yaqona*. A bush fallow system is followed. *Yaqona* and taro are intercropped in new gardens, 2 crops of taro being harvested in 18 months. The *yaqona* is harvested after 5 years, after which the area reverts to fallow. New gardens tend to be established on the steep sunny northern slopes with clear felling of the forest cover, moving progressively down the slope, causing severe erosion which may inhibit the return of the forest.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

The area has been well enumerated in a series of surveys over different areas since 1953, the last being in 1958.

Survey No.	Locality	Area (ac)	Intensity & method	Stocking rate	
				m^3/ha	Hsl ft/ac
4/53	West Bank Navua	6 327	4% 50 chain grid	33	4 500
5/55	East Bank Navua	3 600	4% 50 chain grid	19	2 500
3/55	Somosomo-Vunamoli	12 250	4% systematic grid	48	6 500
4/56	United Lumber Co	8 720	4% systematic grid	41	5 500
5/56	South-West of Valley	7 660	4% systematic grid	27	3 700
3/58	South Valley	22 900	4% systematic grid	44	6 000

EXPLOITATION PAST AND PRESENT

The Viti Timber Milling Company works the Ngaloa Concession lying south of the Navua River between the Navua gorge and Yarawa. The Company has a series of well supervised annual felling coupes beside its access road, and areas have been approximately allocated up to 1972. The concession started in 1964 and is supposed to last 30 years. Outturn from the mill in 1968 was 6 320 m^3 (2.1 million Hsl ft) of timber.

The Navutulevu sawmill works the area locally known as Rajaram's Concession lying west of the Ngaloa Concession and north of the Navua River. It works on a series of well supervised annual licences to ensure systematic exploitation. Its 30-year concession started in 1962. Outturn from the mill in 1968 was 12 030 m^3 (4.0 million Hsl ft).

Lal Mohamed's sawmill is supplied with timber from an area on the western fringe of the catchment, but the sawmill did not begin to operate on a big scale until 1968. At first most of his produce came from outside this area. He operates on a long term licence which came into effect in 1968. In that year the outturn from the mill was 2 410 m^3 (0.8 million Hsl ft).

Ram Bissessar's sawmill is under consideration for a concession in this area at the time of survey.

A number of small licences exist in this catchment. One Fijian licensee works near the edge of the Navua Gorge above Namato rapids. Another Fijian licensee works on the river frontage above Namuamua using 4 or 5 teams of bullocks. The logs are then pushed over a cliff (as on the Namato rapids licence) and made up into rafts. He has a 3 year local lease over 40 ha (100 ac) with a 400 m (1 320 ft) dragging track. Outturn is some 18 m (6 000 Hsl ft) (50 small logs) a week cut and hauled to riverside and consists mostly of 'floaters', *kauvula*, *kaudamu*, some *bau* and *mavota*. Rafting to the Navua Sawmills takes 2 to 3 days where the logs are rolled onto lorries on the beach near the Navua bridge.

SAWMILLS

The Viti Timber Milling Company has a main mill built outside the catchment and a board mill inside. The main mill machinery, consisting of a breakdown rack circular saw and a number of resaws, is in the process of modernisation. The board mill was closed down at the time of the survey.

The Navutulevu sawmill has had a series of sites and moved to the present one beside the Volosa creek in 1964. The mill is modern by local standards, all the machines are on an upper floor powered by large diesel engines beneath. It is designed on the 'green chain' principle, logs being broken down at one end on a rack circular saw, and the slabs passing along to the resaws on a conveyor belt to produce end-trimmed timber at the far end where it is dipped in preservative and stacked.

Pit sawing has been practised intermittently in the past, the only pitsaw now working is at Saliandrau supplying the village.

PLANTATION SPECIES AND AGE CLASS

In 1966 243 ha (610 ac) of large leaf mahogany *(Swietenia macrophylla)* were line-planted at various spacings in the logged out forest near the Volosa creek in the Nambukelevu South-West catchment.

No further planting had taken place by the time the enumeration was completed in the area.

Some 182 ha (450 ac) was being prepared for mahogany plantation in this catchment in 1968. The rows are at 10 m (33 ft) spacing and the area is alongside the road where it forks on reaching the catchment boundary. A further 312 ha (1 300 ac) of exploited forest was prepared and planted in 1969.

EXISTING ACCESS ROUTES

The Queens Road has a number of feeder roads which extend into this catchment.

The road to the Viti Timber Milling Company sawmill leaves the Queens Road at Ngaloa. This has been metalled for much of its route, and at the time of the survey the trace had reached Waimbongi village.

The road to the Navutulevu Sawmill Company leaves the Queens Road at Vuniyawa one mile east of Namboutini. The road crosses the watershed into the Navua Valley at an elevation of 457 m (1 500 ft), descends to the sawmill beside Volosa creek and on to Nambukelevu village and crosses the Navua River to the north bank.

The road to the proposed Lal Mohamed sawmill leaves the Queens Road at Vatukarasa, passes through Mbalenambelo and rises to the watershed at the western end of the catchment. It is 24 km (15 mi) long.

The Navua river is navigable by 9 m (30 ft) powered punt to the deep gorge below Nambukelevu where rapids and shallows make navigation difficult. The open valley sides below Nakandikandi Creek down to Navua offers a good road alignment. Logs can be floated from Waimbongi village down to Navua, but the river is too shallow above Waimbongi, except in periods of flood. The Navua is deeply gorged above Vitongo Creek but a droving track passes to Navua. The usual flood level of the river is 3.7 m (12 ft) but it is liable to flash floods, rising up to 6 m (20 ft) at the bends and whilst it can come up within the space of one hour it usually drops to normal levels within 2 to 3 hours of the rain ceasing. The river is tidal as far as the suspension bridge above Navua. The Navua has two rapids, neither dangerous if care is taken, at Naimato and Nukusere village; they are no deterrent to rafting. Some narrow bends, seasonal shallows and rock outcrops require considerable local knowledge to navigate.

The Wainomoli River does not serve as a natural access route to the sub-catchment; its course is winding; its valley steep and for most of its length the river bed is uneven. The best route from Nambukelevu village is the ridge forming the north-western catchment boundary.

The village of Matokana lies north of the Navua watershed. The road from Singatoka reaches Saweni on the Singatoka River, from there horse and foot trails follow up the river to Lato Creek, following it as far as the Nandruku Creek and on to a ridge just north of Matokana.

The Wainikoroiluva River is only navigable by 9 m (30 ft) powered motorboat from Namuamua village to Wainindoi Creek below Nakavika village. Beyond this there is a large waterfall and whirlpool. Timber rafts can use the river from below the Wailoaloa Creek but only with difficulty above the Wainasomba Creek. Above Saliandrau village it is too shallow for most of the year to carry motorboats or rafts.

Pack horses carrying up to 90 kg (200 lb) are the main method of conveying produce in this valley.

The main tracks are:

1. From Namuamua to Nambukelevu
2. From Namuamua to Naraiyawa village (4 hours riding, laden)
3. A branch up the Wainiyavu Creek to Navaundra village
4. A branch from the ridge above Nakavika village to Nakavika and Nakorowaiwai villages
5. From Nakorowaiwai village over the ridge to Namosi village on the Waindina Creek (3 hours riding)
6. A branch from foothills above Navunikambi village to Nandoli and Korovou villages
7. From Nasau village to Wainimakutu and over the ridge to Nasauvere on the Wainimala River (3 hours riding)
8. From Naraiyawa village over the ridge to Nakoso village on the Nasa Creek in the Singatoka valley (9 hours riding).

THE ENUMERATION

LAYOUT OF SURVEY

Wainikovu The upper Wainikovu River runs roughly parallel to the coast, so it was possible to extend the layout for the Suva-Navua coastal strip (See Part 5).

Wainikoroiluva The base line was taken parallel to the Wainikoroiluva River and one line cut in each 2 000 m (6 560 ft) section to run from the foot of the Korombasambasanga range westwards.

Waionamoli The base line followed the Waionamoli River and lines were cut to run right across the catchment from east to west one in each 2 000 m (6 560 ft) section.

Nambukelevu North-East and South-East These two areas shared a common base line along the Navua River, but the starting points of the lines were chosen separately by reference to random numbers.

Nambukelevu North-West and South-West These two subcatchments shared a common base line of the upper Navua River. The lines to go north and south were chosen separately.

Mavuvu This small sub-catchment had a base line along the Mavuvu Creek and short lines running north-west and south-west.

TIMBER VOLUMES

Enumerated areas of the Navua forest types are given in Table 12 below. Apart from some blocks of protection forest in the Korombasambasanga and Wainikoroiluva hills, the forest has been almost completely enumerated. The Navua catchment contains 57 222 ha (141 295 ac) of production forest, which makes up 77% of the forest area, whereas non-commercial forest covers only 8% of the area (6 073 ha (15 006 ac). Forty eight percent of the forest is forest type C1, well stocked mixed forest on moderate to steep short slopes, and 16% is forest type G, moderately stocked mixed forest on moderate to steep short slopes.

The volume of standing timber in the enumerated forest is summarised in Table 13, from which it can be seen that the production forest contains nearly 4 million m^3 (trees over 40 cm (16 in) d.b.h. species group 1-4, 1 327 million Hsl ft) of timber. All the catchments except Mavuvu contain between a quarter and half a million cubic metres of timber in the production forest types. The Wainikovu catchment contains 47 000 m^3 (16 million Hsl ft) of non-commercial forest, mostly in forest type HS, low-stocked *sacau-yaka* forest. Protection forest occurs in Wainikoroiluva, Nambukelevu North-East And Waionamoli catchments with respective volumes of 71 000, 78 000 and 128 000 m^3 (trees over 40 cm d.b.h. species groups 1-4, 24, 26 and 43 million Hsl ft).

In the production forest, with the exception of Mavuvu catchment, the sampling error is within accepted limit in all catchments with percentage errors of 9 to 12. In the non-commercial forest and protection forest the error is large which is partly due to the small areas and low stocking of these types, but also to the fact that the gross volume is reduced by taking 40 cm d.b.h. as the minimum diameter and subtracting species group 5.

TABLE 12 Enumerated areas of forest types in the Navua Catchment Group (ha)

Forest type	Wainikovu	Wainikoro -iluva	Waionamoli	Nambukelevu North-East	Nambukelevu South-East	Mavuvu	Nambukelevu North West	Nambukelevu South-West	Total enumerated area		% enumerated forest
									ha	ac	
G(L)	-	90	-	-	-	-	-	-	90	222	<1
H	149	49	-	72	-	-	-	-	270	667	1
HS	1 592	-	-	-	-	-	-	-	1 592	3 934	2
J	144	-	-	-	-	-	-	-	144	356	<1
K	-	648	-	-	190	-	-	-	838	2 071	1
S	-	1 004	828	477	173	151	124	382	3 139	7 756	4
Non-commercial	1 885	1 791	828	549	363	151	124	382	6 073	15 006	8
C1	2 943	3 964	5 936	6 085	8 969	43	4 592	3 174	36 086	89 169	48
C1(L)	-	-	-	-	300	-	-	-	300	741	<1
C2	-	938	301	1 017	782	-	-	962	4 000	9 884	5
CY	-	-	-	1 060	3 059	-	-	-	4 119	10 178	6
E	-	-	219	-	62	-	-	45	326	806	1
G	1 191	750	1 678	1 532	2 459	1 171	1 076	2 110	11 967	29 570	16
GY	-	-	-	-	424	-	-	-	424	1 048	1
Production	4 134	5 652	8 134	9 694	16 055	1 594	5 668	6 291	57 222	141 396	77
B	-	157	234	-	-	-	-	119	510	1 260	1
CS	843	489	2 915	-	50	377	1 304	694	6 672	16 487	9
GS	-	1 782	-	2 260	-	228	-	-	4 270	10 551	5
Protection	843	2 428	3 149	2 260	50	605	1 304	813	11 452	28 298	15
Total									74 747	184 700	

TABLE 13 Volume of timber from trees over 40 cm d.b.h., species group 1-4, reliable minimum estimate and percentage errors by catchment and management category, Navua Catchment Group ('000 m^3)

Management and catchment	Volume >40 cm s.g. 1-4	Sampling error <40 cm s.g. 1-4	Degrees of freedom	Confidence limit P <0.05	r.m.e. P <0.025	% error	Volume (million Hsl ft) >40 cm s.g. 1-4
Non-commercial							
Wainikovu	47	9	7	21	26	45	16
W' koroiluva	18	4	9	10	8	56	6
Waionamoli	12	2	3	6	6	50	4
N' levu NE	3	1	3	3	0	100	1
N' levu SE	7	1	2	4	3	57	2
Mavuvu	4	1	1	13	0	>100	1
N' levu NW	3	-	-	-	-	-	1
N' levu SW	6	1	3	3	3	50	2
Total	100				46		33
Production							
Wainikovu	271	14	10	31	240	11	90
W' koroiluva	337	28	8	65	272	19	112
Waionamoli	538	31	14	66	472	12	179
N' levu NE	794	32	17	68	726	9	264
N' levu SE	1 166	64	35	130	1 036	11	388
Mavuvu	70	8	5	21	49	30	23
N' levu NW	444	30	8	69	375	16	148
N' levu SW	369	21	17	44	325	12	123
Total	3 989				3 495		1 327
Protection							
Wainikovu	33	7	2	30	3	91	11
W' koroiluva	71	12	9	27	44	38	24
Waionamoli	128	13	6	32	96	25	43
N' levu NE	78	7	5	18	60	23	26
N' levu SE	1	-	-	-	-	-	-
Mavuvu	13	-	-	-	-	-	4
N' levu NW	48	8	1	102	-	71	16
N' levu SW	36	6	5	15	21	42	12
Total	408				224		136

DESCRIPTION OF FOREST TYPES

The forest types are listed by catchments in Table 14 which shows timber volumes, sampling error and net stocking of commercially valuable species.

TABLE 14 Total volumes and sampling errors of forest types in the Navua Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter & sp. group			Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
	(1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4				
Wainikovu							
H	8	6	4	1	1	27	Non-commercial
HS	61	47	40	9	13	25	
J	6	4	3	-	1	21	
Subtotal			47	9	15	25	
C1	303	250	215	12	72	73	Production
G	83	66	56	8	19	47	
Subtotal			271	14	91	66	
CS	50	39	33	7	11	39	Protection
Wainikoroiluva							
G(L)	2	2	1	0	0	11	Non-commercial
H	1	0	0	-	0	0	
K	24	19	13	3	4	20	
S	9	7	4	1	1	4	
Subtotal			18	4	5	10	
C1	385	305	279	28	93	70	Production
C2	74	56	42	3	14	45	
G	30	22	16	4	5	21	
Subtotal			337	28	112	60	
B	0	0	0	0	0	0	Protection
CS	36	27	25	6	11	67	
GS	83	61	46	11	15	26	
Subtotal			71	12	26	33	
Waionamoli							
S	33	23	12	2	4	14	Non-commercial

Table 14 (continued)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m3/ha) for (3)	Management category
C1	649	508	422	29	140	71	Production
C2	34	28	22	6	7	73	
E	19	14	12	2	4	55	
G	131	100	82	5	27	49	
Subtotal			538	31	178	66	
B	13	11	7	2	2	30	Protection
CS	211	167	121	13	40	42	
Subtotal			128	13	42	41	
Nambukelevu North-East							
H	1	1	0	0	0	0	Non-commercial
S	11	9	3	1	1	6	
Subtotal			3	1	1	5	
C1	787	636	524	28	174	86	Production
C2	139	115	107	11	36	105	
CY	164	126	112	7	37	106	
G	91	68	51	10	17	33	
Subtotal			794	32	264	82	
GS	142	114	78	7	26	35	Protection
Nambukelevu South-East							
K	12	10	5	-	2	26	Non-commercial
S	5	3	2	1	1	12	
Subtotal			7	1	3	19	
C1	1 082	852	711	57	237	79	Production
C1(L)	22	16	11	2	4	37	
C2	77	57	48	0	16	61	
CY	391	303	273	28	91	89	
E	4	2	1	-	0	16	
G	175	135	104	12	35	42	
GY	30	22	18	3	6	42	
Subtotal			1 166	64	389	73	

Table 14 (continued)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
CS	7	2	1	-	0	20	Protection
Mavuvu							
S	6	5	4	1	1	26	Non-commercial
C1	39	31	27	3	9	64	Production
G	68	59	43	7	14	37	
Subtotal			70	8	23	44	
CS	20	17	12	-	4	32	Protection
GS	5	1	1	-	0	0	
Subtotal			13	-	4	20	
Nambukelevu North-West							
S	7	6	3	-	1	24	Non-commercial
C1	577	473	393	30	131	86	Production
G	80	65	51	5	17	47	
Subtotal			444	30	148	78	
CS	86	58	48	8	16	37	Protection
Nambukelevu South-West							
S	11	9	6	1	2	16	Non-commercial
C1	358	285	226	18	75	71	Production
C2	100	81	65	6	22	68	
E	1	1	0	-	0	0	
G	131	98	78	8	26	37	
Subtotal			369	21	123	59	
B	6	5	4	1	1	34	Protection
CS	52	39	32	6	11	46	
Subtotal			36	6	12	44	

DESCRIPTION OF FOREST TYPES

C1: Well stocked mixed forest on moderate to steep short slopes

This catchment was enumerated early in the survey and the definition for the type has been based largely on its appearance in the Navua. It is adequately described in Part 4. The stocking of commercially valuable species is remarkably uniform in the seven catchments (excluding Mavuvu) ranging from 70 to 86 m^3/ha (trees over 40 cm d.b.h. species group 1-4, 9 433 to 11 589 Hsl ft/ac). It seems that in Fiji the best stocked forest of broad leaved trees develops on steep slopes, where soil creep ensures that a constant supply of nutrients can come from the parent material.

CY: Well stocked *sacau* forest

Like forest type C1 the definition for this type was worked out in the Navua catchment (see description in Part 4). It occurs on a particular land form feature, mostly along the southern watershed of the Nambukelevu South-East catchment. The stocking of usable timber species is 89 m^3/ha (11 994 Hsl ft/ac), but 30 m^3/ha (4 043 Hsl ft/ac) of this total is *sacau*, a heavy hardwood, dark red in colour, which is suitable for flooring and structural work. It does not have a ready market in Fiji.

G: Moderately stocked mixed forest on moderate to steep short slopes

This type has not such a wide occurrence as forest type C1 but covers more than 1 000 ha (2 471 ac) in all catchments. The stocking of usable timber is variable ranging from 21 to 47 m^3/ha (trees over 40 cm d.b.h. species 1-4, 2 830-6 334 Hsl ft/ac). Its species composition would indicate that it is a seral stage towards forest type C1, but it may represent the limit of development of the forest through some inhibiting factor such as soil or aspect.

CS: Moderately stocked forest on long very steep slopes

This type covers large areas in the Waionamoli and Nambukelevu North-West catchments, where it was first noted and defined (and also in the Waimanu). In the Waionamoli catchment it covers the hills that rise to the peak Tikituru and the forest has a high proportion of *sasauwira* and *koka*. In the Nambukelevu North-West catchment it covers the hills that surround Tuvutau (Mt Gordon); the predominant species are *kauvula* and *damanu*.

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

The division of the area into catchments for the purpose of the enumeration does not make good units for exploitation. Ideally the boundaries between concession areas should follow watersheds not main rivers.

The grouping of catchments for the purpose of forest management is determined by the existing access routes. In the west the road to the Navutulevu sawmill and Nambukelevu village is a focal point for the exploitation of the eastern halves of the Nambukelevu North-West and South-West, and Waionamoli catchments. Similarly the new road that is used by the Viti Timber Milling Company at Ngaloa and comes down to the Navua River near the village of Waimbongi, makes the Nambukelevu North-East and South-East catchments into an exploitation unit. This leaves the block of forest type C1 in the centre of the Wainikoroiluva catchment to be worked on its own. The good forest that lies round the fringe of the Wainikovu catchment forms a separate entity, which can be worked with good forest left at the extreme western end of the Suva-Navua Coastal Strip. At present the western part of the Nambukelevu North-West and South-West catchments are being exploited on a long term licence by Lal Mohammed, who has built an extraction route 24 km (15 mi) long from Mbalenambelo in the next valley to the west. It is recommended that these parts of the catchments be treated separately. They fall into the Western Division administered for forestry from Lautoka, whereas the rest of the catchment falls into the Southern Division.

PROPOSED ACCESS ROUTES

The Wainikovu catchment could be opened up by continuing the road from the Navua waterworks up the Wainikavika Creek onto the southern ridge where good forest occurs. From the top of the ridge it could be extended east and west into the good forest.

The best access into the Wainikoroiluva catchment would be to continue the existing road from Waimbongi to Namuamua, an important village at the junction of the Wainikoroiluva and Navua Rivers. From Namuamua the road could run northwards following the existing track that links the villages on the upper reaches of the river.

A better alternative to the present road that reaches Nambukelevu South-West catchment from Mbalenambelo would be a road cut directly north-east from the south coast, either opposite Votualailai, where a road already runs 5 km (3 mi) inland, or from Mbiausevu past the Korolevu airstrip. From the watershed it should run down to the Navua to where it meets the Numbuonamboto Creek.

If the road up the Singatoka valley were extended past Keiyasi, it would be possible to approach the Waionamoli catchment from the north. A horse track exists following the Lato Creek from the Singatoka River past Vunatoto to Matokana.

PROPOSED TREATMENT OF FOREST TYPES

Production forest Four million m^3 (1 330 million Hsl ft) of Viti Levu's total volume of 7 million m^3 (2 330 million Hsl ft) occurs in the catchment, which makes it the most important area for timber production in Fiji. The production forest types have been listed under the catchments in Table 14. Forest type C1 can be regenerated by conversion to mahogany plantations but it is recommended that further study is done before artificial regeneration is attempted in forest types G and CY.

Protection forest High hill ranges surround the north-east, north and north-west sides of this catchment which are subject to heavy rainfall. It is recommended that the protection forest that has been mapped on these hills be left unexploited, because flooding of the Navua River causes damage to the extensive Navua flats, where rice growing and grazing are carried on, as well as damage to banana plantations which occur from Namuamua westwards.

PART 5. THE SOUTH COAST CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The area consists of the south coast of Viti Levu, which has been divided into two catchments: Catchment 66/1,the Navua-Singatoka Coastal Strip, which runs from Navua westwards to the forest limit just west of Singatoka, and Catchment 67/1,the Suva-Navua Coastal Strip, which runs from Navua to the limit of forest above the suburbs of Suva.

The area constitutes the major part of the tikinas of Mbaravi, Serua (southern outlier), Nuku, Veivatuloa, Suva and a small part of Naitasiri in Nandronga and Navossa, Serua, Namosi and Rewa Provinces.

CLIMATE

The climatic zone along the coast from Suva to the Vatuloa River has a heavy mean annual rainfall of more than 3 810 mm (150 in) and a very weak or no dry season (See text Map 4). From Vatuloa River westwards as far as Vunaniu Bay rising onto the watershed is in climatic zone E with a moderate mean annual rainfall of 3 050-3 810 mm (120-150 in) and a weak or very weak dry season, lasting only two months. Westwards climate zone D is drier with a mean annual rainfall of 2 540-3 300 mm (100-130 in) and a 3 to 5 month dry season. The hills are constantly exposed to the south-east trade winds. A map of the paths of the hurricanes since 1900 shows a high concentration on the Suva-Navua coast. Although they come from the north the winds come with considerable force and do damage to property and forest alike.

GEOLOGY

Along the watershed the hills are underlain by undifferentiated rocks of the Wainimala Group, which are of Eocene to Miocene age and are the oldest rocks in Fiji. They consist of Numbuonamboto volcanic conglomerate, Lokalevu keratophyre and Tawavatu tuff, which have been intruded in the west, inland from Korolevu, by tonalite to diorite of the Tholo Plutonics Group. A fringe of younger rocks (Mio-Pliocene age) lies along the coast. These are Serua conglomerate in the west and Veisari andesite in the east of the Mendrausuthu Andesitic Group. Recent alluvium has been deposited at the mouth of the Navua and on the flat valleys of all the major creeks.

LANDFORM AND SOILS

The watershed between the south coast and the inland catchments lies at an elevation of about 305-457 m (1 000-1 500 ft). It consists of a high line of hills that fall away steeply towards the coast and then level out to form a series of long rounded saddles of land that slope gradually to the sea. The rivers have flat valleys which extend back into the hills for a distance of 3-5 km (2-3 mi).

The soils on the forest-covered hills are mostly humic latosols of the Visa soil set (83). The most widespread soil type is Serua steepland clay and bouldery clay (839), which is derived from basic rocks under wet climatic conditions. The soil profile shows 8 cm (3 in) of reddish brown friable clay, on 60 cm (2 ft) of red friable clay with a moderately to strongly developed very fine angular fragmented structure; rock is reached at 90-120 cm (3-4 ft). The soils are strongly acid with a moderate to low base status. On the long rounded hills that run out to the sea the moderate phase (83 gM) of this soil type is usually found, which has a deeper profile. At the western end of the area red yellow podsolic soils occur on the watershed underlain by intruded diorite rock. The soil type is Narayawa stony sandy clay (90 a). Clay soils occur on the flat valley floors of the streams, the common type being Navua clay (44 a).

VEGETATION

The forest cover has been removed from flat country and areas near the villages on the main road. Between the rivers it extends to the coast on the higher ground but in a modified form due to the process of continuous selective logging, that has gone on for the past 60 years. In the Suva-Navua Coastal Strip all the forest east of the Nambukavesi Creek has been selectively logged, using bullocks for extraction. Only a small area of good forest remains on the hills that form the watershed. In the Navua-Singatoka Coastal Strip logging extends up the main river valleys leaving only a fringe of forest type C1 1.6-2.2 km (1-2 mi) from the watershed. The forest types improve in stocking with increasing distance from the road. On the flat land in the river valleys grass occurs in many places planted with rubber about 60 years ago. Mixed shrub grows on the slopes near to villages; swamp grassland with *Pandanus* occurs near Navua. Mangrove is to be found in the intertidal zone at the mouths of the rivers and heads of the bays.

POPULATION AND LAND TENURE

The population consists of 5 600 Fijians, 3 200 Indians and 890 of other races making a total of 9 690 persons. This figure excludes the suburbs of Suva and Navua township and environs. The villages lie on the Queens Road or along the coast connected by feeder roads with the Queens Road. Only at the extreme western end of the area are there any villages that lie north of the main road.

Large blocks of freehold land occur in the following places:- along the south coast surrounding Nakorombamba peak, at Namboro north-east of Nambukavesi, including the whole of the Navua delta, west of Wainiyambia extending almost to the watershed, between Korovou and Yarawa and at Korolevu. Between these extensive areas of freehold land Native Reserve fills in the coast line, with only small gaps, one east of Na vasi and the other at Lombau. Most of the well forested country remains in Fijian ownership but not in Native Reserve.

PRESENT LAND USE

Fifty or sixty years ago sugar cane was grown in the Navua delta, but now rice is the main crop, grown by the Indian farmers. They are also engaged in some dairying and cattle raising. A large Friesian herd, owned by Morris Hedstroms, is kept on the Navua grasslands. The Fijians are engaged in producing bananas, coconuts, vegetables and *yaqona* as cash crops as well as in sub-sistence farming.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

Several enumerations have been carried out by the Forest Department between 1953 and 1960. These are summarised in the following table:-

TABLE 15 Enumerations carried out by the Forest Department in the South Coast Catchment Group, Viti Levu.

Name of enumeration	Locality	Method and minimum girth	Forest area		Stocking	
			ha	ac	m^3/ha	Hsl ft/ac
No 6, 1953 Korolevu	Komave-Namanda West Navua-Singatoka	Systematic lines 1% 1.5 m (5 ft)	3 730	9 216	24	3 200
No 3, 1956 Nambere	Nambere Central Suva-Navua 67/1	Systematic lines 10% 1.5 m (5 ft)	486	1 200	13	1 800
No 1, 1960 Ngaloa	Ngaloa East Navua-Singatoka	Systematic grid 10% 1.2 m (4 ft)	728	1 800	52	7 000
No 2, 1960 Yarawa	Yarawa Navua-Singatoka	Systematic lines 8% 1.2 m (4 ft)	138	342	37	5 000

A 4 ft (122 cm) girth limit is roughly equivalent to a limit of 40 cm (16 in) d.b.h. and a 5 ft (152 cm) to 50 cm (20 in) d.b.h. The above stocking rates correspond to the results of the present survey with good forest at Ngaloa and Yarawa (before they were logged) and poor forest at Namboro and Korolevu.

EXPLOITATION PAST AND PRESENT

More than 30 small sawmills draw their supplies from over 100 scattered annual licence areas over native lands and some freehold lands to supply the local market. The large concerns, Navutulevu Sawmilling and Viti Timber Milling Company, now have concessions further into the forest in the Navua catchment.

SAWMILLS

The sawmill of the Viti Timber Milling Company is at Ngaloa about 1.6 km (1 mi) from the village. Small sawmilling businesses are situated all down this coast, some flourishing and some derelict, supplied by loggers cutting on annual licences. One such mill at Wainandoi still has a steam traction engine, from which the wheels have been removed, driving a saw bench. The mill cuts timber for the manufacture of banana boxes.

PLANTATION SPECIES

Extensive areas of mahogany plantation are situated at Ngaloa and on the road inland to Nambukelevu. The former have been planted on the forest logged by the Viti Timber Milling Company and the latter in forest logged by the Navutulevu Sawmilling Company. Small plantations also planted with mahogany occur at Lami behind the cement factory and at Yarawa.

EXISTING ACCESS ROUTES

The main road round the southern coast goes from Suva through Navua town to Singatoka. From it a series of feeder roads penetrate the hill country to the north. At Naikorokoro a road follows the creek for a short distance inland connecting with a track that crosses the Waimanu valley and goes to Nasirotu on the Waindina River. The Lombau settlement scheme is reached by a short road near the Lombau River. North of Navua town one road goes up to the Navua waterworks following the Wainikavika Creek and another goes on the Navua River. Past Navua to the west Latchman's Timber road continues inland to the forest margin. From Ngaloa a new road, built by the Forest Department, goes down to the Navua at Waimbongi. From Vuniyawa a road goes north to Nambukelevu village on the Navua. A road goes as far as Mbiausevu leaving the main road near the hotel at Korolevu. Another road, used for timber extraction in the past, goes north from Votualailai.

Many of the rivers are used for floating rafts of logs down to the main road.

THE ENUMERATION

LAYOUT OF SURVEY

In the Navua-Singatoka Coastal Strip the base line follows the coastline and has a slight angle in it opposite Vunaniu Bay. The lines run roughly north-south. In the Suva-Navua Coastal Strip the base line is not parallel to the coast but runs east-west so that the lines which are cut south-north may cross the ridges at an angle.

TIMBER VOLUMES

Areas of the forest types are given in Table 16 below.

TABLE 16 Enumerated areas of forest types in South Coast Catchment Group (ha)

Forest type	Navua-Singatoka Coastal Strip	Suva-Navua Coastal Strip	Total enumerated area		% of enumerated forest
			ha	ac	
G(L)	2 746	-	2 746	6 785	7
H	1 111	5 303	6 414	15 849	18
J	-	2 007	2 007	4 959	6
K	2 021	-	2 021	4 994	6
S	832	-	832	2 056	2
Non-commercial	6 710	7 310	14 020	34 643	39
C1	5 428	1 667	7 095	17 532	19
C1(L)	1 163	-	1 163	2 874	3
CY	417	-	417	1 030	1
G	4 506	451	4 957	12 249	14
GV	1 072	-	1 072	2 649	3
Production	12 586	2 118	14 704	36 334	40
B	156	222	378	934	1
CS	1 829	5 351	7 180	17 742	20
Protection	1 985	5 573	7 558	18 676	21
Total			36 282	89 653	

The extent of modification of the vegetation is indicated by the high proportion of non-commercial forest types, which cover 14 020 ha (34 643 ac), which is 39% of the enumerated area. The sampling layout covered all the forest area north of the Queens Road so the enumerated area is very nearly the total area of forest cover.

The volume of standing timber in the enumerated forest is summarised in Table 17. The production forest contains 934 000 m^3 (311 million Hsl ft) of timber including trees over 40 cm d.b.h. species group 1-4, with a reliable minimum estimate of 831 000 m^3 (277 million Hsl ft). Equivalent figures for the non-commercial forest are 223 000 and 175 000 m^3 (74 and 58 million Hsl ft) and for the protection forest 308 000 and 256 000 m^3 (103 and 85 million Hsl ft).

TABLE 17 Volume of timber from trees over 40 cm d.b.h., species group 1-4, reliable minimum estimate, and percentage error by catchment and management category, South Coast Catchment Group (000 m^3)

Management and catchment	Volume >40 cm s.g. 1-4	Sampling error >40 cm s.g. 1-4	Degrees of freedom	Confidence limit P<0.05	r.m.e. P<0.025	% error	Volume >40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Navua-Singatoka	89	10	25	21	68	24	30
Suva-Navua	134	13	26	27	107	20	45
Total	223				175		75
Production							
Navua-Singatoka	772	39	46	79	693	10	257
Suva-Navua	162	10	7	24	138	15	54
Total	934				831		311
Protection							
Navua-Singatoka	87	11	14	24	63	28	29
Suva-Navua	221	13	12	28	193	13	74
Total	308				256		103

In the production forest the sampling error is within the stipulated limit with percentage errors of 10 and 15% in catchments 66/1 and 67/1 respectively. In the non-commercial forest and protection forest the error is higher but not far outside the prescribed limit of 20%.

DESCRIPTION OF FOREST TYPES

The forest types are listed by catchment in Table 18 below, which shows timber volumes, sampling errors, and net stocking of commercially valuable species.

TABLE 18 Total volumes and sampling errors of forest types in the South Coast Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter & sp. group			Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m3/ha) for (3)	Management category
	(1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4				
Navua-Singatoka							
G(L)	133	91	61	5	20	22	Non-
H	24	11	6	8	2	5	commercial
K	59	42	17	3	6	8	
S	14	10	5	1	2	6	
Subtotal			89	10	30	13	
C1	686	536	434	29	144	80	Production
C1(L)	91	56	41	8	14	35	
CY	48	37	33	6	8	55	
G	387	297	238	24	79	53	
GV	55	43	26	9	9	24	
Subtotal			772	39	254	61	
B	2	1	1	1	0	6	Protection
CS	158	118	86	11	29	47	
Subtotal			87	11	29	44	
Suva-Navua							
H	206	148	117	13	39	22	Non-
J	32	23	17	4	6	8	commercial
Subtotal			134	13	45	18	
C1	195	158	139	10	46	83	Production
G	30	25	23	2	8	51	
Subtotal			162	10	54	76	
B	4	3	3	0	1	14	Protection
CS	346	267	218	13	73	41	
Subtotal			221	13	74	40	

Type G(L): Low-stocked logged mixed forest on moderate to steep short slopes; **H**: Logged-out forest

Forest type G(L) in the Navua-Singatoka Coastal Strip is very similar to forest type H in the Suva-Navua Coastal Strip. Both have been subjected to a process of prolonged selective logging resulting in a stocking of commercially usable timber of 22 m^3/ha (2 965 Hsl ft/ac). These types

form a broad zone fringing the forest from Suva to Singatoka. South of the main road the forest has been further depleted with a stocking of only 8 m^3/ha (1 078 Hsl ft/ac) in forest type J. To the north some areas show a less severe stage of the selective logging process, in the form of forest type C1(L), whereas in others, forest type G and forest type C1 occur. The forest type S that occurs on the hills in the Navua-Singatoka Coastal Strip is probably the result of earlier cultivation in the last century.

Type C1: Well stocked mixed forest on moderate to steep short slopes

This type still exists on the watershed spreading down for about 1.6-2.2 km (1-2 mi) towards the coast at the western end of the Suva-Navua Coastal Strip and intermittently along the Navua-Singatoka Coastal Strip. It has a stocking of 80 m^3/ha (10 781 Hsl ft/ac) and contains *kaudamu*, *kauvula*, *yasiyasi* and *damanu*.

Type CS: Moderately stocked forest on long very steep slopes

This type covers the hills that form the watershed of the Suva-Navua Coastal Strip extending southwards as far as the logged forest. The comparatively low stocking and absence of species like *damanu* and *dakua makadre* suggest that logging operations have extended into this steep country.

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

The good forest at the western end of the Suva-Navua Coastal Strip should be combined with the Wainikovu forest in the Navua catchment. At the eastern end of the Navua-Singatoka Coastal Strip good forest lies on the watershed extending as far as the Ngaloa mahogany plantations. This forest could be combined with the forest of the Nambukelevu South-East catchment in the Navua. It is already served by the access road to the Viti Timber Milling Company concession. The forest at the extreme western end of the Navua-Singatoka catchment could be combined with the Nambukelevu South-West catchment.

PROPOSED ACCESS ROUTES

This is about the only forest area in Fiji that does not have an access problem. Apart from the roads described under 'existing access routes' innumerable tracks and logging skids penetrate the forest.

The western end of the Suva-Navua Coastal Strip can be opened up by continuing the road that goes to the Navua waterworks up the Wainikavika Creek. Other areas of well stocked forest are already served by existing access routes.

PROPOSED TREATMENT OF FOREST TYPES

Non-commercial forest Nearly 40% of the forest cover is made up of non-commercial forest types, the present derelict condition of which is due to logging. Although the difficulties of regeneration by either natural or artificial means are great, it is felt that this large area of accessible moderate sloping land should be producing something. Measurements on some mature forest species indicate that the rate of growth of trees like *kaudamu* and *damanu* is slow. Perhaps more attention could be paid to the pioneer species of the Fiji forest such as *kauvula* and *mako*. The Leyland grazing areas near to Namboro indicate that formidably steep slopes can be grazed. It may be possible to convert the easier slopes now covered with low forest to grasslands.

Production forest The forest types suitable for timber production are listed in Table 18.

Protection forest It is recommended that forest types CS and B are not included in a felling plan. The existing forest cover stabilises the soil and controls run off. Logging operations would be uneconomic and unwise.

PART 6. THE KANDAVU EAST AND WEST CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The island of Kandavu lies 96 km (60 mi) south of Suva on latidude 19^{O} and between 178^{O} and 178^{O} 30' E of longitude. The island is divided into three distinct land masses by two waists. The western land mass, which includes part of the Nambukelevu and Tavuki tikinas, and the eastern section including part of Natheva and Nakasaleka tikinas have been enumerated as Kandavu West and East respectively. The central land mass called Tavuki has not been enumerated because it was the subject of a forest inventory many years ago and is currently being exploited by the Kandavu Timber Company.

CLIMATE

This long thin island lies east-north-east to west-south-west across the prevailing wind. As a result climatic zones follow the watershed with the windward side of the island having a very weak dry season and a moderate to high mean annual rainfall of 2 030 - 3 300 mm (80-130 in), whereas the leeward side has a three month dry season and 2 030 - 2 540 mm (80-100 in) of rain in a year.

GEOLOGY

Kandavu is a volcanic island composed essentially of andesites with more flows in the west (Nambukelevu) than in the east (Natheva and Tavuki). Altered limestones are of limited occurrence (Romanu, 1959). The embayed coastline is the result of considerable subsidence of the land mass.

LANDFORM AND SOILS

The western land mass has several peaks over 425 m (1 400 ft) and a central ridge that does not drop below 215 m (700 ft). At the extreme western end a steep volcanic cone, Ndelainambukelevu, rises to 805 m (2 642 ft). The streams of the northern coast flow in relatively wide valley floors with very steep sides, the whole land mass being very steep and dissected. The central part of the island (Tavuki) has gentler slopes. It consists of a dissected plateau at an elevation of 274 m (900 ft) lying between the peaks of Vunindilo and Manggove in the west and Korotu in the east. The eastern land mass is steep with peaks of 634 m (2 082 ft) at Mbiloniyanggona and 447 m (1 464 ft) at Koronimbanuve.

Red yellow podsolic soils cover the western land mass, the leeward side of the central land mass, and the windward side of the eastern land mass. Humic latosols cover the rest of the area with small patches of nigrescent soils on the northern coast. The red yellow podsolic soil type on the windward side of the island is Bukulevu bouldery clay whereas on the leeward side are found Namuana stony sandy clay (92 d) and Rauriko stony sandy clay (92 e). The humic latosol that occurs in the central and eastern land masses is Nacula steepland clay.

VEGETATION

Forest is to be found on the high ground and also on the windward side of the island except for a narrow strip of cultivation around the coast. On the leeward side of the island the forest has been replaced by grass, shrubs and isolated trees, which extend over 1.6 km (1 mi) inland in the west but form only a narrow fringe in the centre and east, except near centres of population.

On the central land mass the quality of the forest is good containing *dakua makadre* and *kauvula*. In the west it is poor with a low canopy and a high proportion of the less valuable species. In

the east although much of the forest is poor, influenced by the very steep slopes, there are some well stocked areas.

POPULATION AND LAND TENURE

The population of Kandavu is Fijian with 8 426 Fijians, 3 Indians and 202 of other races. There are about 86 villages, which are scattered round the coast, none of them sited more than 1.6 km (1 mi) inland.

The land is largely Fijian owned, although there are a few blocks of alienated land, notably near Ngaloa Harbour and on the northern coast between Naikorokoro and Ndaku Bay.

PRESENT LAND USE

The farmers of Kandavu have a high reputation for producing taro and other root crops. Elaborate stone terraces, in which taro was irrigated, are to be seen sometimes in use. The traditional Fijian crops are grown for subsistence and for export. There is some export of coconuts. The network of roads radiating from the sawmill at Naikorokoro all over Tavuki has led to the opening up of this section of the island and in recent years large clearings have been created for new coconut plantations.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

A systematic 4% timber enumeration was carried out over 3 465 ha (8 562 ac) of Tavuki in 1957. All trees greater than 39 cm d.b.h. (15 in) were measured and the results showed a timber stocking of 66 m^3/ha (8 894 Hsl ft/ac).

EXPLOITATION PAST AND PRESENT

The Kandavu Timber Company, a subsidiary of the Pacific Lumber Company, has a concession over part of the Tavuki tikina.

SAWMILLS

The Kandavu Timber Company have a sawmill at Naikorokoro on the northern coast. The sawn timber is shipped by local vessel to Suva or Lautoka. In 1967 the intake into the mill was 5 000 m^3 (1 673 497 Hsl ft).

PLANTATION SPECIES AND AGE CLASS

Trial plantings of mahogany (*Swietenia*) have been established in the felled forest in Tavuki but no details as to planting date and rate of growth are available.

EXISTING ACCESS ROUTES

A road runs from Vunisea in Namalata Bay on the north coast to the sawmill at Naikorokoro. Subsidiary roads, extended from the timber exploitation area, serve several villages on the south coast of the central land mass. The main line of communication is the sea. Every village has its punt or small launch with an outboard motor, used for fishing and obtaining supplies. Two or three small ships, one of them owned by the Kandavu Provincial council, sail between Suva and the ports of Kandavu, taking one week to 10 days to work round the island unloading supplies and loading copra and root crops.

There are few paths across the island but the villages are linked along the coast by well used tracks.

THE ENUMERATION

LAYOUT OF SURVEY

In Kandavu West the lines run almost north-south across the forest from Nasau in the west to Namalata in the east. In Kandavu East the lines have been cut on a north north-east bearing and extend from Vunisei to just east of Kavala Bay.

TIMBER VOLUMES

The enumerated areas of forest in the different forest types are given in Table 19.

TABLE 19 Enumerated areas of forest types in Kandavu East and West Catchment Group (ha)

Forest type	Kandavu East	Kandavu West	Total enumerated area		% of total forest
			ha	ac	
DR	264	-	264	652	2
J	-	89	89	220	1
Non commercial	264	89	353	872	3
C1	1 590	-	1 590	3 929	13
CY	552	-	552	1 364	5
G	1 384	-	1 384	3 420	12
GV	-	125	125	309	1
Production	3 526	125	3 651	9 022	31
B	-	80	80	198	1
CS	-	3 408	3 408	8 421	29
GS	523	-	523	1 292	4
S1	1 136	2 663	3 799	9 387	32
Protection	1 659	6 151	7 810	19 298	66
Total			11 814	29 192	

From the table it can be seen that the production forest lies in Kandavu East, while Kandavu West consists almost entirely of protection forest.

The timber volumes are summarised in Table 20, which gives the usable volume, sampling error and reliable minimum estimate for each catchment and management category.

TABLE 20 Volume of timber from trees over 40 cm d.b.h., species group 1 - 4, reliable minimum estimate and percentage errors by catchment and management category, Kandavu East and West Catchment Group ('000 m^3)

Management and catchment	Volume >40 cm s.g. 1-4	Sampling error >40 cm s.g. 1-4	Degrees of freedom	Confidence limit p <0.05	r.m.e p = 0.025	% error	Volume 40 cm (16 in) s.g. 1-4 (million Hsl ft)
Non-commercial							
Kandavu East	2	-	-	-	-	-	1
Kandavu West	1	<1	1	5	0	>100	0
Total	3			-			1
Production							
Kandavu East	260	14	17	29	231	11	86
Kandavu West	2	-	-	-	0	-	1
Total	262				231		87
Protection							
Kandavu East	22	4	4	12	10	52	7
Kandavu West	152	12	14	27	125	18	50
Total	174				135		57

The production forest of the Kandavu East catchment contains 260 000 m^3 (86 million Hsl ft, trees over 40 cm d.b.h. species groups 1-4) for which the reliable minimum estimate is 231 000 m^3. Kandavu West contains mostly protection forest which has a standing volume of 152 000 m^3 (50 million Hsl ft) and a reliable minimum estimate of 125 000 m (42 million Hsl ft).

The percentage errors for the production forest of Kandavu East and the protection forest of Kandavu West are below the 20% level. The percentage error for the non-commercial forest in both catchments is very high or not calculable because of insufficient sampling.

DESCRIPTION OF FOREST TYPES

In Table 21 the timber volume, sampling error, area and stocking of each forest type are listed by management categories for the two catchments.

TABLE 21 Total volumes and sampling error of forest types in the Kandavu East and West Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter and species group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 16 in 1-4	Sampling error for (3)	Volume million Hsl ft for (3)	Stocking m^3/ha for (2)	Management category
Kandavu East							
DR	9	5	2	-	1	8	Non-commercial
C1	179	157	137	11	46	86	Production
CY	86	76	68	6	23	123	
G	78	68	55	5	18	40	
Subtotal			260	14	87	74	
GS	21	18	14	4	5	27	Protection
S1	16	11	8	1	3	7	
Subtotal			22	4	8	13	
Kandavu West							
J	2	1	1	<1	0	11	Non-commercial
GV	4	3	2	-	1	16	Production
B	1	1	1	-	0	13	Protection
CS	211	184	129	12	43	38	
S1	52	43	22	4	7	8	
Subtotal			152	12	50	25	

C1: Well stocked mixed forest on moderate to steep, short slopes

This forest type covers an area of 1 590 ha (3 929 ac) on the middle slopes in the centre of Kandavu East. *Kauvula, yasiyasi* and *kaudamu* are the predominant species with *damanu, mala* and *dakua makadre* less common. The overall timber stocking of trees over 40 cm d.b.h. species groups 1 - 4 is 86 m^3/ha (11 589 Hsl ft/ac). Although the type has more *kauvula* and less *damanu* than usual it contains only a small proportion of 'others' and is a useful type for exploitation.

CY: Well stocked *sacau* forest

This forest type covers an area of 552 ha (1 364 ac) at the south-east end of Kandavu East, along the hills exposed to the trade winds, from Korongatule to just west of Nungganungga. It occurs on the red yellow podsolic soil, Bukulevu bouldery clay (91 b). *Sacau* and *yasiyasi* predominate,

associated with moderate quantities of *kauvula*, *kaudamu*, *dakua salusalu* and a little *buabua*. The overall stocking is very high: 123 m^3/ha (16 575 Hsl ft/ac) of trees over 40 cm d.b.h. (species groups 1-4).

G: Moderately stocked mixed forest on moderate to steep, short slopes

This type occurs in the centre of Kandavu East in the headwaters of the Waimbusi and adjacent creeks covering an area of 1 384 ha (3 420 ac). *Kauvula* is the most abundant species with lesser quantities of *yasiyasi* and *kaudamu* producing an overall stocking of 40 m^3/ha (5 390 Hsl ft/ac) of trees over 40 cm d.b.h. (species groups 1-4).

CS: Moderately stocked forest on long very steep slopes

This forest type covers all the high ground of Kandavu West with a total enumerated area of 3 408 ha (8 421 ac). *Kauvula* and 'others' are the common species. Included in 'others' are *qereqaqa* (H 412), a common tree that has not yet been identified, *Aglaia axillaris* and *Elattostachys falcata*. The forest often has no understorey but the ground is covered with ferns 50 cm (20 in) high giving the forest the appearance of a temperate beech woodland. Overall stocking is 62 m^3/ha (8 355 Hsl ft/ac) of trees over 35 cm d.b.h., but this is reduced to 38 m^3/ha (5 121 Hsl ft/ac) when the species group 5 has been subtracted and 40 cm d.b.h. is the minimum diameter.

S1: Low stocked open canopy woodland on very steep slopes

In both Kandavu West and East this type occurs as a broad belt 0.8 km (0.5 mi) wide from the forest margin on the leeward side of the island and also in pockets near the coast on the windward side. It covers a total of 3 799 ha (9 387 ac) and is the forest type covering the largest area, occupying 32% of the forest cover. 'Others' has the highest stocking including an unusual tree, *lutulutu* (*Macaranga seemannii*), collected during the survey as well as the more common *doi* and *salato*. Other species are *kauvula*, *kandavu*, *sasauwira* and *koka* giving an overall stocking of 20 m^3/ha (2 695 Hsl ft/ac) trees over 35 cm d.b.h. (14 in) or 8 m^3/ha (1 078 Hsl ft/ac), (trees over 40 cm d.b.h., species groups 1-4).

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

Kandavu West is not suitable for commercial exploitation because most of the area is very steep and the forest is poor in valuable commercial species. Reconnaissance enumeration surveys conducted by the Kandavu Timber Company confirmed this view. In Kandavu East the production forest lies south of a line between the peaks of Koronimbanuve and Mbiloniyanggona and extends eastwards through the very rich forest type CY to the Korongatule peak. This forest could be exploited as an extension of the Central Tavuki licence area at present under exploitation.

PROPOSED ACCESS ROUTES

The central part of the island, Tavuki, is well served by roads, as a result of timber exploitation, and it would not be difficult to extend the existing road system as far as Vunisei on Ndaku Bay. From here a road alignment could either go due east to the twin peaks of Koronimbanuve and Ndovumalai, tapping the forest from the main watershed, or it could follow the coast round the east side of Soso Bay and go inland along one of the ridges near Yavitu village.

PROPOSED TREATMENT OF FOREST TYPES

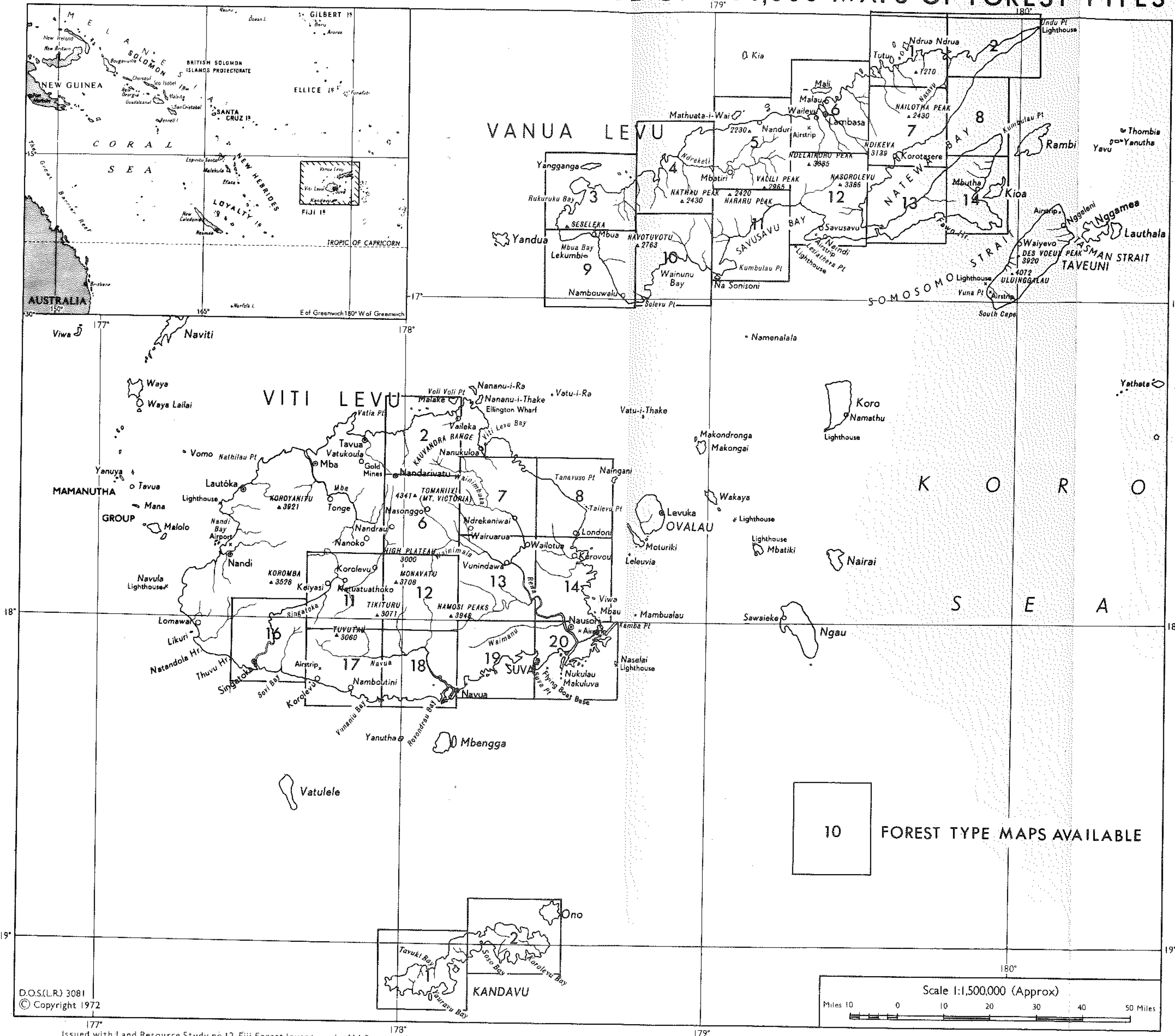
Non-commercial forest Non-commercial forest covers only 3% of the enumerated forest area but there is a bigger area, not included in the enumeration, on the southern side of Kandavu East.

Production forest Production forest covers 3 651 ha (9 022 ac) or 31% of the enumerated area, providing a standing volume of 262 000 m^3 (87 million Hsl ft, trees over 40 cm d.b.h., species groups 1-4) and a r.m.e. of 231 000 m^3 (77 million Hsl ft). Practically all of this occurs in Kandavu East.

Protection forest Of the enumerated forest area 7 810 ha (19 299 ac) or 66% are recommended for protection. This includes all the forest cover in Kandavu West and the hills in the centre and north side of Kandavu East. A limited amount of soil surveying in Kandavu West indicated that the soils on the hills are thin above rock scree and that the large trees play an important part in stabilisation.

FIJI ISLANDS

COVERAGE OF 1:50,000 MAPS OF FOREST TYPES



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Text Map 6

CATCHMENT GROUPS

VITI LEVU

Miles 5 0 5 10 15 20 Miles

17°15'S 177°15' 177°30' 177°45' 178°00' 178°15' 178°30' East of Greenwich 178°45' 17°15'S

17°30' 17°45' 18°00' 18°15' 18°30' 18°45' 19°00' 19°15'

Lautoka

Nandi

TAWA 59/9

NAITALEIRA 60/1

NDAWASAMU 60/2

LONDONI 60/3

NANDARIVATU 64/1

NANDARIVATU

NANUKU 59/6

SOLIKANA 64/2

WAINIMBUKA 59/10

WAINIMALA 59/7

TAILEVU

WAIMBULA 60/4

REWA

SOVI 59/3

LOMAIVUNA 59/5

WAINDRANDRA 59/4

WAINIKORO ILUVA 65/2

WAINDINA 59/2

WAIMANU 59/1

WAIONAMOLI 65/3

NAMBUKELEVU NORTH-EAST 65/4

NAMBUKELEVU NORTH-WEST 65/7

NAVUA

NAMBUKELEVU SOUTH-WEST 65/6

NAMBUKELEVU SOUTH-EAST 65/5

WAINIKOYU 65/1

SOUTH COAST

SUVA-NAVUA COASTAL STRIP 67/1

SUVA

SOUTH COAST

NAVUA-SINGATOKA COASTAL STRIP 66/1

KANDAVU EAST 22/1

KANDAVU WEST 22/1

KANDAVU

Enumerated Forest

D.O.S. 3104

Prepared by the Directorate of Overseas Surveys 1972

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Foreign and Commonwealth Office
Overseas Development Administration

Fiji Forest Inventory
Volume 3
Catchment Groups of Vanua Levu

by

M J Berry and W J Howard

Land Resource Study No. 12

Land Resources Division, Tolworth Tower,
Surbiton, Surrey, England

LIST OF VOLUMES

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PARTS 1 - 10

PART 1. THE MBUA NORTH CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The area consists of 4 catchments:

2/1	Mbua	8/1	Sarowangga
6/1	Kavula	10/1	Naimbulu

They are located to the north-west of Vanua Levu Island in Mbua Province. The limits of the area are indicated by the sea coast to the north and west, the ridge between Nambiti River and Ndrala Creek to the east, and the main watershed of the island to the south. The area falls mostly into Mbua tikina and a small part in Mathuata tikina in Mbua Province.

CLIMATE

All of the Mbua catchment falls into climate zone B with a long intense dry season, with more than 5 months, June to October, having less than 152 mm (6 in) of monthly rain, and a low rainfall of less than 2 540 mm (100 in) a year. Two other catchments Kavula and Sarowangga have a climate stratified by the elevation. The upper slopes to the south on the main island watershed have a very weak or no dry season and heavy rainfall. As the elevation decreases towards the north the average annual rainfall decreases, and the number of dry months with less than 152 mm (6 in) of rain increases. Eventually on the coastal plains there is the long intensive dry season and low rainfall as in Mbua catchment (see Text Map 5). Naimbulu catchment similarly shows a decrease in annual rainfall with a decrease in altitude, but does not reach such dry conditions at the coast, where, although the dry season is long and intensive, there is a moderate rainfall of 2 540-3 300 mm (100-130 in) per annum.

Northerly gales and winds of hurricane force do considerable damage to the forest cover at the heads of exposed valleys. Large areas of windthrow are not uncommon, and height growth may well be affected as was observed during the field work in these catchments.

GEOLOGY

The geology of this area is diverse. To the north-west the rugged mountainous areas around Rukuruku Bay consists of an isolated outcrop of the Natewa Volcanics Group, here diversified into the Monkey Face Volcanic basic flows, grits and breccias. To the south and east the Mbua basalts reach as far as the Lekutu river estuary. Across the Lekutu River the low plateau of the Nasarowangga river system is underlain by plugs and breccias of hornblende andesite of the Natewa Volcanics Group.

LANDFORM AND SOILS

Both the southern boundary and the western tip of this area are steep. The southern edge is radially dissected by ridges and rivers, running down from Navotuvotu mountain, while the east is more diversely broken into rugged mountains. Between these two lie the flat-topped gently sloping ridge country of the Mbua basalts. To the east is the flat erosion surface of the Nasarowangga Plateau at 61 m (200 ft) above sea level.

The rugged land above Rukuruku Bay is overlain by the humic latosols of the Nawavi stony and bouldery clay (86 c) and the steep slopes to the south by Tailevu stony and bouldery clay (84 b). The plateau has talasinga soils (ferruginous latosols) of the Bua clay (35 c) to the west and Lekutu silty clays (35 b) to the east.

VEGETATION

The western area is mostly poor *velau* forest and scrub on the steep ground, with gulley forest of raintree and Sapotaceae occurring in the grassland. The talasinga areas zre mostly under mission grass, with fern, *nokonoko* and *Pandanus* in places. To the south the Tailevu stony and bouldery clays and Londoni clays carry tropical rain forest characterised by a large proportion of moderate to poorly stocked forest, containing *velau*, until the higher rainfall of the main watershed is reached.

POPULATION AND LAND TENURE

The population is sparse and scattered and consisted in 1966 of 1 715 Fijians and 1 639 Indians. Since the previous census in 1956, the Fijian population has increased by 17%, much below the 32% national average, and the Indian population by 60%, almost double the average.

The Fijians live in some 12 coastal and inland villages and on scattered farms: with one exception, Nawailevu, they do not live along the main road. The Indian settlements such as Korokande and Motukombuli occur along the main road and border the flats of main rivers such as the Sarowangga, Kavula, Lawaki and Lekutu, and the estuarine flats on the coast. Here they grow rice and graze cattle.

All the forested and grassland hills are Fijian owned, but none are Native Reserve. There are large blocks of Native Reserves at Nawailevu, Mbanikea, Ndelainavoa and Namuavoivoi, and along the coast.

The Indian farmers work both lease land and large freehold blocks, the latter giving them security of tenure in the irrigated rice land.

The large mission grass flats (considered as possible plantation and beef ranching sites) are almost entirely Fijian owned, but are not in Native Reserve.

PRESENT LAND USE

The Fijian farmers are mostly engaged in subsistence cropping of cassava, taro, yams and some rice. Poor communications to the inland villages preclude much marketing of cash crops although some *yaqona* is sold. The coastal villages produce copra for sale and so do some inland villages such as Kavula and Namuavoivoi. There is no near market for root crops.

Grazing by Fijian-owned herds of beef cattle and horses is uncontrolled and the higher ground is overgrazed mission grass. The highest ground is almost ungrazed on the other hand. Nowhere is there improved pasture, and burning has depleted the ungrazed areas further, especially in the old eroded plateau forming the Nasarowangga flats. The Indian farmers are primarily rice producers in new settlement areas. The rice is sold as well as consumed locally, and subsistence crops are produced. No sugar cane is grown in this area. The Indian herds are better managed with some store feeding for personal milk production. Goat herds are frequent, but little dairy produce appears to be sold.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

No enumerations have taken place in the survey area.

EXPLOITATION PAST AND PRESENT

The area falls within the Fiji Forest Industries Option area but no felling on a commercial scale has occurred. Sandalwood was exported from the western coast in the early part of the 19th century.

SAWMILLS

There are no sawmills in the area.

PLANTATION SPECIES AND AGE CLASS

No plantations existed at the time of enumeration.

EXISTING ACCESS ROUTES

The main road from Lambasa to Nambouwalou passes to the north of the enumerated area. Neither this road nor the coastal track passes through commercial forest of any value. Earth access roads, suitable for land-rovers, reach the Tavua River crossing before the Namuavoivoi village and the Kavula River crossing before Kavula village. Both these roads continue as horse tracks to the farthest farms, and thence as hunting tracks into the watersheds of the Kavula and Sarowangga catchments and along the valleys of the creeks where the commercial forest lies. Their alignment with a few changes should prove adequate for timber extraction roads. A hunting track with a suitable alignment runs from Nasarowangga to Nasingasinga and Tambulotu via the watershed ridge of the Sarowangga catchment, above Kulasisi Creek off the Nambuna River, and thence to Thongea on the south coast as a horse track. A foot track runs from the road at Namuavoivoi to Thongea, crossing the watershed above Singgawe Creek, and passing through Navakasali village from whence it is a horse track. A horse track runs from Mbua village over the watershed of Mbua catchment, above Ndevoka Creek off the Mbua River, to Nasau village on the north coast.

The best access route is considered to be the track from Nasingasinga over to Thongea, which can probably be re-routed along the ridge track above the Wainunu valley.

The Sarowangga and Lekutu Rivers are navigable as far as the Indian settlement near Nandrika and the entrance of Kavula Creek respectively. The freighter 'Fiji Princess' loads cattle beside the main road near Sarowangga.

THE ENUMERATION

LAYOUT OF SURVEY

In Mbua catchment a reconnaissance layout was used with two lines sampling the forest to the north of the road and one line to the south. The Kavula, Sarowangga and Naimbulu catchments shared a base line, which ran along the upper reaches of the Kavula River. Nine lines were cut each running right across the catchments from watershed to watershed.

TIMBER VOLUMES

Total enumerated areas of the forest types are given in Table 1. In Mbua, Kavula, and Naimbulu the enumerated production forest represents about half the total production forest, whereas in the Sarowangga catchment about two thirds of the production forest has been enumerated. In the production forest, type GV is the most widespread, while in the non-commercial forest type P is common. Protection forest is not extensive in this group of catchments, covering only 9% of the total area.

TABLE 1 Enumerated areas of forest types in the Mbua North Catchment Group (ha)

Forest type	Mbua	Kavula	Sarowangga	Naimbulu	Total enumerated area		% of enumerated forest
					ha	ac	
GD	-	-	210	-	210	519	1
P	105	569	1 385	-	2 059	5 088	15
V	228	30	351	84	693	1 712	5
VB	33	-	-	123	156	385	1
Non-commercial	366	599	1 946	207	3 118	7 705	22
C1	-	485	1 278	-	1 763	4 356	13
CY	-	-	50	-	50	124	<1
DK	-	-	500	-	500	1 236	4
G	-	537	996	-	1 533	3 788	11
GB	168	-	-	-	168	415	1
GV	1 743	595	1 848	964	5 150	12 726	36
GV(L)	353	-	-	-	353	872	3
KD	187	-	-	-	187	462	1
VS	62	-	-	-	62	153	<1
Production	2 513	1 617	4 672	964	9 766	24 132	69
B	121	-	62	-	183	452	1
CS	316	277	-	-	593	1 465	5
GS	-	-	-	152	152	376	1
S1	146	27	109	-	282	697	2
Protection	583	304	171	152	1 210	2 990	9
Total					14 094	34 827	

The volumes of timber in the four catchments are summarised in Table 2. In the production forest the volume of usable timber in the catchment group is 373 000 m^3 (124 million Hsl ft) giving a figure for the reliable minimum estimate of 278 000 m^3 (93 million Hsl ft)

In the production forest, the sampling error is within the prescribed limit for the Mbua and Sarowangga catchments, just outside for Kavula catchment (percentage error 24%) and excessively high for Naimbulu catchment, because of the low stocking. In the non-commercial and protection forest the errors are high or not calculated, because only small areas of forest containing low volumes of usable timber were sampled.

TABLE 2 Volume of timber from trees over 40 cm d.b.h., species group 1-4, reliable minimum estimate and percentage errors by catchment and management category, Mbua North Catchment Group ('000 m^3)

Management and catchment	Volume 40 cm s.g. 1-4	Sampling error >40 cm s.g. 1-4	Degrees of freedom	Confidence limit $p<0.05$	r.m.e. $p<0.025$	% error	Volume >40 cm s.g. 1-4 (million Hsl ft)
Non-commercial Forest							
Mbua	7	2	4	6	1	86	2
Kavula	7	1	1	13	0	100	2
Sarowangga	30	4	3	12	18	40	10
Naimbulu	2	-	-	-	-	-	1
Total	46				19		15
Production							
Mbua	82	6	5	15	67	18	27
Kavula	75	7	5	18	57	24	25
Sarowangga	191	16	8	37	154	19	64
Naimbulu	25	8	3	25	0	100	8
Total	373				278		124
Protection Forest							
Mbua	16	(3)	1	-	-	-	5
Kavula	16	(1)	1	-	-	-	5
Sarowangga	1	-	0	-	-	-	0
Naimbulu	5	-	0	-	-	-	2
Total	37						12

DESCRIPTION OF FOREST TYPES

The forest types occurring in this group of catchments are listed in Table 3, which shows the timber volumes, sampling errors and net stocking of usable timber. This area has a climate with a strong dry season with the result that the forest types are dominated by *velau* and associated dry zone species. The most widespread of the dry zone forest types is GV, which covers an enumerated area of about 5 000 ha (12 000 ac) and has a stocking of usable timber of about 25 m^3/ha (3 369 Hsl ft/ac). Other forest types of the dry climate are GB, GD, VB and GV(L).

P: Low stocked old orchard *dawa-ivi* forest

This type occurs in the Kavula and Sarowangga catchments. The enumeration in Sarowangga shows a high stocking of the edible fruit tree *dawa*, associated with secondary regrowth species such as *sasauwira* and *koka*. This kind of forest grows near old village sites: these are marked near Nawailevu and Namuavoivoi on the old Native Land Trust Board maps.

TABLE 3 Total volumes and sampling errors of forest types in the Mbua North Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1 - 5	(2) 40 cm 1 - 5	(3) 40 cm 1 - 4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
Mbua							
P	9	8	3	1	1	28	Non-commercial
V	24	17	4	2	1	18	
VB	1	1	0	-	0	-	
Subtotal			7	2	2	19	
GB	18	14	10	-	3	59	Production
GV	63	50	37	1?	12	21	
GV(L)	37	28	18	5	6	51	
KD	26	19	14	3	5	75	
VS	5	5	3	-	1	49	
Subtotal			82	6	27	32	
B	0	0	0	0	0	-	Protection
CS	33	26	14	3	5	44	
S1	7	5	2	-	1	14	
Subtotal			16	3	6	27	
Kavula							
P	14	11	7	1	2	12	Non-commercial
V	1	<1	<1	-	0	-	
Subtotal			7	1	2	12	
C1	45	39	33	6	11	70	Production
G	38	34	25	3	8	50	
GV	32	22	17	-	6	29	
Subtotal			75	7	25	46	
CS	23	18	15	-	5	54	Protection
S1	1	1	1	<1	0	37	
Subtotal			16	<1	5	52	
Sarawangga							
GD	11	8	7	-	2	33	Non-commercial
P	63	56	20	4	7	15	
V	19	14	3	<1	1	8	
Subtotal			30	4	10	15	
C1	141	121	96	14	32	75	Production
CY	6	5	5	-	2	100	
DK	12	10	9	-	3	18	
G	42	36	29	6	10	29	
GV	137	109	52	4	17	28	
Subtotal			191	16	64	40	
B	1	<1	<1	-	0	-	Protection
S1	0	0	0	-	0	-	
Subtotal			<1	-	0	-	

TABLE 3 (continued)

Catchment and forest type	Minimum diameter & sp. group			Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
	(1) 35 cm 1 - 5	(2) 40 cm 1 - 5	(3) 40 cm 1 - 4				
Naimbulu							
V	9	6	1	-	0	12	Non-
VB	3	2	1	<1	0	8	commercial
Subtotal			2	-	1	10	
GV	54	44	25	8	8	26	Production
GS	17	14	5	-	2	38	Protection

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

The overall stocking over most of this area is poor, only the slopes beneath the main watershed are of value for commercial logging. The area falls within Fiji Forest Industries' option area. It can best be worked by an extension of the existing feeder roads from the Lambasa main road as an entity, since it is not practicable for reasons of access to join this with the Ndreketi South Catchment Group.

PROPOSED ACCESS ROUTES

From the main Lambasa road the village feeder roads to Mbanikea, Namuavoivoi and Nasingasinga can be extended, following the approximate alignment of the hunting tracks. The only merchantable forest exists beyond the limits of rafting. It would be difficult to extend the Bull Brothers road from the Ndrawa catchment to the west to cross many steep narrow valleys.

PROPOSED TREATMENT OF FOREST TYPES

The best forest is somewhat inaccessible which rules out mahogany plantations on this steep ground. Adequate areas of grassland exist suitable for plantations if leases can be obtained. A combination of planting with village grazing might reduce fire risk, and influence the villagers to lease the land for pine plantations. Much of the area is covered by forest type GV, which could provide timber for local use. After that it could be cleared for cultivation if the population increases.

PART 2. THE MBUA SOUTH CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The area consists of two catchments, Ndama (4/1) and Nalomate (5/1).

They are located in south-west Vanua Levu in Mbua Province. The limits of the area are defined by the sea to the south and west, the Wainunu River estuary to the east and the main watershed of the island to the north. The area falls into the tikina of Vuya and Wainunu.

CLIMATE

The climate of the Ndama catchment varies markedly from high rainfall on the steep slopes south and west of Navotuvotu (climate zone F) to drier conditions on the flat coastal plateau (Climate zone B). The high ground has a very weak or no dry season and heavy rainfall of more than 3 810 mm (150 in) a year. The coastal plain, some 8 km (5 mi) to the west has a long intensive dry season of more than 5 months and a low rainfall of 1 780-2 540 mm (70-100 in) a year. This is abated somewhat in the foothills behind the coast, where a moderate dry season of 3-5 months and a moderate rainfall of up to 4 060 mm (160 in) a year occurs.

GEOLOGY

The area lies on Mbua olivine basalts with the exception of a small area of sedimentary alluvium around Ndawa, and the hydrothermally altered volcanic caldera flow running from Navotuvotu to Nasolo village. The floor of the caldera contains older Ndriti basic flows similar to the Natewa Volcanics.

LANDFORM AND SOILS

Most of the area consists of steep flat-topped ridges between deeply cut radial streams, emanting from the rim of the old Seatura volcano at Navotuvotu, now marking the edge of the caldera scarp. This caldera reaches south to the coast and is breached here by the Nasolo valley. It is also breached near Ndriti by the Ndama River running in a fault. This is the only low-lying area carrying forest.

The steep hill slopes consist largely of Seatura steepland stony and bouldery clay (83d) associated with humic latosols, being strongly weathered steepland soils, derived from young basalts and basic andesites. The Ndriti valley carries alluvial clays similar to the Sigatoka clay loams (7b); the centre of the Ndriti gap carries Ndriti hill soils (37b), acidic red-yellow podsolics, of little use for agriculture. The foothills of the ridges to the west carry Cuku steepland stony sandy clays (93b), acidic, red-yellow podsolic steepland soils. The windward coast of the Nalomate catchment carries Solevu hill soils (27eh), slightly acidic humic latosols, very like Lodoni soils but better than this soil elsewhere; parts are utilised for agricultural subsistence cropping.

VEGETATION

Seatura steepland soils are covered with very poorly stocked high forest. In many places this is inaccessible. The Ndriti area has better, more accessible forest cover. The Cuku steepland soils carry poor forest, *doi*, talasinga ferns and *Casuarina* with patches of cultivation. The steep Solevu hill soils are mostly cultivated in gardens with increasing areas under new coconut plantations.

POPULATION AND LAND TENURE

The coastal part of this catchment was settled at an early stage in Fijian history. It was in fact an early centre of the sandalwood trade, and some European freehold blocks still exist. The inhabitants of Levuka settled around Solevu Bay after banishment by Thakombau in 1844. The population is still confined to coastal villages and settlements and, with the exception of Nadriti and Nasolo, the villages are all close to the main road.

In 1966 there were 3 181 Fijians, 1 135 Indians and 321 of other races. Since the previous census in 1956 the Fijian population has increased by 34%, about the same as the national average, and the Indian population has increased by 44%. Other races, mainly part European, have remained much the same with a small increase of 6% over the 10 years.

The Fijians live in some 21 coastal and two inland villages close to the main road. The Indians live in scattered freeholdings and leases on the west coast around Mbua and in the large settlements of Vunivau and Korovou.

With the exception of one block of Crown land south of Nalomate Creek, all the steepland behind the coast is Fijian owned, but none is Native Reserve. There are large blocks of Native Reserve behind Nawatha, Ndama, Nasolo and Ndaria villages and a coastal fringe. Large freehold blocks occur north of Mbua and at Vunivau (Indian settlements), Nasamu and north of Sawani.

PRESENT LAND USE

The Fijian farmers grow subsistence crops, but also produce copra as a cash crop since most live near the main road. Some cash crops such as root crops are exported by ships using Nambouwalu jetty. There is a European sheep farm at Navunivesi. The Indian population in the settlements produce rice as a cash crop and some cattle are grazed near houses. The large area of flat grazing land found in Mbua North, do not occur here south of Nawatha village.

Mr Edwards runs a sheep farm carrying 100 head of Corriedale and half bred sheep at Navunivesi freehold. Apart from the Department of Agriculture's Experimental Sheep Farm at Nawaithomba in Viti Levu, this is the only sheep flock in Fiji. Stocks are of reasonable quality though production of meat is low.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

No enumerations have taken place within the survey area.

EXPLOITATION PAST AND PRESENT

The area falls within the Fiji Forest Industries Option Area, but no felling on a commercial scale has occurred. Sandalwood was exported from the Mbua town area in the early 19th century.

SAWMILLS

There are no sawmills in the area.

PLANTATION SPECIES AND AGE CLASS

No plantations had been established at the time of the enumeration.

EXISTING ACCESS ROUTES

Absence of inland villages and the steep valleys below Navotuvotu mean there are few tracks into inland farms. A notable exception is the land-rover track (at present impassable beyond

Nangandoa village) that goes from Ndama to Ndriti and thence as a foot and horse track through the Ndriti gap to Nasole and Nasawana villages on the south coast. This track does not pass through good forest but can be used as a base road. Mbua Bay has a depth of 7 to 9 fathoms and is protected by a large reef. The delta of the Mbua River has two channels navigable by lighters. Coastal copra boats use Nambouwalu and Ndaria as ports of call.

THE ENUMERATION

LAYOUT OF SURVEY

The Ndama catchment has no forest on the cultivated flats west of Navotuvotu, and much of the immature, deeply-cut, radial valleys above it are too steep to be considered for commercial felling. An exception is an area of flat ground east of Ndriti village which appeared to contain about 1 000 ha (2 470 ac) of reasonable forest. Two lines were put in running in an east-west direction.

The Nalomate catchment contains mostly moderately stocked forest. Steep land lies to the west and north-west on the basaltic valleys to the east of Navotuvotu. The remaining, less steep area from Sawani to Ndaria was sampled using a base line parallel to the coast and five lines running from the coast to the watershed.

TIMBER VOLUMES

The enumerated areas of the forest types are given in Table 4 below. These two catchments contain 27% non-commercial forest, 36% production forest and 37% protection forest. About half the production forest in the Nalomate catchment has been enumerated, but in both catchments only small parts of the non-commercial and protection forest have been enumerated.

Total volumes for the three management categories are given in Table 5.

TABLE 4 Enumerated areas of forest types in the Mbua South Catchment Group (ha) in hectares

Forest type	Ndama	Nalomate	Total enumerated area		% of enumerated area
			ha	ac	
J	-	196	196	484	5
Non-commercial	-	196	196	484	5
C1	127	313	440	1 087	11
CY	-	27	27	67	1
DK	-	16	16	40	<1
DS	-	395	395	976	10
G	79	1 343	1 422	3 514	37
GS	745	-	745	1 841	19
Production	951	2 094	3 045	7 524	79
CS	-	320	320	791	9
S1	119	175	294	726	8
Protection	119	495	614	1 517	16
Total			3 855	9 525	

The enumerated volume in the production forest is 106 000 m^3 (35 million Hsl ft, trees over 40 cm d.b.h. species groups 1-4) with a r.m.e. of 74 000 m^3 (24 million Hsl ft). This volume occurs mostly in the Nalomate catchment.

The sampling error for the production forest for Nalomate catchment is within the 20% error limit. In Ndama catchment the errors for the forest types are high or not calculated, due to insufficient sampling in all three management categories.

TABLE 5 Volume of timber from trees over 40 cm d.b.h., species group 1-4, reliable minimum estimate and percentage errors by catchment and management category, Mbua south Catchment Group ('000 m^3)

Management and Catchment	Volume >40 cm s.g. 1-4	Sampling error 40 cm s.g. 1-4	Degrees of freedom	Confidence limit $p<0.05$	r.m.e. $p<0.025$	% error	Volume >40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Nalomate	< 1	-	0	-	-	-	0
Production							
Ndama	21	-	-	-	-	-	7
Nalomate	85	5	7	11	74	13	28
Total	106				74		35
Protection							
Ndama	< 1	-	-	-	-	-	0
Nalomate	18	3	11	38	0	> 100	6
Total	18						6

DESCRIPTION OF FOREST TYPES

The forest types occurring in these two catchments are listed in Table 6 which shows timber volumes, sampling errors and net stocking of usable timber species. The forest types which have been enumerated are those associated with conditions of high rainfall and no appreciable dry season, whereas those that have not been enumerated, types GV and GV(L), are associated with a lower rainfall and an extended dry season.

In Nalomate catchment the forest types are situated in broad zones parallel with the coast. Type J with a low stocking borders the cultivated and bush fallow land and has a stocking of only 1 m^3/ha (135 Hsl ft/ac) of usable timber. Further inland on the moderately sloping terrain forest type G is the common type with a stocking of usable timber of 27 m^3/ha (3 639 Hsl ft/ac) made up of species like *yasiyasi*, *sa* and *bauvudi*. As the slopes become steeper, moving towards the watershed, forest type CS and finally BS cover the hills. These protection forest types cover the flanks of the volcanic centre at Navotuvotu and, although the stocking is moderate (50 m^3/ha, 6 738 Hsl ft/ac, 40 cm, d.b.h. sp. group 1-4), the forest should be protected. On the other side of Nayotuvotu peak, forest type GS occurs in the Ndama catchment. This type has a stocking of 19 m^3/ha (3 908 Hsl ft/ac, 40 cm d.b.h. sp. group 1-4) and a species composition that includes *kaudamu*, *yasiyasi* and *damanu*.

TABLE 6 Total volumes and sampling errors of forest types in Mbua South Catchment Group ('000m^3)

Catchment and forest type	Minimum diameter and sp. group			Sampling error for(3)	Volume (million Hsl ft) for(3)	Stocking (m^3/ha) for(3)	Management Category
	(1) 35 cm 1-5	(2) 45 cm 1-5	(3) 40 cm 1-4				
Ndama							
C1	7	5	4	0	1	31	Production
G	4	3	3	0	1	38	
GS	24	18	14	1	5	19	
Subtotal	35	26	21	1	7	22	
S1	1	1	<1	0	0	-	Protection
Subtotal	1	-	<1		0	-	
Nalomate							
J	1	1	<1	-	0	-	Non-Commercial
C1	37	33	25	-	8	80	Production
CY	2	2	2	-	1	74	
DK	1	1	1	-	0	62	
DS	31	26	21	4	7	53	
G	71	59	36	3	12	27	
Subtotal			85	5	28	40	
CS	28	24	16	3	5	50	Protection
S1	2	2	2	-	1	11	
Subtotal			18	3	6	36	

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

Poor timber stocking and difficulties of access make the Ndama catchment unsuitable for production of timber. Most of the forest cover of this catchment is in protection forest.

The Nalomate catchment could be added to the Wainunu catchment for the purpose of forest management. There is no doubt that access to the rich forests of Wainunu will also serve this catchment. On the other hand the production forest types are separated by areas of grass and shrub along the Korolevu, Kawakawa and Nalomate Rivers, which would increase the length of road not serving production forest and hence the cost of extraction.

PROPOSED ACCESS ROUTES

The main road, extended from Nambouwalu, has reached as far as Nasawana, south-west of the area of production forest (1969) It is planned to extend this road to Thongea. This will open up this catchment for exploitation, but the road to the Fiji Forest Industries mill at Malau will be long and circuitous. Fiji Forest Industries plan instead to exploit the Wainunu catchment by a road from Ndreketi in the north. Such a road would greatly shorten the haulage distance.

PROPOSED TREATMENT OF FOREST TYPES

Forest type GS in the Ndama catchment can be logged selectively provided access routes are carefully planned and the canopy cover is not completely destroyed.

PART 3. THE COASTAL WEST CENTRAL CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The area consists of 3 catchments as follows:-

9/1 Wainunu
13/1 Yanawai
14/1 Kumbulau

They are located on the south-west coast of Vanua Levu largely in Mbua and Thakaundrove provinces with the northern extremities of the Wainunu and Yanawai catchments falling within Mathuata province.

The area is bounded to the south by the coast; to the east by the ridge running from Tavea peak to the sea at Yanawai point; to the west by the scarp marking the edge of the plateau above Nalomate River in the south-west and the headwaters of the Sarowangga River in the north-west; and to the north by the ridge running between Ndelanathau and Tavea peaks.

The area falls within the tikinas of Wainunu, Wailevu, Mathuata and Vuya.

CLIMATE

Most of the Wainunu catchment and all of the Yanawai catchment have a very weak or no dry season, with a mean annual rainfall well in excess of 5 080 mm (200 in) a year in the hills (climate zone F). This is because both valleys face into the south-east trade winds and are surrounded by mountains.

The Kumbulau catchment and the Wainunu estuary have a weak dry season (1-2 months) and a moderate rainfall ranging from 3 050 - 3 810 (120 - 150 in) a year. The Kumbulau peninsula has a moderate dry season and a moderate rainfall with less than 2 540 mm (100 in) a year: in the period from June to September, less than 150 mm (6 in) of rain may fall. The mean annual temperature is 25°C (77°F).

GEOLOGY

This area lies mostly on the volcanic Mbua basalts, although in Kambulau catchment these are overlaid by sedimentary mudstones, sandstones and grits. Around Rokothivia Bay on Kumbulau peninsula breccias of the Natewa Volcanic group occur, made up of coarse hornblende andesites.

LANDFORD AND SOILS

The Wainunu catchment flanks the Mbua Volcano and consists of two plateaux. The higher plateau at 244 m (800 ft) is believed to have been caused by the youngest (Pleistocene) slow-flowing basalt filling the old valleys. This plateau covers about 64 km^2(25 mi^2) of flat land deeply incised by the streams of the Wainunu system. Below this and to the south is a second plateau system at 61 m (200 ft), caused by erosion.

The Wainunu and Yanawai plateaux carry mostly Nakavika clays and gravelly clays (28b) strongly acid and with a very low base status: the Wainunu hill soils (28aH) on the moderately-sloped plateaux are used for agriculture. The steeper valleys carry Seatura steepland stony and bouldery clays (83d). This soil covers most of the forested area of Kumbulau mainland, with some Lombau steepland bouldery clay (83f). All are humic latosols derived from intermediate or basic parent materials in a high rainfall area.

VEGETATION

Most of the area is covered with well-stocked tropical rain forest. The sides of the steep river valleys have been cultivated in the past and are scrub and grass covered.

On the plateaux east of the Wainunu River the forest is poorer and swamps occur surrounded by *sacau* and *yaka* forest lying on soil 28b. Coconut and cocoa groves remain reasonably productive on coast and alluvial flats. Due to the steepness of the hills near the coast, silt does not accumulate and mangrove is not so common as on the north coast.

POPULATION AND LAND TENURE

The population of this group of catchments is made up of roughly 1 500 Fijians, 170 Indians and 40 of other races. The villages are situated mainly along the coast with the villages of Thongea and Ndawara at the head of the Thongea estuary of the Wainunu and Yanawai Rivers.

A large block of freehold land, called Yandali, lies to the east of the lower Yanawai River. Native Reserve occupies most of the coast line and extends up the Wainunu River to encompass the small villages there, and up the Yanawai River. Two blocks of Crown land occur in the Wainunu catchment, one on its eastern bank and one to the east of Ndavutu creek just above the freehold land. The rest of the area including most of the forested land is under Fijian ownership and not reserved.

PRESENT LAND USE

Copra production is the main cash crop both for the Fijians and the private estate owners. Apart from copra the people raise traditional subsistence crops and do some fishing. The Indian population are engaged in a limited amount of rice production.

Large tea, rubber and coffee plantations were found abandoned.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

No Government enumerations have been carried out in the survey area. This is perhaps one of the richest areas in Vanua Levu and many reconnaissances have been carried out.

EXPLOITATION PAST AND PRESENT

The area falls within the Fiji Forest Industries option area. A sawmill on the Yanawai River downstream of Ndawara has been built, a few extraction tracks cleared, and some felling has taken place. Extraction over this broken ground is difficult without an extensive road system, and the sawmill has not been operating on a commercial scale for a long time. The Wainunu estuary has a large part- European population and timber from their large freehold blocks, east of the Wainunu estuary, has supplied the local demand for boat building materials for some considerable time.

The area around the Mount Kasi goldmine, not operational since 1943, has been felled for the supply of mining materials and clear-felled over the open-cast mine working.

SAWMILLS

There is one sawmill at Ndawara below the village. At the time of the survey it was managed by Mr Bentley for the Fiji Development Corporation. Although of modern design and well sited in its own concession area it was not in production, and was for sale.

PLANTATION SPECIES AND AGE CLASS

No plantations were noted at the time of enumeration.

EXISTING ACCESS ROUTES

There are at present no main roads serving this area. A good horse track along the coast links Ndaria in the west with Ndawara to the east as part of the main coastal track. The main Lambasa to Nambouwalu road will eventually reach Ndaria and Thongea but the track had only reached Nakawakawa village in 1969 and was metalled only as far as Nasawana village. It would be possible to extend this road up past Thongea to Nandua, and over to Ndawara, thence up the old mining track to Mount Kasi. This track extends to Vatuvonu village, and linked the Mount Kasi goldmine to the inland refuge of the Australian and Fijian miners' families during the Second World War.

Access from the north could be achieved by extending the Bull Brothers Road from Ndreketi village, or by improving the horse tracks leading in from the villages of Namuavoivoi, Nasarowangga, Nasingasinga and Vuinanggalutu.

Coastal copra boats can load from lighters off Ndaria and Ndawara villages. At a suitable stage of the tide coastal craft can reach Kathiwangga estate to load. Lighters can get up to Thongea on the Wainunu River, and up past Ndawara on the Yanawai River possibly as far as Vuthi Creek during the wet season from November to March.

In spite of the short run of both main rivers it would be possible to raft logs down river and by sea to the main road.

THE ENUMERATION

LAYOUT OF SURVEY

All 3 catchments whilst similar in vegetation are of such differing topography that each catchment was given its own layout. The Wainunu catchment had a base line parallel to the Wainunu River estuary and 20 lines selected, one to the east and one to the west for each 2 000 m (6 560 ft) section, since the vegetation and topography differed markedly either side of the river. The Yanawai catchment had a base line parallel with the Yanawai River estuary. Due to comparatively similar vegetation and topography one line was put right across the catchment for every section. The Kumbulau catchment had a base line along the coast and one line cut for each section running from the coast to the watershed.

TIMBER VOLUMES

The enumerated areas of the forest types are given in Table 7. All 3 catchments were given a complete coverage of lines so the enumerated area very nearly represents the total area of forest types. A high proportion of the forest is production forest (83%) covering 24 808 ha (61 300 ac). Important forest types are DS, C1, SK and GV. Protection forest covers 15% of the enumerated area and non-commercial forest 2%.

TABLE 7 Enumerated areas of forest types in Coastal West Central Catchment Group, (ha)

Forest type	Wainunu	Yanawai	Kumbulau	Total enumerated	Area	% enumerated forest
				ha	ac	
GD	144	-	-	144	356	1
P	318	-	73	391	966	1
V	14	-	111	125	309	<1
Non-commercial	476	-	184	660	1 631	2
C1	1 114	1 584	270	2 968	7 334	10
CY	1 222	-	-	1 222	3 020	4
DK	667	157	-	824	2 036	3
DS	6 606	971	1 036	8 613	21 283	29
DS2	236	-	-	236	583	1
G	1 276	284	261	1 821	4 500	6
GS	-	1 245	-	1 245	3 076	4
GY	160	4	433	597	1 475	2
GV	1 471	219	960	2 650	6 548	9
GV(H)	-	-	560	560	1 384	2
GV(L)	116	-	1 122	1 238	3 059	4
SK	1 071	1 220	543	2 834	7 003	9
Production	13 939	5 584	5 185	24 808	61 300	83
B	-	138	-	138	341	1
CS	306	1 414	202	1 922	4 749	7
S1	829	783	623	2 235	5 523	7
Protection	1 135	3 580	825	4 295	10 613	15
Total				29 763	73 544	

The volumes of standing timber are summarised in Table 8. The production forest contains a usable volume of 1 497 000 m^3 (498 million Hsl ft) and a reliable minimum estate of 1 368 000 m^3 (455 million Hsl ft, trees over 40 cm d.b.h. species groups 1-4); of this 807 000 m^3 (269 million Hsl ft) are in the Wainunu catchment. The protection forest has a standing volume of 131 000 m^3 (44 million Hsl ft).

The sampling error in the production forest is well within the prescribed 20% error being 7, 10 and 11% for the Wainunu, Yanawai and Kumbulau catchments respectively. The error for the protection forest is just beyond the limit for Yanawai and Kumbulau catchments but high for Wainunu.

TABLE 8 Volume of timber from trees over 40 cm d.b.h. species group 1-4, reliable minimum estimate and percentage error by catchment and management category, Coastal West Central Catchment Group ('000 m^3).

Management and Catchment	Volume 40 cm s.g. 1-4	Sampling error >40 cm s.g. 1-4	Degrees of freedom	Confidence limit $p<0.05$	r.m.e. $p<0.025$	% error	Volume >40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Wainunu	10	3	5	8	2	80	3
Kumbulau	1	1	1	13	0	>100	0
Total	11				2		
Production							
Wainunu	870	31	55	63	807	7	290
Yanawai	353	17	13	37	316	10	177
Kumbulau	274	14	19	29	245	11	91
Total	1 497				1 368		
Protection							
Wainunu	20	3	6	7	13	35	7
Yanawai	95	11	15	23	72	24	32
Kumbulau	16	1	2	4	12	25	5
Total	131				97		44

DESCRIPTION OF FOREST TYPES

The forest types are listed in Table 9 which gives standing volume, sampling error, net stocking and groups them by management category.

TABLE 9 Total volumes and sampling errors of forest types in the Coastal West Central Catchment Group ('000 m^3)

Catchment for forest type	Minimum diameter & sp. group			Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
	(1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4				
Wainunu							
GD	11	9	7	3	2	49	Non-Commercial
P	9	7	3	1	1	9	
V	1	1	<1	-	0	-	
Sub-total			10	3	3	21	
C1	136	115	89	11	30	80	Production
CY	160	135	111	8	37	91	
DK	23	21	19	-	6	28	

TABLE 9 (continued)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
DS	756	644	480	25	160	73	
DS2	10	9	6	2	2	25	
G	97	79	47	6	16	37	
GY	13	10	9	1	3	56	
GV	102	82	40	6	13	27	
GV(L)	12	10	7	-	2	60	
SK	79	69	62	5	21	58	
Subtotal			870	31	290	62	
CS	22	14	8	-	3	26	Protection
S1	29	24	12	3	4	14	
Subtotal			20	3	7	18	
Yanawai							
C1	217	186	150	12	50	95	Production
DK	8	6	4	-	1	25	
DS	82	72	58	6	19	60	
G	21	16	13	-	4	46	
GS	66	56	45	6	15	36	
GY	1	1	<1	-	0	-	
GV	16	13	8	2	3	37	
SK	95	78	75	9	25	61	
Subtotal			353	17	117		
B	<1	<1	-	-	-	-	Protection
CS	134	115	85	11	28	60	
S1	20	17	10	3	3	13	
Subtotal			95	11	31		
Kumbulau			**14 KUMBULAU**				
P	2	2	<1	-	0	4	Non-
V	11	9	1	<1	0	9	Commercial
Subtotal					0		
C1	34	29	22	4	7	81	Production
DS	111	93	70	10	23	68	
G	20	17	12	-	4	46	
GY	26	21	17	3	6	39	
GV	81	67	42	8	14	44	
GV(H)	54	47	29	-	10	52	
GV(L)	73	58	37	2	12	33	
SK	62	54	45	4	15	83	
Subtotal			274	14	91	53	
CS	23	18	13	-	4	64	Protection
S1	10	9	3	1	1	5	
Subtotal	33	27	16	1	5	19	

Stocking rates for the productive forest types are higher in these 3 catchments than for the same forest types on the north-west side of Vanua Levu.

Type GD: Moderately stocked *velau-yaka* dry-zone forest

In the Wainunu catchment this type is unusual in its high stocking by comparison with the type on high flat ridges in the Mbua North catchments. The aerial photo appearance is similar; but the type in the Wainunu valley besides carrying much *velau*, *sacau* and *yaka* also contains *dakua makadre*, *dakua salusalu*, *damanu* and *moivi*.

Type DK: Moderately stocked *dakua-yaka* forest on undulating country

This type has a better stocking of *dakua makadre* and *damanu* but less *yaka* on the uplands of the Wainunu plateau than occur in other parts of the island. In Yanawai catchment *yaka* is almost absent and *rogi* and *kauvula* take the place of *damanu* due perhaps to less exposure to sea winds, easier slopes and better soils.

Type DS2: Moderately stocked *dakua makadre* and *salusalu* forest on gentle to moderate slopes

This type is restricted to the Wainunu and Seanggangga catchments. The Latter has a better stocking with more *dakua makadre*, but both occur on dry plateaux or flat-topped ridges. There is an absence of *yaka* or *sacau*, which one would expect in this situation, as in SK or DK types found in a similar environment. Were it not for the absence of these species this type could be considered as a seral or possible sub-climax stage in the development of SK or DK type forest.

Type GV: Moderalely stocked *kaudamu-velau* forest on moderate to steep short slopes

Because it is low-lying the Kumbulau peninsula and Wainunu estuary do not experience orographic rainfall and there may be a short dry season in this area. The presence of forest type GV may be due to these slightly drier conditions.

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

These catchments are best combined with the Ndreketi South and Mbua South groups of catchments. The steep ground below Navotuotu peak divides them from the low stocked forest to Mbua North.

PROPOSED ACCESS ROUTES

Since the Wainunu and Yanawai Rivers are not navigable above Thongea and Ndawara respectively it is unlikely that log rafts will be of much use for extracting the logs from the forest.

The main access route into these catchments is over the northern catchment boundary starting from the Nasingasinga feeder road or an extension of the Bull Brothers road. To bring the logs round the south coast through Nambouwalu and thence round to Malau by road would involve a very long road journey.

PROPOSED TREATMENT OF FOREST TYPES

Non-commercial forest even if the non-commercial forest types outside the enumeration area were added to the enumerated types the volume of timber is insignificant. The best course of action is to leave them alone. They will eventually be removed by the attrition of creating new sites for gardens and for the modest local demands for building. In many villages that sell copra, the houses are build of sawn timber (Douglas fir) brought in by the boats that take out the copra. The only buildings built with local timber are the kitchens.

Production forest This group of catchments contains the biggest volume of timber in Vanua Levu. As well as the well stocked forest types of mixed species, such as forest type C1 and GV, there are the forest types rich in the softwood species such as forest type DS, DK and SK.

Protection forest Protection forest occurs mostly in the Yanawai catchments along its northern watershed and in the centre. No felling in the protection forest is recommended.

PART 4. THE NDREKETI NORTH CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The area consists of 3 catchments, one of which, Vatusomi, adjoins the coast and carries no commercial forest of any size. The catchments are as follows:

11/4 Ndoloko
11/6 Vatusomi
11/7 Vunimako

They are located mid-west on the north coast of Vanua Levu from Nanduri town to Nambekavu village in Mathuata province and constitute the northern slopes of the Ndreketi river valley.

The limits of the area are indicated by the sea to the north, the Ndreketi river to the south and west and the main Lambasa to Nambouwalu road to the east. The area falls into the tikina of Mathuata.

CLIMATE

The climate over the whole of this area has a long intense dry season, with usually more than 5 months of the year June/October, receiving less than 150 mm (6 in) of rain a month (climate zone band C). The rainfall over most of the area is moderate, between 2 540 to 3 300 mm (100 to 130 in) a year, except on the steep slopes south of the Nawavi range where it is unkikely to exceed 2 540 mm (100 in) a year. The Nawavi range acts as a windbreak and no extensive gale damage was seen.

GEOLOGY

This area, like the Ndreketi South catchment falls into three different groups. To the north the parent material consists of breccias, flows, grits and tuffs of basic andesite to basalt of the Natewa Volcanics Group. The Nawavi range at its highest point is capped with pummice of the Undu Volcanics Group.

Over most of the central area of the Natewa Volcanic Group the valleys are infilled by coarse Ndreketi grit, interbedded with volcanic flows, mudstones and hydrothermally altered breccias forming a sedimentary basin. To the west the Natewa Volcanic Group extends southwards with Mbua basalts coming in at the coast west of Ndreketi.

LANDFORM AND SOILS

The Nawavi range to the north creates a steep but short hill barrier between this area and the coastal fringe, which levels out to the sedimentary Ndreketi basin in the South. To the west beyond Vumimako settlement the landscape is again undulating to steep over the southern extension of the Natewa Volcanics.

The soils of the steep northern part of the catchments are all humic latosols. Nawavi stony and bouldery clay (86c) is interspersed with areas of Rukuruku clays (32b) and Makomako hill soils (32aH) on moderate to strongly rolling slopes. The central basin is ferruginous latosols mostly Nambiti and Bua hill soils (35eH) and 35cH) and Bua gravelly clays (35c).

VEGETATION

The vegetation over the humic latosols is usually poorly stocked forest, the very strong dry season producing *Velau*, *buabua* and *yaka* type forest. The ferruginous latosols over the central area carry typical *talasiga* vegetation, with bracken, *doi*, *Pandanus* and *nokonoko*. This is typical of the area under plantation of pine at Seanggangga.

POPULATION AND LAND TENURE

The total population of this area, including the villages along the coast, is 1 400 persons of whom about 800 are Fijian, 500 Indian and 100 of other races. Fijian villages are mostly on the coast and along the Ndreketi River. Indian settlements occur along the Ndreketi River and in the flat areas of the Vunimako catchment.

Large blocks of freehold land extend for 1.6 to 3 km (1 to 2 mi) either side of Ndreketi River extending as far east as Mbatiri village. Native Reserve land fills in the gaps in the freehold land along the banks of the Ndreketi River and occurs around the coast. Practically all the forest land in this group of catchments is under Fijian ownership and not in Native Reserve.

PRESENT LAND USE

Apart from the Fijian resettlement schemes on the better *talasiga* soils of the Nabiti clays, gravelly clays and Bua clays at Vunimako, the Fijian population relies upon subsistence agriculture and fishing, with copra as a cash crop. In the resettlement area cash crops of groundnuts and rice as well as subsistence crops are produced. Several blocks of freehold land are producing copra and beef (Bull Brothers), rice (Indian farmers at the roadside and near the road past Natua settlement) and beef and pig farms (John Miller). A few Fijians occupy hamlets on the Vunimako approach road, mostly cultivating cleared *velau* woodland: their number is increasing as the road improves and extends.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

No enumerations other than in the Ndoloko proposed forest reserve have taken place in the survey area.

EXPLOITATION PAST AND PRESENT

The area falls within the Fiji Forest Industries option area. It has been worked over by the Bull Brothers in the past and much of the *Buabua* timber of any size has gone from the Ndoloko proposed forest reserve.

PLANTATION SPECIES AND AGE CLASS

No plantations were noted at the time of enumeration. The *buabua* sample plot in the Ndoloko proposed forest reserve is measured regularly and some weeding is carried out in it. A small amount of tree planting has been done by Bull Brothers.

EXISTING ACCESS ROUTES

An all-weather gravelled road enters the area at Natua settlement and runs through to the resettlement scheme at Vunimako. An earth road suitable for land-rovers extends as far as Vatusomi Creek, which has not yet been bridged and continues to the coast at Raviravi. A south fork at Natua reaches the Ndreketi River at Vuninggolinggoli Creek. The final alignment will be metalled to link the coastal villages with Lambasa.

There are a number of foot and horse tracks that can be improved or used as base roads. The most important are: from the wharf opposite Nambarata to Nambekavu; from the Indian settlement where Ndoloko Creek enters the Ndreketi River to Navindamu and Nuivua village on the coast; from where the Nakorotolutolu River joins the Ndreketi River to Nuivua village on the coast; and from where the Vunimbelembele River joins the Ndreketi River to the Nanggumu River on the coast. A coastal track links Nambekavu village in the west to Nanduri village in the east, where it reaches the main Lambasa to Nambouwalu road.

Boats can use the Ndreketi River; at high tide lighters can probably reach as far inland as Mbatiri village, 29 ki (18 mi) from the mouth. Larger coastal copra boats load timber at Bull Brothers' sawmill, 6 ki (4 mi) from the mouth.

THE ENUMERATION

LAYOUT OF SURVEY

Due to considerable differences in forest cover the 3 catchments were sampled using separate layouts. The Ndoloko catchment containing dry zone *buabua*, *yaka* and *velau* forest types had a base line parallel to the Ndreketi River. Three lines, one for each 2 000 m (6 560 ft) section ran perpendicular to the base line to cross the topography roughly at right angles. Preliminary reconnaissance in the Vatusomi catchment indicated that the trees were mainly undergirth and consisted of non-commercial species. As result only two lines were cut running due north from a base line along the new access road. The eastern line showed no trees above 35 cm (14 in) d.b.h. so only the data from one line, the western of the two, were computed. Better forest may occur towards the south-eastern watershed but photo-interpretation indicated that the forest is poor and does not merit enumeration. The Vunimako catchment was enumerated more fully. The base line ran parallel to the access road and the lines, sampling the raised dissected slopes of the Ndreketi valley, cut right across from the foot of the Nawavi hill range in the north to the watershed in the south. The lines are in places discontinuous where they cut through rice fields, grass or coconut plantation.

TIMBER VOLUMES

Enumerated areas for the forest types are shown in Table 10 below.

TABLE 10 Enumerated areas of forest types in the Ndreketi North Catchment Group (ha)

Forest type	Ndoloko	Vatusomi	Vunimako	Total enumerated area		% of enumerated forest
				ha	ac	
J	3	-	-	3	7	<1
P	65	-	-	65	161	1
S	-	-	295	295	729	4
V	-	-	163	163	403	3
VB	815	-	370	1 185	2 928	17
Non-commercial	883	-	828	1 711	4 228	25
G	-	-	99	99	245	1
GB	-	-	1 190	1 190	2 940	17
GS	-	-	109	109	269	2
GV	1 855	467	527	2 849	7 040	42
GV(H)	-	-	482	482	1 191	7
GV(L)	-	-	342	342	845	5
Production	1 855	467	2 749	5 071	12 530	74
S1	65	-	-	65	161	1
Protection	65	-	-	65	161	1
Total				8 847	16 919	

In the Vatusomi catchment the enumerated area of forest type GV does not represent the total area since this type extends along the southern watershed. In the Vunimako catchment about 1 600 ha (2 620 ac) of forest type GB lie outside the enumerated area along the western side of the catchment. On the gentle slopes of the Ndreketi catchment there is no protection forest except for about 370 ha (914 ac) outside the enumerated area along the northern watershed of the Vunimako catchment.

The volume of standing timber in the enumerated forest is summarised in Table 11. Ndoloko and Vunimako catchments contain some non-commercial forest with a net volume of 23 000 m^3 (8 million Hsl ft). The production forest lies in the Ndoloko and Vunimako catchments; these have volumes of 53 000 and 102 000 m^3 (18 and 34 million Hsl ft) and reliable minimum estimates of 19 000 and 80 000 m^3 respectively (6 and 27 million Hsl ft).

Sampling error is high for the non-commercial and protection forest. A more satisfactory figure of 22% is achieved in the Vunimako production forest. In the Ndoloko catchment the percentage error for the production forest is high because, although the area sampled is relatively large, there were only three sampling lines.

TABLE 11 Volume of timber from trees over 40 cm d.b.h., species group 1 - 4, reliable minimum estimate and percentage error by catchment and management category, Ndeketi North Catchment Group ('000 m^3)

Management and catchment	Volume 40 cm s.g. 1-4	Sampling error > 40 cm s.g. 1-4	Degrees of freedom	Confidence limit $p < 0.05$	r.m.e. $p < 0.025$	% error	Volume 40 cm 16 in s.g. 1-4 (million Hsl ft)
Non-commercial							
Ndoloko	11	3	5	8	3	73	4
Vunimako	12	4	8	9	3	75	4
Total	23				6		8
Production							
Ndoloko	53	8	2	34	19	64	17
Vatusomi	2	-	-	-	-	-	1
Vunimako	102	10	13	22	80	22	34
Total	157				99		52

DESCRIPTION OF FOREST TYPES

The forest types occuring in this group of catchments are listed in Table 12, which shows timber volumes, sampling error and net stocking of usable timber species. Many of the forest types show the influence of the long intense dry season that occurs on this side of Vanua Levu. This is reflected in the preponderance of dry zone species such as *velau*, *yaka*, *waciwaci*, *buabua* and *sa*. There is no well stocked forest and the moderately stocked forest contains a high proportion of *velau* and unusable species such as *sa*.

TABLE 12 Total volumes and sampling errors of forest types in the Ndreketi Catchment Group, volumes in ('000 m^3)

Catchment and forest type	Minimum diameter and sp. group			Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
	(1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4				
Ndoloko							
J	<1	<1	0	-	0	-	Non-
P	<1	<1	0	-	0	-	commercial
VB	31	22	11	3	4	13	
Subtotal			11	3	4		
GV	116	88	53	8	18	28	Production
S1	2	1	0	-	0	-	Protection
Vatusomi							
GV	5	4	2	-	1	4	Production
Vunimako							
S	10	7	4	2	1	13	Non-
V	1	1	0	<1	0	-	commercial
VB	13	10	8	3	3	21	
Subtotal			12	4	4	14	
G	7	5	3	-	1	30	Production
GB	108	82	56	9	19	47	
GS	10	7	2	1	1	18	
GV	33	25	12	3	4	23	
GV(H)	35	27	20	2	7	41	
GV(L)	20	16	9	1	3	26	
Subtotal			102	10	25	38	

Type S1: Low-stocked open woodland on very steep slopes

This type carries a very low stocking in the Ndoloko catchment often carrying bamboo on the south facing slopes and only small sized *yaka*, *buabua* and Meliaceae on the northern slopes.

Type GV: Moderately stocked *kaudamu-velau* forest on moderate to steep short slopes

This forest type has a very low stocking of merchantable trees in the Vatusomi catchment, but in the Ndoloko and Vunimako catchments the stocking is similar to the rest of Vanua Levu.

Type VB: Moderately stocked *velau-buabua* forest

This type contains *velau*, *yaka* and *buabua* and is found on flat upland sites, which under the dry conditions that prevail suffer from a water deficit during the period May to September

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

The general low stocking rate of most of the forest, makes it unlikely that this area will be worked commercially. The Ndoloko and Vatusomi catchments are isolated by the Ndreketi River.

PROPOSED ACCESS

The existing development road serves the Vunimako catchment and could be extended to serve the other two catchments.

PROPOSED TREATMENT OF FOREST TYPES

This area is unlikely to be exploited commercially. It can serve a useful purpose in supplying local needs for house posts of the durable *buabua* timber. The non-commercial forest types could be converted to pine plantations. From the land tenure point of view there might be less objection to the conversion of already forested areas to plantations since there would be no conflict with grazing interests.

PART 5. THE NDREKETI SOUTH CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The area consists of five catchments:

11/1 Nanenivunda
11/2 Narailangi
11/8 Nasuva
11/9 Seanggangga and
11/10 Ndrawa

They are located in the centre of Vanua Levu mid-west from Nasealevu village to Nambiti village in Mathuata province.

The limits of the area are indicated approximately by the Ndreketi River to the north, the ridge dividing the Nambiti River and Ndrala Creek to the west, the ridge dividing Nanenivunda River and the headwaters of the Namuka Creek to the east, and the main watershed of the island to the south as far east as Ndelaikoro.

The area falls into the tikina of Sasa and Mathuata, and partially into Wailevu.

CLIMATE

From the main island watershed the climate becomes progressively drier towards the north-west. At the watershed the climate has a very weak or no dry season and a high mean annual rainfall of more than 3 810 mm (150 in). Immediately to the north-west there is a moderate rainfall of 2 540 to 4 060 mm (100-160 in) and moderate dry season, and over the Ndreketi River itself, there is a long intensive dry season (more than 5 months with less than 150 mm (6 in) of rain) and a mean annual rainfall of 2 540 to 3 300 mm (100-130 in).

GEOLOGY

Geologically this area falls into three different groups. To the east the parent material consists of rocks of the Natewa Volcanics group which are breccias, flows, grits and tuffs varying from basic andesites to basalts. Centrally these are overlaid by sedimentary mudstones and sandstones with interbedded flows and volcanic tuffs. Mbua basalts with interbedded sedimentary rocks occur west of Ndreketi.

LANDFORM AND SOILS

The area under Natewa Volcanics falls steeply away from the central backbone running the length of this group of catchments from the peaks of Ndelanathau, Tavea, Valili and on towards Ndelaikoro. Below this backbone to the east, the landform is characterised by a series of ridges and creek valleys such as Nasuva and Seanggangga. Centrally the sediments form a basin where they filled an old valley between volcanic centres. This results in an upland basin, a broad valley dissected by the Ndreketi River giving the Ndreketi North and Ndreketi South catchments. The latter is drained by the Nambunambuna, Naua and Navuturerengga creek systems, with their typical waterfalls. To the west, the steep slopes below Ndelanathau drained by the Nambiti River system, level out on to the Mbua Volcanic flows which have been eroded to a 60 m (200 ft) plateau. Part of this plateau is in the Naimbulu catchment (10/1).

Most of the soils over the Natewa Volcanics to the east are strongly weathered humic latosols of low base status. They have been mapped by Twyford and Wright as Nailoca steepland bouldery clay (83e), lying on the high ground along the catchment watersheds. Below this on the sedimentary rocks the soils are more diverse, varying from the gley soils of good potential on alluvial flats near the mouth of the Ndreketi (Narewa clays: 51, through the nigrescent soils (Momi clay: 16c,

and hill soils 16cH), to the ferruginous latosols *(talasiga)* soils (Nabiti clays and gravelly clays: 35e. Above these and below the Nailoca hill soils are more humic latosols, the Nacula steepland clays (84c) and Vuya bouldery clays (85a) and Delainacau sandy clays (40a). Soils over the Mbua basalts to the west are influenced by the drier conditions which prevail and are mostly Kavula steepland bouldery brown clays (86b) and Nacula steepland clays (84c).

VEGETATION

The steeper slopes to the east and south under humic latosols of the Nailoca series carry poorly stocked high forest. Below the high ground past burning and cultivation in an area of moderate rainfall with 3 to 5 months dry season, has led to mixed grassland invading the forest. especially the *velau* forest types around Saivou village and Seangganga.

The central sedimentary basin carries the best stocked high forest, lying north-east of Ndelanathau peak, particularly on the Delainacau sandy clays. To the east cultivation on these moderately fertile soils, reduces the vegetation to a mixed grassland and *talasiga* vegetation.

West of the Nambiti River past cultivation on the Kavula clays has reduced much of the vegetation to fallow scrub. The southern, steeper end of the catchment on this soil series carries well stocked forest.

POPULATION AND LAND TENURE

The population consists of about 2 000 Fijians, 1 800 Indians, and 50 of other races. Fijian villages lie on the main road from Lambasa to Nambouwalu, along the Ndreketi River and a few lie in or bordering the forest further inland to the south. The Indians live near the Ndreketi River in settlements in the grassland areas.

Freehold land lies along the Ndreketi River in large rectangular blocks as far as Mbatiri village. Native Reserves surround the villages of Vunisea, Nasingasinga and Nambiti in the west, Vuinanggalutu, Nayarailangi, Naravuka and Saivou in the centre and Nathaurokovi, Nanivunda, Vuiranggilai and Nasealevu in the east. A large block of Crown land lies in the loop of the Ndreketi River just east of Mbatiri village, and covers the southern tip of the Nairailangi catchment.

PRESENT LAND USE

The Fijian population farm small alluvial flats and hillsides near some 10 inland villages. In most cases these villages have reasonably easy access to the main Lambasa road, and produce cash crops of taro, copra and kava. Some groundnuts are grown on the alluvial pockets along the main rivers Seangganga, Navuturerengga, Ndrawa and Naua, and their tributaries the Narenggai, Naruwai, Volivoli and Nambunambuna creeks. Near the main road Indian rice farmers cultivate the flats and an Indian beef scheme failed here on the large expanses of wire grass *(Sporobolus sp.)* now grazed by small village herds. The Saivou village beef scheme covers felled forest areas of *para (Brachiaria mutica)* and carpet grasses *(Axonopus sp.)*. The pine plantation and nursery at Seangganga offer a source of employment which will expand as harvesting starts. Although suitable planting land would appear to be present, it has proved difficult to lease from the present owners, and further establishment work does not appear to be forthcoming. The Seangganga Agricultural Research Station on *talasiga* soils is largely used for trials of citrus, cashew and coconut plantations, and for grazing by a herd of Santa Gertrudis cattle.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

In the Ndrawa catchment 9 310 ha (23 000 ac) were enumerated close to the Bull Brothers' concession in enumeration No 6 of 1956. A systematic grid sampling at an intensity of 4%, measuring all trees over 5 ft girth (50 cm d.b.h.), was made. An overall average of 22 m^3/ha (3 000 Hsl ft/ac) was recorded. An area of 400 ha (1 000 ac) yielded 30 m^3/ha. (4 043 Hsl ft/ac).

EXPLOITATION PAST AND PRESENT

This area is in the Fiji Forest Industries concession except where the Bull Brothers have a licence. Two areas in this catchment group have been exploited in the past by Bull Brothers at Ndreketi; these are concessions obtained many years ago from the landowners, and worked selectively for at least the past 10 years, mostly for *dakua makadre* and *buabua*. One area is on the plateau to the south of Ndreketi village between the main road and Ndelanathau situated in the upper drainage system of the Navuturerengga River. It still contains much good forest. The second area is around Naravuka and Saivou villages, largely logged for *buabua* timber, and little accessible timber remains close to the road. Occasional felling occurs to supply sawn timber for village use. An example was a felling of 35 trees, mostly *dakua* and *bauvudi*, by Bull Brothers in an area south of Nasingasinga village, to be sawn at their mill for the villagers to build a school house.

SAWMILLS

No sawmills exist in the area.

PLANTATION SPECIES AND AGE CLASSES

In addition to the extensive plantations of *Pinus caribaea var. hondurensis* planted from 1955 up to the present time on the *talasiga* lands around Seangganga station, there are trial blocks of *Eucalyptus* near Ndreketi and Maramarua villages.

EXISTING ACCESS ROUTES

The main Lambasa to Nambouwalu road forms the northern boundary of these catchments. There are a number of all-weather land-rover tracks coming off this road to reach Saivou, Naravuka, Nayarailangi, Vunisea and Nasingasinga villages passing through commercial forest. A road system serves the Seangganga pine plantations and fire towers. The road to Vunisea has been extended well into the forest worked by Bull Brothers. It is unusable beyond Vaisea hamlet above Vunisea village.

The main rivers cannot be used for any commercial log rafting above the last inland village on their banks.

Hunting and horse-tracks on reasonable alignments cross the watershed to the south coast. The most useful are as follows

1. A foot track from Saivou village to Waisali village which follows the Volivoli Creek to fork near Waisavu waterfall southwards to Nakasa village on the coast, and eastwards up Nanggalaka Creek over to Waisali Creek and down to Waisali village. A second track to Waisali village runs from Saivou up Narenggai Creek turning south-east to link up with the other track before crossing the watershed. It can be used at least part of the way by horses.

2. A horse-track leads from Naravuka village across to Valeni village on the south coast.

3. A foot-track leads from Vuinanggalutu village along the Ndrawa River and Vatumburu Creek to the Mount Kasi goldmine and then to Ndawara village near the coast.

4. A good horse-track is in use from Nasingasinga village, past Ndelanathau, to Tambulotu hamlet on the Wainunu River and thence to Thongea near the coast.

THE ENUMERATION

LAYOUT OF SURVEY

The Narailangi, Seangganga and Ndrawa catchments shared a common base line aligned along the main road between Ndreketi village and Naravuka village. A line was cut in each 2 000 m (6 560 ft) section regardless of catchment boundaries and the area divided into catchments after the

field work, for the purpose of computation. In the Nanenivunda catchment the base line followed the Navenivunda Creek with lines cut right across the catchment in each section. In the Nasuva catchment the base line was cut parallel to the Mataindongo Creek and only 2 lines were cut at the head of the valley in the completely forest-covered area.

TIMBER VOLUMES

The enumerated areas of the forest types are given in Table 13. This table shows that production forest covers 18 180 ha (44 930 ac) or 70% of the enumerated area. Forest types GV, DS and C1 cover the largest areas. In Narailangi there are about 850 ha (2 100 ac) of forest type GV outside the enumerated area and about 500 ha (1 235 ac) of the same type outside the enumerated area in the Nasuva catchment.

TABLE 13 Enumerated areas of forest types in the Ndreketi South Catchment Group (ha)

Forest type	Nanenivunda	Narailangi	Nasuva	Seanggangga	Ndrawa	Total enumerated area		% of enumerated forest
						ha	ac	
H	359	-	-	-	-	359	887	1
J	-	-	-	-	171	171	423	1
P	-	134	-	329	479	942	2 328	4
RT	-	-	-	-	140	140	346	<1
S	229	-	-	-	-	229	566	1
V	98	88	80	464	421	1 151	2 844	4
VB	-	92	-	38	-	130	321	1
VF	-	-	-	-	592	592	1 463	2
Non-commercial	686	314	80	831	1 803	3 714	9 178	14
C1	63	244	174	94	1 995	2 570	6 351	10
DK	-	120	-	-	-	120	297	1
DS	-	650	120	701	1 835	3 306	8 169	13
DS2	-	-	-	373	-	373	922	1
G	-	-	-	337	252	589	1 455	2
GB	-	546	-	118	-	664	1 641	3
GB(L)	-	277	-	-	-	277	684	1
GDK	289	-	-	-	-	289	714	1
GS	-	670	-	439	2 233	3 342	8 258	13
GV	3 019	91	451	534	1 282	5 377	13 287	21
GV(H)	-	-	-	-	73	73	180	<1
GV(L)	-	679	-	74	377	1 130	2 792	4
GY	-	39	-	-	-	39	96	<1
VS	-	-	-	-	33	33	82	<1
Production	3 371	3 316	745	2 670	8 080	18 182	44 928	70
BS	891	-	-	-	-	891	2 202	4
GDS	72	-	-	-	-	72	178	<1
S1	-	286	202	513	2 163	3 164	7 818	12
Protection	963	286	202	513	2 163	4 127	10 198	16
Total						26 023	64 304	

The volumes of standing timber are summarised in Table 14. The enumerated volume of what is considered usable timber, that is, trees over 40 cm d.b.h. and species groups 1-4, in the production forest is 782 000 m^3 (260 million Hsl ft) with a reliable minimum estimate of 657 000 m^3 (219 million Hsl ft). Narailangi and Seanggangga catchments have reliable minimum estimates of 138 and 106 000 m^3 respectively (46 and 35 million Hsl ft) while Ndrawa has 328 000 m^3 (109 million Hsl ft). Volumes in the non-commercial and protection forest are 58 000 m^3 and 87 000 m^3 respectively (19 and 29 million Hsl ft).

TABLE 14 Volume of timber from trees over 40 cm d.b.h. species group 1-4, reliable minimum estimate and percentage error by catchment and management category, Ndreketi South South Catchment Group ('000m^3)

Management and catchment	Volume 40 cm s g. 1-4	Sampling error 40 cm s.g. 1-4	Degrees of freedom	Confidence limit $p < 0.05$	r.m.e. $p < 0.025$	% error	Volume 40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Nanenivunda	13	1	6	2	11	15	4
Narailangi	6	1	6	2	4	33	2
Nasuva	1	-	0	-	-	-	0
Seangganga	14	2	8	5	9	36	5
Ndrawa	24	2	8	5	19	21	8
Total	58				43		19
Production							
Nanenivunda	91	8	5	21	70	23	31
Narailangi	157	9	16	19	138	12	52
Nasuva	40	2	1	25	15	63	13
Seangganga	124	8	8	18	106	15	41
Ndrawa	370	20	16	42	328	10	123
Total	782				657		260
Protection							
Nanenivunda	27	6	6	15	12	56	9
Narailangi	10	4	3	13	0	>100	3
Nasuva	4	-	0	0	0	-	1
Seangganga	8	-	2	9	0	60	3
Ndrawa	38	4	10	9	29	24	13
Total	87				41		29

The sampling error is satisfactory for the production forest, being within or near the 20% prescribed error level, for all but the Nasuva catchment. This catchment had a reconnaissance survey with only 2 lines sampling the forest. In the protection forest the sampling error is high in all catchments due to the low sampling and the low stocking of the forest types included in this management category.

DESCRIPTION OF FOREST TYPES

The forest types occurring in this group of catchments are listed in Table 15, which shows timber volumes, sampling errors and net stocking of usable timber. The timber volume is from forest types of the wet climatic conditions with no or very little dry season, such as forest types C1 and DS. Forest types GV and GB in which *velau* is a major constituent and which occur under conditions in which there is a marked dry season also provide good volumes of timber.

DK: Moderately stocked *dakua-yaka* forest on undulating country

This forest type in the Narailangi catchment is virtually the same as forest type GDK in the Nanenivunda catchment. Both have the usual *dakua makadre*, *kaudamu*, *yasiyasi* and *yaka* association, with a high proportion of *kaunicina* not seen in these types elsewhere.

DS: Well stocked *dakua makadre* and *salusalu* forest on steep slopes

Forest type DS has the normal frequency of *dakua salusalu, damanu* and *yasiyasi* throughout all the catchments, but the lower elevation found in the Narailangi and Nasuva catchments seems to lead to a higher proportion of *vesi* in the former, and *rosawa* and *moivi* in the latter, at the expense of *dakua makadre*, which in these two catchments is less common than usual in this forest type.

GS: Low-stocked forest on short, very steep slopes

This type occurs in the Narailangi and Ndrawa catchments with a high stocking of about 70 m^3/ha (9 435 Hsl ft/ac) and merchantable stands of *yasiyasi, kaudamu, damanu* and some *vesi*.

C1: Well stocked mixed forest on moderate to steep short slopes

This type covers nearly 2 000 ha (4 940 ac) in the Ndrawa catchment and occurs to a lesser extent in all the other catchments of the group. The stocking in the Ndrawa is low due to felling in the past. It is higher in the other catchments except Nanenivunda where it is also low.

TABLE 15 Total volumes and sampling errors of forest types in the Ndreketi South Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter and sp. group			Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management Category
	(1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4				
Nanenivunda							
H	17	13	10	1	3	28	Non-
S	5	4	1	< 1	0	4	Commercial
V	5	3	2	1	2	20	
Subtotal			13	1	5	19	
C1	5	4	3	-	1	48	Production
GDK	13	11	9	1	3	31	
GV	146	120	79	8	26	26	
Subtotal			91	8	30	27	
BS	40	35	25	6	8	28	Protection
GDS	2	2	2	< 1	1	28	
Subtotal			27	6	9	28	
Narailangi							
P	7	6	2	< 1	1	15	Non-
V	7	5	1	< 1	0	11	Commercial
VB	7	5	3	1	1	33	
Subtotal			6	1	2	19	
C1	24	18	14	4	5	57	Production
DK	5	5	4	1	1	33	
DS	65	57	42	5	14	65	
GB	42	33	25	4	8	46	
GB(L)	17	13	9	1	3	32	
GS	47	42	19	3	6	28	
GV	4	3	1	-	0	11	
GV(L)	71	53	40	4	13	59	
GY	4	4	3	-	1	77	
Subtotal			157	9	52	52	
S1	22	16	10	4	3	35	Protection

TABLE 15 Continued

Catchment and forest type	Minimum diameter and sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management Category
Nasuva							
V	5	4	1	-	0	13	Non-Commercial
C1	21	20	17	-	6	98	Production
DS	11	9	8	-	3	67	
GV	28	25	15	2	5	33	
S1	11	10	4	-	1	20	Protection
Seanggangga							
P	15	12	5	2	2	15	Non-Commercial
V	40	29	7	1	2	15	
VB	5	4	2	-	1	53	
Subtotal			14	2	5	17	
C1	16	13	9	-	3	96	Production
DS	55	50	45	6	15	64	
DS2	20	20	17	-	6	46	
G	24	17	13	3	4	39	
GB	15	12	11	-	4	93	
GS	16	12	7	2	2	16	
GV	38	31	19	3	6	36	
GV(L)	8	7	3	-	1	41	
Subtotal			124	8	39	52	
S1	28	22	8	-	3	16	Protection
Ndrawa							
J	2	1	< 1	-	0	1	Non-Commercial
P	38	34	12	2	4	25	
RT	5	4	3	-	1	21	
V	31	21	4	1	1	10	
VF	14	11	5	1	2	8	
Subtotal			24	2	8	13	
C1	201	167	121	8	40	61	Production
DS	172	145	107	8	36	58	
G	22	19	12	-	4	48	
GS	177	152	87	16	29	39	
GV	67	52	32	6	11	25	
GV(H)	2	1	1	-	0	14	
GV(L)	18	13	9	2	3	24	
VS	2	1	1	20	0	30	
Subtotal			370		123	48	
S1	77	64	38	4	13	18	Protection

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

Given the existing road system, combination of these catchments either with the Wainunu catchment to the south or the Ndreketi North Catchment Group, would seem impractical. If the Fiji Forest Industries decide to gain access to the Wainunu catchment from the north, the picture might be altered, particularly in respect of the Ndrawa catchment.

PROPOSED ACCEDS ROUTES

The main Lambasa to Nambouwalu road and the Ndreketi River act as access routes to the northern parts of this catchment group. A logging road gaining access to the Sasa felling block, exists at the southern end of the catchment. This could be extended westwards to exploit the rest of the forest type GV but the forest gets increasingly poor to the west. The good forest in the Nasuva, Narailangi and Seanggangga catchments lies along the southern watershed. This could be reached by feeder roads running south from the main Lambasa-Nambouwalu road, which runs far inland at this point. Two feeder roads already exist entering the Ndrawa area, one finishes at Nasingasinga village and the other runs from Ndreketi village into the forest in a southerly direction.

PROPOSED TREATMENT OF FOREST TYPES

Non-commercial forest. The non-commercial forest types J, P, RT , S, VB and VF should provide a source of timber for local use. At the existing population density they would not be used up in the foreseeable future and no treatment is envisaged. Forest type H in the Sasa felling area should be regenerated in order to maintain a sustained yield of timber.

Production forest. The production forest types are suitable for commercial exploitation. It is considered that only the areas of forest type C1 and the gentler slopes carrying forest type DS would be suitable for plantations, on the premise that, since they carry well stocked forest now, they would provide the best plantation sites.

Protection forest. The areas under forest type GDS, GS, BS and S1 would be best left unlogged, with the exception of forest type GS in the Narailangi and Ndrawa catchments, where controlled logging could be carried out.

PART 6. THE COASTAL EAST CENTRAL CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The area consists of 2 catchments, 15/1 Wailevu and 19/1 Nasekawa. They are located on the south central coast of Vanua Levu Island in Thakaundrove province. The limits of the area to the south are the northern shore of Savusavu Bay continuing from Nakoso village up the main ridge to Mariko peak. To the north the boundary is the Valili range forming part of the main watershed of the island; to the east it is the main ridge joining Ndelaikoro to Nasorolevu and Mariko peaks, and to the west the ridge running from Tavea peak to the sea at Yanawai Point.

The area falls within the tikina of Wailevu and partially into Vaturova.

CLIMATE

Because the prevailing winds are the South-Easterly Trades, the high north-east south-west watershed causes a marked increase in the rainfall with rising elevation. Nearly the whole comes in climate zone F with a very weak or no dry season with heavy rainfall of over 3 810 mm (150 in) a year, reaching 5 080 mm (200 in) on the watershed. An exception is the coastal fringe, which has a weak dry season (only July may be dry) and moderate rainfall averaging 3 050-3 810 mm (120-150 in) per year.

GEOLOGY

The area lies over the Natewa Volcanics and is part of the Korotini table-land, with breccias, flows, grits and tuffs. These are commonly dark fine-grained basic andesite, but can range from basalt to acid andesite. To the west, inland, are the Mbua basalts with interbedded sediments. Towards the coast near Valeni the basalts underlie level areas of sedimentary mudstones.

The coast of the Wailevu catchment consists of raised beach deposits of windblown sand over coral rubble.

LANDFORM AND SOILS

The Wailevu catchment is surrounded by the Valili range to the north, forming a steep ridge about 305 m (1 000 ft) above the surrounding country with peaks at Tavea 670 m (2 198 ft), Valili 904 m (2 966 ft) and Mathakani 575 m (1 887 ft). To the south below the steep ridge the landform levels off suddenly, but is dissected into north-south ridges by a series of short fast-flowing creeks, before falling steeply to the raised beach. The only flat land is formed by the raised beaches and estuarine flats.

The Nasekawa catchment consists of the basin of the Nasekawa River and its main tributary the Turiwai, probably following a major fault. South and east of the steep ridges forming the catchment boundary the country is steep and deeply ridged. These ridges continue down to the main Turiwai Creek which has high, fairly steep banks between Mbangata and Mbiaungunu villages. The catchment thus consists of a herring bone pattern of steep ridges with high flat or rounded summits. The only flat land is found at high elevation south of the Turiwai and at lower elevation in the narrow valley of the Thambeu Creek and the Nasekawa estuary flats.

In the Wailevu catchment the great majority of soils on the basic andesites which form the steep main watershed of the island, in this high rainfall area, are strongly weathered humic latosols with a low base status. Typical is the Nailoca steepland stony and bouldery, clay-loam and clay (83e and 83eM). On the steeper ridge sides the steep phase (83e) is most frequent, but where the land levels out, the moderately steep phase (83eM) occurs.

In the Nasekawa catchment the very steep slopes on both sides of the catchment boundary show the very steep phase 83eT but elsewhere the soils are the same as in the Wailevu catchment.

VEGETATION

Apart from the raised beaches and some flat land up the river estuaries which, for the most part, are cultivated with copra, cocoa and subsistence crops, the slopes of the Wailevu catchment are under tropical rain forest. The steep terrain has precluded any commercial felling.

In the Nasekawa catchment, inland villages are more numerous, with Waisali village on the creek of that name, and two villages, Nakawanga and Mbiaungunu, on the Turiwai. There is a considerable area of grassland in this catchment, spreading up the rivers, probably from past cultivation when the area was more heavily populated. The remainder of the catchment is under tropical rain forest.

POPULATION AND LAND TENURE

The population consists of 1 800 Fijians, less than 100 Indians and about 30 of other races. The Fijian villages mostly lie on the coast with only Vatuvonu village lying inland in the Wailevu catchment, but in the Nasekawa catchment several villages are situated on the Turiwai River.

Four deserted village sites occur in the Nasekawa catchment which appears, from the vegetation cover, to have had extensive cutting of the forest in the distant past. The well forested Wailevu catchment, on the other hand, has only one deserted village site.

Large blocks of freehold land occur at the mouth of the Nasekawa River, just east of Natua village, and from the mouth of the Yanawai River to the mouth of the Natulatha Creek west of Naingganggi village. Between these, the whole coast line is filled in with areas of land held in Native Reserve, which extend up the Turiwai and Ndrakaniwai Creeks in Nasekawa catchment. This leaves the forest land under Fijian ownership but not in Native Reserve.

PRESENT LAND USE

With the exception of the three villages on the Turiwai Creek in Nasekawa catchment and one, Vatuvonu village, in the Wailevu catchment, all the villages are sited along the coast growing and drying their own copra in communal drying sheds. Yagrona is produced and sold in Savusavu, and any villagers visiting Savusavu by boat carry over taro, citrus and cocoa. Subsistence agriculture is common, but on the rich alluvial flats in both catchments, cash crops such as copra, cocoa and citrus can be grown. There are several large freehold coconut estates such as Mr Thaggard's at Natua. With improvements in communications, particularly roads to Savusavu, the agricultural potential would be greater, similar, for instance, to the south coast of the Natewa Peninsula.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

No enumerations have been carried out in the survey area.

EXPLOITATION PAST AND PRESENT

The area falls within the Fiji Forest Industries option area. No commercial felling has occurred.

SAWMILLS

There are no sawmills in the area.

PLANTATION SPECIES AND AGE CLASS

No plantations were noted at the time of the enumeration.

EXISTING ACCESS ROUTES

There is a coastal track, suitable for horses, along the beach and foreshore between Ndreketi village (not Mathuata Province) and Savusavu Bay, which swings inland west of Lauthala continuing west to Ndawara. This track continues to the east from Ndreketi to Mbangata, Sueni and Lambasa. An easier route continues from Mbangata up the Turiwai Creek as far as the Nakawanga and Mbiaungunu villages and continues as a horse track to Navakuru village along Thambau Creek, finally reaching Lambasa.

There are a series of tracks from the coast inland. The more important of these run from Naingganggi and Valeni to Vatuvonu and thence to Vuinanggalutu with a branch to Ndawara: from Valeni to Nayarailangi, and from Valeni to Naravuka on the main road. A foot track runs from Ndreketi village to Waisali village inland. None of the rivers in Wailevu catchment are navigable by timber rafts, and the Nasekawa River is only navigable below Nakarawanga village, except when in flood.

THE ENUMERATION

LAYOUT OF SURVEY

Due to the shape of the Wailevu catchment it was not possible to position the base line so that the lines cross the topography at right angles, with the result that the lines are liable to run up ridges and valleys, not across them. The base line was chosen parallel to the coast and one line located in each section to run from the coast to the watershed. The layout of 12 lines completely covered the forest area. In the Nasekawa catchment the base line was chosen along the Turiwai Creek, where it branches from the Nasekawa River. The layout of lines only covered those parts of the forest with some potential for timber production. Separate starting points were chosen for the lines running north and south of the base line.

TIMBER VOLUMES

From Table 16 it can be seen that production forest covers an area of 13 166 ha (32 533 ac) or 65% of the enumerated area. Forest type DS covers nearly 5 000 ha (12 355 ac) and occurs in both catchments. Other useful forest types covering extensive areas are forest types CI, GV, SK and SV. In both catchments there are considerable areas of protection forest, particularly of forest type S1, low stocked open canopy woodland on very steep slopes, which covers a total enumerated area of nearly 3 000 ha (7 415 ac).

TABLE 16 Enumerated areas of forest types in Coastal East Central Catchment Group (ha)

Forest type	Wailevu	Nasekawa	Total enumerated area		% of enumerated forest
			ha	ac	
KF	-	1 431	1 431	3 536	7
V	136	-	136	336	1
Non-commercial	136	1 431	1 567	3 872	8
C1	164	1 141	1 305	3 225	6
CY	129	-	129	319	1
DK	56	137	193	477	1
DS	3 698	1 299	4 997	12 347	25
DS2	179	-	179	442	1
G	1 203	200	1 403	3 467	7
GS	1 299	79	1 378	3 405	7
GV	1 749	-	1 749	4 322	9
GV(L)	60	-	60	148	<1
SK	1 878	-	1 878	4 640	9
SV	1 273	-	1 273	3 146	6
Production	11 688	2 856	14 544	35 938	72
B	47	59	106	262	1
CS	919	151	1 070	2 644	5
S1	2 767	198	2 965	7 327	14
Protection	3 733	408	4 141	10 233	20
Total			20 252	50 043	

The volumes of standing timber are summarised by management categories in Table 17. The volume of production forest in the two catchments if 799 000 m^3 (266 million Hsl ft) with a reliable minimum estimate of 725 000 m^3 (240 million Hsl ft). Most of this volume comes from the Wailevu catchment. Non-commercial forest occurs mostly in the Nasekawa catchment, which has a standing volume of 15 000 m^3 (5 million Hsl ft).

TABLE 17 Volume of timber from trees over 40 cm d.b.h. species group 1-4, reliable minimum estimate and percentage error by catchment and management category, Coastal East Central Catchment Group ('000 m^3)

Management and catchment	Volume 40 cm s.g. 1-4	Sampling error > 40 cm s.g. 1-4	Degrees of Freedom	Confidence limit p <0.05	r.m.e. p <0.025	% error	Volume 40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Wailevu	1	1	2	4	0	<100	0
Nasekawa	15	3	3	10	5	67	5
Total	16				5		5
Production							
Wailevu	614	20	33	41	573	7	204
Nasekawa	185	15	10	33	152	18	62
Total	799				725		266
Protection							
Wailevu	117	13	19	27	90	23	39
Nasekawa	12	-	-	-	-	-	4
Total	129						43

In the production forest the percentage error lies within the prescribed limit of 20% with figures for Wailevu (7%) and Nasekawa (18%). The protection forest in Wailevu is near the limit but the protection forest in Nasekawa and the non-commercial forest in both catchments have sampling errors that are either very high or not calculated due to insufficient sampling.

DESCRIPTION OF FOREST TYPES

The forest types are listed in Table 18, which gives standing volume, sampling error and net stocking, grouped by management category.

TABLE 18 Total volumes and sampling errors of forest types in the Coastal East Central Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter & sp. group			Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
	(1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4				
Wailevu							
V	11	9	1	1	0	7	Non-commercial
C1	23	19	16	4	5	98	Production
CY	14	11	11	-	4	85	
DK	3	2	2	-	1	36	
DS	396	341	275	15	92	74	
DS2	11	10	9	1	3	50	
G	76	62	47	4	16	39	
GS	98	81	58	8	19	45	
GV	108	86	51	6	17	29	
GV(L)	2	1	1	-	0	17	
SK	125	97	87	6	29	46	
SV	94	74	57	4	19	45	
Subtotal			614	20	205	54	
B	1	1	<1	<1	0	0	Protection
CS	67	61	46	4	15	50	
S1	140	118	71	10	24	26	
Subtotal			117	10	39	43	
Nasekawa							
KF	28	24	15	3	5	10	Non-commercial
C1	102	92	72	7	24	63	Production
DK	11	11	11	-	4	80	
DS	128	116	94	13	31	72	
G	9	7	6	1	2	30	
GS	3	3	2	-	1	13	
Subtotal			185	15	62		
B	2	2	1	-	0	17	Protection
CS	12	10	9	-	3	60	
S1	2	2	2	1	1	10	
Subtotal			12	1	4		

Type KF: Low-stocked blocks of forest in grassland

This forest type, for which a full description is given in Volume 1, occurs only in the Nasekawa catchment. It covers large areas outside the enumerated area to the north of the Turiwai Creek and to a limited extent to the south. It is almost certainly the result of clearing for farming in the post. The Native Land Commission Sheets show four deserted village sites in this catchment, indicating that the area used to be more heavily populated.

Type DS: Well stocked *dakua makadre* and *salusalu* forest on steep slopes

This type occurs in both catchments on the middle slopes half way between the coast and the watershed, as well as on the slopes coming up to the watershed. The species composition for the Wailevu catchment is given in Volume 1. Nasekawa has similar stockings of *dakua makadre* and *dakua salusalu* but higher stockings of *damanu* and *kaudamu* at 16 and 14 m^3/ha respectively (trees over 35 cm d.b.h., 2 156 and 1 887 Hsl ft/ac).

Type GV: Moderately stocked *kaudamu-velau* forest on moderate to steep short slopes

This forest type lies along the forest margin inland from the coast. It is similar in species composition to the normal type except for a slightly larger amount of *dakua makadre* and a large stocking of *yasiyasi*. Its presence here is probably due to the slightly drier climate that occurs along the coast allowing burning for a few months, which results in the *velau* regenerating from seed at the expense of the heavy fruited, fire tender forest species.

Type GS: Low-stocked forest on short, very steep slopes

In the Nasekawa catchment this type has a very low stocking, which makes it unsuitable for exploitation regardless of slope. In Wailevu the stocking is higher (45 m^3/ha 6 065 Hsl ft/ac) with valuable species such as *damanu*, *dakua salusalu* and *rogi*. It has been included in the production forest in these two catchments because the slopes are not so steep here and the catchment watersheds are protected with forest type BS and CS.

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

The majority of the good timber lies in the north-west of the Wailevu catchment and the far east of the Nasekawa catchment. As the ridge dividing them is steep the catchments should be worked separately, with Wailevu being combined with Yanawai catchment and Nasekawa combined with the Lambasa catchment.

PROPOSED ACCESS ROUTES

If the Koroutari road reaches Savusavu, the Wailevu catchment could be logged with a series of feeder roads into the interior removing timber to the coast, rafting to Savusavu and thence over the extended Koroutari road to the mill. A better access route from the western part of Wailevu might be along the old Mount Kasi gold mine road, which goes through Vatuvonu and then heads north towards Ndreketi on the north side of the island. The timber in the eastern part of Nasekawa catchment could be extracted by a road following the horse track that joins Sueni and Navakuvu villages in Lambasa catchment with the villages on the Turiwai River.

PROPOSED TREATMENT OF FOREST TYPES

Non-commercial forest. The non-commercial forest types KF, V and J (outside the enumerated area) have a high proportion of *velau* in their species composition. They have no commercial value and require no treatment in the foreseeable future.

Production forest. The forest types suitable for commercial exploitation are C1, CY, DK, DS, DS2, G, GV, SK and SV. These have varying stockings of usable timber, ranging from 98 to 29 m^3ha (13 205 to 3 908 Hsl ft/ac) but the overall stocking for Wailevu is 54 m^3/ha (7 277 Hsl ft ac) and for Nasekawa 66 m^3/ha (8 895 Hsl ft/ac). The western part of Wailevu has good forest,

rich in the softwood species, which makes it an attractive proposition for exploitation, only marred by the difficulties of access. Nasekawa on the other hand, due to the steepness of the terrain and the fragmented nature of the good forest, does not offer good exploitation prospects.

Protection forest. Forest types B, CS, GS and S1 would be best left unlogged. However, since forest type GS contains a good proportion of *dakua salusalu* and *damanu* in the Wailevu catchment, restricted logging may have to be allowed, preferably with a high girth limit to encourage a selection system. Although forest type CS also contains some *damanu* and a little *dakua makadre*, logging is not recommended in either the Wailevu or Nasekawa catchments.

PART 7. THE LAMBASA AND THE NORTH-EAST CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The catchments lie to the north of the main chain of hills that divides Vanua Levu and occupy the north-eastern half of the island. The following are included:

16/1	Tambia	23/1	Nayarambale
18/1	Lambasa	25/1	Wainikoro
21/1	Naggawa	26/1	Numbu

They are named after the main rivers, which flow in a northerly or north-westerly direction in broad valleys, separated by steep hills.

The area falls into Lambasa tikina in Mathuata Province in the north and Vaturova and Sanggani tikina of Thakaundrove Province in the south.

CLIMATE

The main chain of hills that forms the southern limit of the area has a climate with a mean annual rainfall of more than 3 810 mm (150 in) and a very weak or no dry season (zone F). Northwards this grades sharply into a zone with an annual rainfall of 2 540 - 3 810 mm (100 - 150 in) and a moderate dry season with 3 - 5 months having less than 152 mm (6 in) of rain (zone D). The high hills that jut out towards the coast have a long intense dry season of more than 5 months having less than 152 mm (6 in) of rain and a mean annual rainfall of 2 540 - 3 300 mm (100 - 130 in) (zone C). Lambasa and the alluvial plains at sea level have a rainfall of 1 650 - 2 540 mm (65 - 100 in) and a long and intense dry season of more than 5 months (zone A). In this zone more than 510 mm (20 in) is needed to bring the mean monthly rainfall to a minimum of 152 mm (6 in).

Mean monthly rainfall figures for Lambasa mill and Nakoroutori are given for periods of 10 and 6 years respectively.

TABLE 19 Mean monthly rainfall figures for Lambasa mill and Nakoroutari in millimetres and inches

Location	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
mm													
Lambasa	328	401	347	266	75	51	38	49	91	96	191	220	2 155
Nakoroutari	375	398	400	266	87	83	56	52	89	121	270	323	2 529
in													
Lambasa	12.96	15.80	13.68	10.47	2.97	2.00	1.48	1.94	3.57	3.79	7.52	8.66	84.86
Nakoroutari	14.77	15.67	15.76	10.47	3.45	3.30	2.24	2.08	3.54	4.79	10.63	12.73	99.57

The temperature ranges through narrow limits. The mean monthly maximum at Lambasa mill is 30.9°C (87.6°F) in January, falls to 28.3°C (82.9°F) in July and rises gradually to reach the January figure once again. The mean minimum follows the same pattern being highest in February (22.7°C) 72.9°F), and lowest in July (19.1°C, 66.4°F).

GEOLOGY

Breccias, flows, grits and tuffs of the Natewa Volcanic Group underlie the hills that form the western and southern boundaries of the area. The steep hills that lie at right angles to the coast and separate the Nggawa, Mbuthaisau, Wainikoro and Langalanga Rivers are underlain by rocks of the Undu Volcanics Group from pumice and rhyolite to dacite. Alluvium lies on the flat low-lying land either side of the main rivers near their mouths. Mudstones, sandstones and tuffs lie between the Wailevu and Lambasa Rivers and to the east of the Nggawa River.

LANDFORD AND SOILS

Alluvial plains extend inland on either side of the main rivers for distances of from 6.4 to 10 km (4-6 mi). Moderate slopes extend inland usually as far as the head of the catchment; they are grass-covered or cultivated near the coast and forest-covered inland. The catchments are separated by steep forest-covered hills, reaching an elevation of 305-457 m (1 000 - 1 500 ft), and extending from the main range of hills that runs down the length of the island, to the coast.

Steeply dissected country at an elevation of 610-915 m (2 000 - 3 000 ft) exists at the southern end of the Lambasa catchment, but no extensive area of this kind of country exists in the other catchments. High peaks lie along the southern watershed of the area with elevations of 915-1 035 m (3 000 - 3 400 ft). A good idea of the landform of these catchments is given by the photograph illustrating forest type GDS.

Gley soils occur on the alluvium at the mouth of the main rivers particularly the Lambasa, Mbuthaisau and Wainikoro. The moderate slopes in the vicinity of Lambasa have Ferruginous latosols (*Talasiga* soils) on the heavily populated dry zone areas. The moderate slopes that border the rivers higher up have humic latosol soils, Solevu clay and silty clay loam (27e). The hill soils reflect the geology with the acid rocks of the Undu Volcanics group giving rise to red yellow podsolic soils and the more basic Natewa Volcanics rocks giving rise to humic latosols. The widespread red yellow podsolic soil is Cuku stony sandy clay (93b). This is derived from rhyolite, pumiceous tuff and agglomerate, ranging to acid andesite tuff and agglomerate. It shows 8 cm (3 in) of very dark grey firm to friable, stone and sandy clay, overlying 13 cm (5 in) of dark reddish brown firm clay of moderately developed fine blocky structure on pale yellow and red decomposing rock, with red clay between rock fragments. The widespread humic latosol on the steep hills of the interior is Nailoca steepland bouldery clay (83e). This is a strongly weathered humic latosol of low base status derived from andesites. On steep slopes it shows 15 cm (6 in) of reddish brown friable stoney clay, on 20 cm (8 in) of red brown friable clay, with a few stones, overlying varicoloured rubbly clay containing much decomposing tuff and agglomerate. A humic latosol that is common locally on the hills between the Namoli and Nggawa Rivers in the Nggawa catchment is Vuya steepland bouldery clay (85a). It is developed from basic andesite and basalt and consists of dark reddish brown clay to a depth of 53 cm (21 in) on docomposing rock.

VEGETATION

Between the cultivated alluvial flats and the forest margin at the foot of the hills is a zone of vegetation consisting of grass, *Casuarina* and grass, or mixed shrubs. This extends up the main rivers but is replaced at the head of the valleys by poorly stocked forest of a secondary nature. The steep hills are forest covered almost to the coast. This forest contains a high proportion of *velau* and, where it has not been logged, some *dakua makadre*. Forest with a considerable proportion of Gymnosperms occurs on the dissected country at high elevations in Lambasa catchment.

Mangrove is common down the north coast of Vanua Levu particularly in the deltas of the Tambia, Lambasa, Wainikoro, Langalanga and Numbu Rivers.

POPULATION AND LAND TENURE

The total population of the area is 35 650 people (Zwart, 1966). Of these 30 491 are Indian, 4 401 are Fijian and 758 are of other races. The Indian people are engaged in sugar-cane farming and live in settlements at the edge of the cane land. The Fijians either live on the coast or inland along the rivers near the forest edge.

Old village sites lie at the heads of the valleys particularly in the Wainikoro, Nayarambale and Nggawa catchments and on the high hills above the cultivated plains. Poor vegetation cover occurs in areas adjacent to the rivers where these old village sites are situated.

The tops of the hills and the hill country at the southern end of the Lambasa catchment are under Fijian ownership but not in Native Reserve. Native Reserve occurs over the moderate slopes surrounding the Fijian villages such as Nandongo, Nayarambale, Ndreketilailai, Sueni and Navakuru. A large part of the production forest in the north-west corner of the Wainikoro catchment has been reserved.

Freehold land is limited in occurence being confined to small blocks of sugar-cane land at the mouths of the Lambasa and Mbuthaisau Rivers.

Crown land covers considerable areas mostly on the hills but, to a small extent on the cane land as well. A large, roughly rectangular, block of Crown land occurs in the middle of the Lambasa catchment centred on Nakoroutari. Other sizeable blocks occur at Mbulileka, inland from Lau Bay, Raranikawai on the Mbuthaisau River and on both sides of the Wainikoro River.

PRESENT LAND USE

Sugar-cane production is the land use of primary importance, employing the considerable Indian population and some Fijians, particularly at harvesting time. Bullocks for work in the cane fields and cows are reared by the Indians on the grasslands adjacent to the cane fields. Extensive rice cultivation occurs on the alluvial flats near the mouth of the Wainikoro River on the opposite side of the river to the main road.

Fijian farming activity takes the form of scattered cultivation of taro, cassava and *yaqona* on the moderate slopes near the villages. Some taro and cassava are grown for sale. Coconut plantations are not common but occur scattered along the coast.

Very good sea fishing exists off the north coast of Vanua Levu.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

No enumerations have been carried out in the area by the Forest Department. J G Groome and Associates have carried out enumerations for Fiji Forest Industries in the Koroutari and Sanggaru Creek areas of the Lambasa catchment. Figures for their enumerations are not available.

EXPLOITATION PAST AND PRESENT

Fiji Forest Industries have a concession over the forest of Vanua Levu which applies to all the area being described here. They have been exploiting the forest in the Koroutari block since 1966. In the past exploitation has been carried on in an area on the western watershed of Lambasa catchment served by the road that passes through Vatulovona.

The forest on the steep slopes adjacent to the cane lands (forest type GDS) is logged for timber and poles for local house-building purposes and is grazed and browsed by cattle from time to time.

SAWMILLS

Fiji Forest Industries have a sawmill at Malau on the north coast loki (6 mi) from Lambasa and opposite Mali Island. At this site they have facilities for preparing and grading logs for export to Australia. Their estimated outturn for the year 1967 was 8 953 m^3 (2 981 486 Hsl ft).

A sawmill used to be in operation beside the Sanggaru Creek on the western side of the Lambasa catchment. It is derelict now.

PLANTATION SPECIES AND AGE CLASS

There are no extensive plantations in this area. Trial plots have been laid out in the felled forest in the eastern part of the Lambasa catchment. Among the species being tried are *Eucalyptus*, mahogany and *Terminalia* sp.

EXISTING ACCESS ROUTES

The main road running up the north coast goes as far as the Langalanga settlement in the Numbu catchment. It follows the coast as far as the Nayarambale catchment where it turns inland following the Mbuthaisau River until a break in the hills affords an easy gradient into the Wainikoro valley. The road runs down beside the Wainikoro River almost to its mouth and finishes at Langalanga about 1.6 km (1 mi) beyond the Langalanga River. A network of subsidiary roads serve the cane growing areas of the Lambasa catchment. The road through Nakoroutari continues into the felling area on the eastern watershed of the Lambasa catchment. It is intended to extend this road southwards to link up with the Savusavu to Vunindongoloa road on the Natewa Bay coast. One road follows the Wailevu valley as far as the VHF mast on top of Ndelaikoro. Another road goes up past Vatulovona to the logging area on the north-west watershed of Lambasa catchment.

Beyond the main roads in all the catchments, tractor or land-rover tracks connect the outlying settlements during the dry season. In the Lambasa catchment Navakuru and Mataloto can be reached by land-rover. In the Nggawa catchment secondary road reaches Ndreketilailai. In the Numbu catchment a network of minor roads connect the Langalanga settlement with Numbu and Nakeliloso.

Produce is brought into Lambasa by barge. Ocean-going ships have to unload at Malau. The road linking Lambasa with the deep port of Savusavu will have great economic importance for Vanua Levu. With a good road system linking the catchments, the rivers lose their importance as means of access.

The northern side of Vanua Levu is linked to the south by tracks which go from the end of the logging track in the Nakoroutari felling area to Nakuluku and Vuinandi and from the felling area to Vunindongoloa. These tracks have a moderate gradient on the Lambasa side but fall steeply to the Natewa Bay coast. Another track crosses the island from north to south from Nayarambale passing through Seavathi and descending to Korotosere on the Natewa Bay coast. Ndreketilailai, Nayarambale and Nandongo are linked by a track which crosses the series of steep hills in a north-easterly direction.

THE ENUMERATION

LAYOUT OF SURVEY

Lambasa is covered by a complete inventory but the other catchments are covered by reconnaissance lines. The base line for the Lambasa catchment lies along the Wairikithake River with lines cut both sides of this river in the high elevation forested country. One line was cut in Nggawa catchment starting from the logging track in the Koroutari felling area. Two short lines were cut in the Nayarambale catchment, one at the extreme southern end and the other from beside the main road in the more moderate sloping country on the north-west side of the catchment. Four lines were cut in the Wainikoro catchment from a base line aligned along the Wainikoro River. Two lines were cut in the Numbu catchment cutting across moderate slopes to steeply rising land near the watershed.

TIMBER VOLUMES

Areas covered by the forest types are laid out in Table 20. The enumerated area of Lambasa which had a complete layout of lines is the same as the total area. In the 'reconnaissance' catchments the proportion of non-commercial and protection forest is high. Forest type J covers a total area of 12 592 ha (31 115 ac) and forest type GDS covers a total area of 11 216 ha (27 715 ac). The production forest covers 30% of the enumerated forest area, occurring in small fragments in all catchments except Lambasa and Wainikoro where it covers large blocks.

TABLE 20 Enumerated area of forest types in Lambasa and North-East Catchment Group (ha)

Forest type	Tambia	Lambasa	Nggawa	Nayarambale	Wainikoro	Numbu	Total enumerated area		% of enumerated forest
							ha	ac	
GD	-	-	-	-	-	209	209	516	1
H	17	358	-	-	-	-	375	927	2
J	241	1 067	500	197	1 466	-	3 471	8 577	20
S	-	533	157	11	223	-	924	2 283	5
V	52	-	66	-	123	192	433	1 070	3
Non-commercial	310	1 958	723	208	1 812	401	5 412	13 373	31
C1	-	504	31	161	-	-	696	1 720	4
G	-	693	-	259	113	-	1 065	2 632	6
GDK	-	1 862	-	-	-	-	1 862	4 601	11
GV	305	-	132	192	636	343	1 653	4 085	9
Production	350	3 059	163	612	749	343	5 276	13 037	30
B	-	299	-	-	91	-	390	964	2
BS	-	2 853	339	-	608	-	3 800	9 390	22
CS	-	1 155	-	-	-	-	1 155	2 854	7
GDS	523	-	-	-	-	855	1 378	3 405	8
Protection	523	4 307	339	-	699	855	6 723	16 613	39
Total							17 411	43 023	

Table 21 shows the timber volume in the catchments. The volume of timber in the production forest is 236 000 m^3 (78 million Hsl ft). This comes mostly from the Lambasa catchment which has a total volume of 169 000 m^3 (56 million Hsl ft) and a reliable minimum estimate of 144 000 m^3 (48 million Hsl ft).

TABLE 21 Volume of timber from trees over 40 cm d.b.h. species group 1-4, reliable minimum estimate and percentage errors by catchment and management category, Lambasa and North-East Catchment Group ('000 m^3)

Management and catchment	Volume 40 cm s.g. 1-4	Sampling error >40 cm s.g. 1-4	Degrees of freedom	Confidence limits p<0.05	r.m.e. p<0.025	% error	Volume 40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Tambia	3	-	-	-	-	-	-
Lambasa	13	1	7	2	11	1	4
Nggawa	5	-	-	-	-	-	2
Nayarambale	3	-	-	-	-	-	1
Wainikoro	4	1	1	13	0	99	1
Numbu	7	-	-	-	-	-	2
	35						11
Production							
Tambia	9	1	1	9	-	>100	3
Lambasa	169	11	9	25	144	10	56
Nggawa	10	-	-	-	-	-	3
Nayarambale	24	-	-	-	-	-	8
Wainikoro	14	2	1	29	-	>100	5
Numbu	10	-	-	-	-	-	3
	236				144		78
Protection							
Tambia	5	-	-	-	-	-	2
Lambasa	132	12	13	25	107	11	44
Nggawa	1	-	-	-	-	-	0
Wainikoro	6	1	1	13	0	>100	2
Numbu	30	5	1	69	0	>100	10
	174				107		58

TABLE 22 Total volumes and sampling errors of forest types in the Lambasa and North-East Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for	Management category
Tambia							Non-Commercial
H	1	1	1	-	0	42	
J	2	1	1	-	0	4	
V	2	2	1	-	0	19	
Subtotal			3	-	1	10	
GV	17	13	9	1	3	26	Production
GDS	13	10	5	-	2	10	Protection

TABLE 22 (continued)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
Lambasa							Non-Commercial
H	16	13	9	-	3	25	
J	7	5	3	1	1	3	
S	3	2	1	<1	-	2	
Subtotal			13	1	4	7	
C1	52	45	36	5	12	71	Production
G	35	28	22	6	7	32	
GDK	146	131	111	7	37	60	
			169	10	56	39	
B	15	14	10	3	3	33	Protection
BS	108	95	74	10	25	26	
CS	71	64	48	4	16	42	
Subtotal			132	11	44	31	
Nggawa							Non-Commercial
J	11	9	4	-	1	8	
S	1	1	-	-	-	-	
V	4	4	1	-	-	15	
Subtotal			5	-	1	7	
C1	7	7	7	-	2	226	Production
GV	7	4	3	-	1	23	
Subtotal			10	-	3	61	
BS	4	3	1	-	0	3	Protection
Nayarambale							Non-Commercial
J	5	4	3	-	1	15	
S	-	-	-	-	-	-	
Subtotal			3	-	1	14	
C1	13	12	10	-	3	62	Production
G	13	13	8	-	3	31	
GV	11	9	6	-	2	31	
Subtotal			24	-	8	39	
Wainikoro							Non-Commercial
J	27	22	3	1	1	2	
S	2	2	1	-	-	4	
V	0	0	0	-	-	-	
Subtotal			4	1	1	2	
G	3	2	2	-	1	18	Production
GV	54	26	12	2	4	19	
Subtotal			14	2	5	19	
B	1	1	<1	-	-	5	Protection
BS	11	9	6	1	2	10	
Subtotal			6	1	2	9	

TABLE 22 (continued)

Catchment and forest type	Minimum diameter & sp. group			Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
	(1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4				
Numbu							Non-Commercial
GD	12	10	6	-	2	29	
V	5	4	1	-	-	5	
Subtotal			7	-	2	17	
GV	23	19	10	-	3	29	Production
GDS	50	41	30	5	10	35	Protection

The enumerated volumes in the non-commercial and protection forest are 35 000 and 174 000 m^3 respectively (11 and 58 million Hsl ft). They do not represent the total volume in these categories since only a small proportion has been enumerated.

Of the 6 catchments of the group only Lambasa had a complete lay-out of lines. In this catchment the percentage errors are less than 20%, being 1% for non-commercial forest, 10% for the production forest and 11% for the protection forest. In the reconnaissance catchments the errors are either very high or not calculable.

DESCRIPTION OF FOREST TYPES

In Table 22 the timber volumes, sampling error and stocking of the forest types are listed by management categories for the catchments.

Unusual and widespread forest types that will be discussed here are DR, J, V, GDK, GV, BS and GDS.

Type DR: Sapindaceae pole forest

On the dry hills in the Nggawa and Nayarambale catchments a low thicket vegetation of almost pure *Aryterya brackenridgei* is found growing to a height of 13 m (43 ft) with a closed canopy. The type can be recognised on the ground by the pale yellow-green colour of the leaves and on the air photographs by the pale tone.

The trees have diameters of from 10 to 20 cm (4-8 in). Associated species are *velau*, *kaudamu* and *cevua*. The ground is covered with regeneration of *Aryterya* and *cevua (Vavaea amicorum)*.

Type J: Low-stocked fringe forest

This type occupies 24% of the total area of forest land. Stocking is low ranging from 4 to 18 m^3/ha (539-2 426 Hsl ft/ac). As the name implies it is usually associated with the forest margin, but in the Nggawa, Nayarambale and Wainikoro catchments it spreads from the river, along which settlement has occurred, to the watershed. The species composition agrees with that given for forest type J in Part 3, Volume 1. In the Nayarambale catchment stockings of *kauvula* and *kaudamu* are 6 m^3/ha (809 Hsl ft/ac) which is high for this forest type.

The high incidence of old village sites in the upper valleys of the Nggawa, Nayarambale and Wainikoro catchments has been noted in a previous section. It seems probable that the widespread occurrence of forest type J is a result of past cultivation. Climatic influences, notably the strong dry season, may play a part in the slow rate of regrowth of these forests.

Type V: *Velau* woodland

Velau woodland covers a total of 3 269 ha (8 078 ac) which is 6% of the forested area. Stocking ranges from 0 to 54 m^3/ha (7 277 Hsl ft/ac). The wide range is due to the fact that the type occurs in small patches in the sampled area. Species composition agrees with the description of the type given in Part 3, Volume 1 with a high proportion of *velau* represented by the high volume for 'others'. The catchment has a total of 54 m^3/ha (7 277 Hsl ft/ac) of which 46 m^3/ha (6 199 Hsl ft/ac) is of 'others'.

Large areas of this type occur at the northern end of the Nayarambale and Wainikoro catchments on moderate sloping ground. It caps the ridges of the steeply rising hills that stand above the flat alluvial plains.

Type GDK: Moderately stocked *dakua makadre* forest on steep slopes at high elevations

This forest type covers an area of 1 862 ha (4 600 ac) in the Lambasa catchment, where there is moderate to steep sloping ground at elevations of from 460 to 610 m (1 500 - 2 000 ft). *Dakua makadre* has a stocking of 14 m^3/ha (1 887 Hsl ft/ac) and *dakua salusalu* 4 m^3/ha (539 Hsl ft/ac). *Kaudamu, damanu, yasiyasi* and *kauvula* have stockings of 9, 8, 6 and 5 m^3/ha respectively (1 213, 1 078, 809 and 674 Hsl ft/ac). The relatively high stocking of *kaudamu* is interesting because in the same forest type in Viti Levu *kaudamu* is virtually absent. This implies that the limit of elevation for *kaudamu* lies between 610 m (2 000 ft), the elevation in the Lambasa catchment, and 915 m (3 000 feet), the elevation of the high plateau in Viti Levu.

Type GV: Moderately stocked *kaudamu-velau* forest on moderate to steep short slopes

This forest type covers a total area of 3 634 ha (8 980 ac) or 7% of the forested area. It covers moderate slopes in the dry climatic zones in the Tambia, Nayarambale, Wainkoro and Numbu catchments.

The structure of the forest is similar to forest type G but *velau* occurs on the exposed ridges and *kaudamu* is much more in evidence than in forest type G. In the Nggawa and Nayarambale catchments stocking of *kaudamu* is 15 and 17 m^3/ha (2 021 and 2 291 Hsl ft/ac) respectively. Other common species are *sa, yasiyasi* and *kauvula*. *Damamu* does not occur in this type. The overall stocking ranges from 33 to 55 m^3/ha (4 447 - 7 412 Hsl ft/ac) which is not too wide a range considering the small areas sampled.

Type BS: Low-stocked forest on very steep or precipitous slopes

Very steep to precipitous slopes with low-stocked forest cover an area of 7 945 ha (19 632 ac) which is 15% of the forest area. The stocking ranges from 33 m^3/ha (4 447 Hsl ft/ac) in Lambasa to 9 m^3/ha (1 215 Hsl ft/ac) in Nggawa catchment.

Forest type BS occurs on the steep hills that rise up to the central north-east to south-west watershed that divides Vanua Levu. The hills that occur in the Lambasa catchment around the upper Wairikithake Creek are typical with huge boulders of breccia continuing for a fall in elevation of 305 m (1 000 ft). Progress up such slopes is made by scrambling over the rocks and hauling oneself from tree to tree. Slopes like this occur over a large part of the Lambasa catchment as well as at the headwaters of the Nggawa and Nayarambale Rivers. The distinction between this type and forest type GDS is made on land form and climatic criteria. With forest type GDS, the slopes are broken up into a pattern of ridges and the type occurs in the dry climatic zone. Forest type BS, on the other hand, has a precipitous slope in one plane and occurs in the wet climatic zone with little or no dry season.

In the Lambasa catchment *damanu* and *dakua makadre* both have stockings of 5 m^3/ha (674 Hsl ft/ac). *Vesi* and *sasauwira* occur with stockings of 1 to 2 m^3/ha (135 - 270 Hsl ft/ac). *Vesi*, in particular, seems to be able to grow under these conditions with its roots twisted into a crevice in the rock.

There is no doubt that this forest type should be a protection category. The reasons for this are:

1. the trees hold the soil and rock scree in place;
2. the forest cover permits absorption of the rain into the soil;
3. extraction equipment used on such slopes would cause rock slips and erosion.

Type GDS: Low-stocked dry-zone forest on long, very steep slopes

About 22% of the forest area (11 216 ha, 27 715 ac) is covered with this forest type, which occupies the steep hills that separate the broad, alluvial valleys. The stocking is variable because the typing has included a wide range of forest cover, from low forest near to settlement that has been felled and browsed, to practically untouched forest as is found on the hills of the Numbu catchment. Here the stocking is 48 m^3/ha (6 468 Hsl ft/ac) with 10 m^3/ha (1 348 Hsl ft/ac) of *dakua makadre*, 6 m^3/ha (809 Hsl ft/ac) of *yasyasi* and 5 m^3/ha (674 Hsl ft/ac) of *damanu*.

This forest type should be protected. This will not be easy because of the pressure from nearby settlements for building poles, firewood and a place to browse draft bullocks and cows. Any protection measure would have to be accompanied by a tree planting programme that would ensure a supply of wood for local use.

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

The two concentrations of production forest occur in the Lambasa catchment and on the north-west watershed of the Wainikoro catchment where it adjoins the Nayarambale catchment. The forest type GV of the Nayarambale and Wainikoro catchments should be combined for the purpose of management. The rest of the forest types in these catchments and all the forest types in the Nggawa and Tambia catchments are not well enough stocked to merit a plan of exploitation.

PROPOSED ACCESS ROUTES

Lambasa The road that serves the Koroutari felling area continues into the forest in a south-easterly direction. It is not known how far this road has reached but the intention is for it to cross the main ridge and link with the Savusavu-Vunindongoloa road.

The alignment of the road that serves the VHF mast on top of Ndelaikoro is not suitable for logging trucks. Fiji Forest Industries have worked out a new alignment to extract the timber from the western end of the Lambasa catchment. It branches off the Ndelaikoro road to approach the catchment from the north-west watershed. The extensive area of forest type GDK on the southern watershed is approached on foot by following the Lovu Creek from Matambolo. This is not practical for a road alignment because of the massive boulders and sudden rise in elevation. An easier route would be to skirt the southern watershed.

Wainikoro and Nayarambale Forest type GV is served by the existing main road.

PROPOSED TREATMENT OF FOREST TYPES

Non-commercial forest 40% of the forested area or 21 000 ha (51 890 ac) falls into the category of non-commercial forest. This is comprised mostly of forest type J, low-stocked fringe forest, with some forest type S, low-stocked open woodland and forest type V, *velau* woodland. The total volume enumerated in these forest types is 35 000 m^3 (11 million Hsl ft). The high proportion of species not suitable for sawing is indicated by the fact that the volume for trees in species groups 1 to 5 is 80 000 m^3 (27 million Hsl ft).

No treatment is recommended for these forest types.

Production forest Production forest covers nearly 9 000 ha (22 239 ac) which is only 18% of the forest area. The forest types considered suitable for exploitation are C1, G, GDK and GV. Forest type C1 is of limited occurance whereas G, GDK and GV are more wide-spread, covering, 5, 4 and 7% of the forest area respectively. Forest type GDK is confined to the Lambasa catchment, where it has a volume of 111 000 m^3 (37 million Hsl ft). Forest type GV is a useful production forest type but it only occurs in a big block in the Wainikoro and Nayarambale catchments.

Yields from forest type GV could be expected to be similar to those obtained from the Sasa felling area.

Protection forest Protection forest covers 21 650 ha (53 500 ac) which is 42% of the forest area. The volume of timber is considerable (174 000 m^3 (58 million Hsl ft) in the enumerated area). Protection is advocated because the slopes on these forest types are so steep that excess runoff and erosion may result from exploitation. In most areas included in these forest types the degree of slopes precludes economic logging. An area of forest type CS in the Lambasa catchment had in fact already been left by Fiji Forest Industries as too steep to log.

PART 8. THE NATEWA BAY CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The catchments lie along the southern shore of the eastern half of Vanua Levu, forming the northern shore of Natewa Bay. The following catchments are included:

20/2	Vaturova	20/4	Vatukaroa
20/3	Nasoni	20/5	Savusavu

The Vaturova, Nasoni and Vatukarova catchments are narrow strips 8 km (5 mi) wide between the coast and the main chain of hills forming the north-west watershed. The Savusavu catchment is wider, and is joined on the south-east to the Natewa Peninsula.

The catchments are in the Savusavu, Vaturova and Sanggani tikinas of Thakaundrove Province.

CLIMATE

Along the coast the climate has a moderate dry season and a mean annual rainfall of 2 540 – 4 060 mm (100 - 160 in). Inland as the land rises the climate changes to one having a very weak or no dry season and heavy rainfall of more the 3 810 mm (150 in) per year (zone F). The broad tract of land between Savusavu Bay in the west and Natewa Bay in the east has an intermediate climate with a weak or very weak dry season and moderate rainfall (zone E). The mean monthly rainfall for Nathekoro (Savusavu airport) is given below. The station is in the moderate dry season belt as can be seen from the rainfall figures for the May to October period.

TABLE 23 Mean monthly rainfall figures in millimetres and inches

Location	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
mm													
Nathekoro	351	274	267	309	163	100	95	105	164	111	245	179	2 369
in													
Airfield	13.85	10.82	10.54	12.18	6.45	3.94	3.75	4.16	6.46	4.39	9.66	7.06	93.28

The mean monthly maximum temperature falls from 30.2°C (86.4°F) in February to 26.4°C (79.5°F) in August, gradually rising thereafter to reach its former level. The mean monthly minimum temperature follows the same pattern with a high of 23.8°C (74.8°F) in January and a low of 21.1°C (70.0°F) in August.

The mean monthly relative humidity, taken at 0600 hours, over a 6 year period shows a maximum of 92.5% in March, 82.2% in August, and 85.6% in December.

Winds come from the south-east in all months, but, during the wet season from November to March, they are more variable with some coming from the north-east.

GEOLOGY

Breccias, flows, grits and tuffs of the Natewa Volcanics Group composed of basic andesite to basalt rock underlie most of the area. Areas of Undu Volcanics comprising flows and tuffs of rhyolite to dacite occur around Sanggani and inland from Vanuavou.

LANDFORM AND SOILS

Most of this area consists of high land falling steeply to the sea from an elevation of over 914 m (3 000 ft) in the west and 549 m (1 800 ft) in the east to sea-level in a distance of under 8 ki (5 mi). The Savusavu catchment has two rivers and a considerable area of moderately sloping ground in the south. In the north along the watershed it resembles the other three coastal catchments. A repeating pattern of landform which correlates with the soil and vegetation cover occurs along the Natewa Bay coast. The rivers flow in a short flat alluvial plain having poor drainage, and either planted with coconuts or covered by grass. Either side of the rivers and parallel to the coast are broad saddles of moderately sloping land with deep humic latosols and a cover of forest. Inland from these the steeply rising land with slopes of 40^{o}-50^{o} is broken by a series of gullies. The soil is shallow above hard rock. The vegetation consists of either open canopy woodland with small trees, shrubs and some reed or low closed canopy forest with a moderate stocking.

Nailoca steepland bouldery clay (83e), a strongly weathered humic latosol of low base status, is the most widespread soil type occuring in the steep forest covered slopes. It shows 15 cm (6 in) of reddish brown friable stony clay on 20 cm (8 in) of red brown friable clay with a few stones overlying rubbly clay containing must decomposing tuff and agglomerate. Soils of the Sote soil suite occur on the broad saddles of moderately sloping country. These have similar profiles to that described above but tend to be deeper. Twyford and Wright (1965) have mapped the shallow black soils that occur on the very steep slopes under an open canopy of trees and shrubs as nigrescent soils. These soils were sampled in the Vaturova catchment and found to consist of 30 cm (12 in) of black loam above hard rock impenetrable with an auger. They are better described as lithosols. Nigrescent soils occur under the mixed shrub and grass on moderate slops in the Savusavu area. Recent alluvial soils are found in the valleys of the main rivers.

VEGETATION

Closed canopy tropical rain forest covers the steep and moderate slopes except for a narrow coastal fringe where the forest has been destroyed. Savusavu has patches of forest in the centre and along the northern hill range. The type of forest ranges from well stocked mixed species forest on the hills of the Vatukaroa catchment to the partially closed canopy forest that covers much of the Savusavu area.

Mixed shrub and grass occur along the coast inland of the strip of coconut plantations. Shrubs and grass extend in a series of semi-circles, emanating from the main villages of Sese, Lakemba, Mbiaungunu, Vanuavou, Korotasere and Viunandi. In the Savusavu catchment mixed shrub and grass occur up the Tambia and Mariko Creeks and break the forest into a mosaic along the southern and western coast. Mangrove is not common but occurs in the deltas of some rivers such as Lakemba and Nainggalonggaloyanga and in thin strips along the shore.

POPULATION AND LAND TENURE

The population of the area is 7 408 persons of whom 5 534 are Fijian, 1 068 are Indian and 806 are of other races. The Fijians live in 58 villages mostly along the coast, but with one or two inland beside rivers. The Indian population is concentrated in the Savusavu catchment, particularly in Savusavu town. The group of other races is confined to the Savusavu area.

It is likely that past population has modified the vegetation in the Savusavu catchment and in the vicinity of Mbiaungunu in the Vatukaroa catchment. In the Savusavu catchment 17 old village sites are marked on the Native Land Commission maps prepared between 1921 and 1936. Four of these sites are beside the upper Mariko Creek and four beside the Tambia Creek. Only two lie on the coast. Peter France in his book *The Charter of the Land* (France, 1969) quotes the tribal history for a *yavusa* in Savusavu and describes how the people took to the hills and returned to the lowlands as the changes in the fortunes of their chief dictated. Such population movements with clearing of new gardens and village sites, subsequently abondoned, would tend to destroy more of the forest than would be needed for shifting cultivation, withou the threat of war.

The forested land from the watershed to within about 2.4 ki (1.5 mi) from the coast is under Fijian ownership and not in Native Reserve. Freehold land given over primarily to coconut plantations lies along the western and southern shores of Vanua Levu and occurs along the Natewa Bay coast at Navorau, Warikamba, Serua, Wainotu, Natasa and Vatukaroa. These estates date from the earliest times of European settlement prior to cession. Native Reserve, in a strip about

2.4 ki (1.5 mi) wide stretches from Wainingandru in the north to Nasinu at the corner, filling in the coastline that is not freehold land. Native Reserve also extends up the Savundrondro, Mariko and Tambia Rivers in the Savusavu catchment and the Nainggalonggaloyanga Creek in the Vaturova catchment.

PRESENT LAND USE

Coconut production is the most important form of livelihood for the people in this area. The plantations fringe the coast line and extend up the main rivers. There is a very small area of young coconut plantation in the vicinity of Savusavu town and small isolated plantations near villages. Rice is grown at Vanuavou and on the Tambia River floodplain near Vunindongoloa. Subsistence crops of taro, cassava and yam are grown on the river flats and in clearings in the forest near the villages. The people of the coastal villages catch fish in Natewa Bay which is deep and has good game fishing.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

No enumerations or reconnaissance surveys have been carried out by the Forest Department in this area.

EXPLOITATION PAST AND PRESENT, AND SAWMILLS

The forest area is under option to Fiji Forest Industries. There is no exploitation going on at present and no sawmills exist in the area.

PLANTATION SPECIES AND AGE CLASS

No plantations exist in the area.

EXISTING ACCESS ROUTES

Main roads follow the coast on 3 sides of the Savusavu catchment. From the south-east corner of the catchment the Hibiscus Highway follows the southern coast of the isthmus to serve the Natewa Peninsula. At Nathavanandi a branch of this road leads north to follow the east coast as far as the Tambia River. A branch road follows up the Mariko River to beyond the village of Korosi. A short road goes east from Savusavu following the Savundrondro River.

None of the rivers is navigable for any length and are not a useful means of access.

Tracks crossing the main ridge from the north side of the island go to Nakuku and Vuinandi from the Koroutari felling area and from Satulaki to Vunindongoloa. A track runs from Nayarambale to Seavathi and Korotasere. From Nathula in the Nasavu catchment tracks run to Mbiaungunu and Lakeemba. In the Savusavu catchment paths connect Mbuthalevu in the east with Savusavu on the west coast and Nakawanga in the Nasekawa catchment.

THE ENUMERATION

LAYOUT OF SURVEY

All the catchments have only had reconnaissance lines cut to sample the high potential forest types. In the Savasavu catchment 3 lines were cut in an approximately north-east direction to sample the forest that lies between the Savundrondro and Mariko Creeks, the Mariko and Tambia Creeks and east of the Tambia Creek. In the Vaturova catchment two lines were cut, one from the

Vaturova Creek in a south-westerly direction and one in a north-westerly direction from near Nakarambo. In the Nasoni catchment 3 lines were cut in a north-westerly direction, one from near Navetau, one from between the Nasoni and Ndawato Creeks and one just east of the Nathombothombo Creek. Similarly 3 lines were cut in the Vatukaroa catchment in a north-westerly direction from near the coastal villages of Namboutini, Sese and Natuvu.

TIMBER VOLUMES

Enumerated areas for the forest types are given by management category in Table 24. From this it can be seen that the area of well stocked forest is small although there is a considerable area of moderately stocked forest.

The volume in the enumerated part of the production forest is 144 000 m^3 (48 million Hsl ft).

As already mentioned in the section above only reconnaissance lines were cut and none of the catchments had a complete layout of lines. Percentage error in the production forest for the Vatukaroa catchment is 21% which is reasonable but for Savusavu, Vaturova and Nasoni it is either not calculable or very high. Since the production forest is not of high potential in these catchments the high error figure does not invalidate the total volume figure for Fiji. On the other hand, if exploitation is considered, a new inventory could be carried out. The results are summarised by management categories in Table 25.

TABLE 24 Enumerated areas of forest types in the Natewa Bay Catchment Group (ha)

Forest type	Savusavu	Vaturova	Nasoni	Vatukaroa	Total enumerated area		% of enumerated forest
					ha	ac	
J	175	136	744	303	1 358	3 356	16
S	436	222	520	273	1 451	3 585	17
Non-commerical	611	358	1 264	576	2 809	6 941	33
C1	-	-	113	725	838	2 071	10
G	255	782	667	789	2 493	6 160	30
GV	199	-	-	-	199	492	2
Production	454	782	780	1 514	3 530	8 723	42
B	-	-	-	56	56	138	1
CS	776	498	400	281	1 955	4 831	23
Protection	776	498	400	337	2 011	4 969	24
Total					8 350	20 633	

TABLE 25 Volume of timbers from trees over 40 cm d.b.h., species group 1-4, reliable minimum estimate and percentage errors by catchment and management category, Natewa Bay Catchment Group ('000 m^3)

Management and Catchment	Volume >40 cm s.g.1-4	Sampling error 40 cm s1g.1-4	Degrees of freedom	Confidence limits p<0.05	r.m.e. p<0.025	% error	Volume 40 cm s.g.1-4 (million Hsl Ft)
Non-Commercial							
Savusavu	1	<1	5	1	0	80	-
Vaturova	1	-	0	-	-	-	-
Nasoni	10	2	4	5	5	50	3
Vatukaroa	3	1	3	2	1	73	1
	14				6		4
Production							
Savusavu	15	-	1	-	-	-	5
Vaturova	43	4	1	51	0	<100	14
Nasoni	20	3	3	9	11	46	7
Vatukaroa	66	5	4	14	52	21	22
	144				63		48
Protection							
Savusavu	30	8	1	103	0	>100	10
Vaturova	24	3	2	32	0	>100	8
Nasoni	14	2	1	22	0	>100	5
Vatukaroa	14	4	2	15	0	>100	5
	83				0		28

DESCRIPTION OF FOREST TYPES

Total volumes are given by forest type in Table 26.

Forest types J, S, G, C1 and CS are important and will be discussed here:-

Type J: Low-stocked fringe forest

This type occurs on the fringe of the non-forest area all the way up the coast. It is widespread in the Nasoni catchment where it lies either side of the Nasoni River on gentle to moderate sloping country.

The forest type has a closed canopy and reaches a height of 17 m (55 ft). Most of the trees are below 35 cm d.b.h. Of the useful species, *kauvula*, *kaudamu*, *sa* and *sasauwira* are common with stockings of 1 to 3 m^3/ha (135-404 Hsl ft/ac) and *koka* and *doi* are locally common. The species that do not reach 35 cm d.b.h. (14 in) include many species of the genus *Ficus (Ficus vitiensis, F.begoniifolia)* and *Allstonia spp.*, *Macaranga spp.* and *Pagiantha thurstonii*.

The stocking in these catchments ranges from 0 to 16 m^3/ha (2 156 Hsl ft/ac).

Type S: Low-stocked open woodland

Forest type S lies between the fringing forest on the moderately sloping ground and the forest-covered steep slopes. In the Savusavu catchment it occurs on the forest margin. This forest type includes a certain amount of land that should be protection forest but it is not possible to subdivide it.

The forest consists of trees and shrubs 10 to 13 m (33 - 43 ft) high with approximately 50% canopy closure. In between the trees are reeds *(Miscanthus)* and hill bamboo *(Schizostachyum)*. Trees and shrubs of the Euphorbiaceae family are common. As some collection of botanical specimens

was carried out in the Vaturova catchment in this type a species list is given below. Common short-boled trees are *koka (Bischofia javanica)*, *doi (Alphitonia sp.)*, *kaudamu (Myristica sp.)* and *Anacalosa lutea*.. Shrubs include the following: *sisisi (Girronniera celtidifolia)*, *Allstonia vitiensis*, *Macaranga seemanii var. seemanii*, *M.secunda*, *yaro (Premna taitensis)*, *Melochia vitiensis*, *Symplocos leptophylla* and *Claoxylon parvicoccum*. In areas with a denser canopy cover small trees rising to a height of about 13 m (43 ft) and with diameters of

TABLE 26 Total volumes and sampling errors of forest types in Natewa Bay Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
Savusavu							
J	0	0	0		-	-	Non-
S	2	2	1	<1	-	2	Commercial
			1	<1	-	2	
G	17	16	12	-	4	47	Production
GV	6	5	3	-	1	15	
			15	-	5	33	
CS	42	36	30	8	10	39	Protection
Vaturova							
S	3	3	1	0	-	5	Non-
J	0	0	0	0	-	-	Commercial
			1	-	-	3	
G	63	52	43	4	14	55	Production
CS	36	30	24	3	8	48	Protection
			24	3		48	
Nasoni							
J	15	12	6	1	2	8	Non-
S	10	9	4	2	1	8	Commercial
			10	2	3	8	
G	30	27	15	3	5	22	Production
C1	8	7	5	1	2	44	
			20	3	7	26	
CS	20	18	14	2	5	35	Protection
Vatukaroa							
J	<1	<1	0	0	0	-	Non-
S	4	4	3	1	1	11	Commercial
			3	1	1	5	
G	27	23	15	3	5	19	Production
C1	82	73	51	5	17	70	
			66	5	22	44	
B	0	0	0	0	0	-	Protection
CS	19	17	14	4	5	50	
			14	4	5	42	

from 20 to 40 cm (8 - 16 in) are found. They include *kuluva (Dillenia biflora)*, *sama (Commersonia bartramia*, *sasauwira (Dysoxylum richii)*, *Makosoi (Cananga odorate)* and *kaudamu (Myristica* spp).

The soil is a dark brown lithosol with about 30 cm (12 in) of loam above stones. Auger penetration is impossible below about 100 cm (39 in).

It seems likely that forest type S occurs in areas that have been cleared for cultivation in the past. The high density of old village sites and peripatetic nature of life in the old days have led to a deterioration in the forest cover. Regrowth of the forest has been slow due probably to some erosion on the steep slopes and to the drier climatic zone of this area. Aspect plays a part in the regrowth of the forest, north and north-east facing slopes tending to be less well-clothed in forest than other slopes.

Type G: Moderately stocked mixed forest on moderate to steep short slopes

Forest type G covers nearly 7 000 ha (17 297 ac), which is 20% of the forest cover. In the Savusavu catchment, the forest type is similar to C1 with a stocking of 4 m^3/ha (539 Hsl ft/ac) of *dakua salusalu*, 5 m^3/ha (674 Hsl ft/ac) of *damanu* and 6 m^3/ha (809 Hsl ft/ac) of *yasiyasi*. Vaturova's forest type G has the astonishingly high stocking for *kaudamu* of 34 m^3/ha (4 582 Hsl ft/ac) compared with a stocking of about 7 m^3/ha (943 Hsl ft/ac) in the other catchments. The Nasoni catchment has a high stocking of *dawa* of 7 m^3/ha (943 Hsl ft/ac) which is unusual and, since *dawa* has an edible fruit, suggests past habitation. The oversall stocking ranges from 29 m^3/ha (3 908 Hsl ft/ac) in the Vatukaroa catchment through 40 (5 390) in the Nasoni catchment to 66 m^3/ha (8 894 Hsl ft/ac) in the Savusavu and Vaturova catchments respectively.

Type C1: Well stocked mixed forest on moderate to steep short slopes

This occurs in the Savusavu, Nasoni and Vatukaroa catchments covering an area of nearly 2 000 ha (4 942 ac) or 6% of the forest cover. The only large single area occurs on the western side of the Vatukaroa catchment in the northern half.

Here the forest contains *dakua makadre* (8 m^3/ha, 1 078 Hsl ft/ac), *dakua salusalu* (1 m^3/ha, 135 Hsl ft/ac), *kaudamu* (12 m^3/ha, 1 617 Hsl ft/ac), (10 m^3/ha, 1 348 Hsl ft/ac) and *kauvula* 6 m^3/ha, 809 Hsl ft/ac) showing that the forest is well stocked. *Damanu* has a low stocking of only 4 m^3/ha (539 Hsl ft/ac). The overall stocking is 100 m^3/ha (13 476 Hsl ft/ac) for trees over 40 cm d.b.h.

Type CS: Moderately stocked forest on long very steep slopes

This forest type occurs in all the catchments over an area of about 5 000 ha (12 355 ac) covering 15% of the forest cover. The type is found on the steep hills that rise up to the watershed and has a low canopy made up of big trees with short boles and spreading crowns.

Species composition includes a stocking to 2 to 5 m^3/ha (270 - 674 Hsl ft/ac) of *dakua makadre* and 2^3m /ha (270 Hsl ft/ac) of *dakua salusalu*. *Damanu* has a stocking of 6 to 12 m^3/ha (809 - 1 617 Hsl ft/ac). The overall stocking ranges from 45 to 60 m^3/ha (6 064 - 8 086 Hsl ft/ac) of trees over 40 cm d.b.h.

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

The best production forest is in the Vatukaroa catchment at the northern end of the group. With 66 000 m^3 (22 million Hsl ft) of standing timber this forest could either be exploited as one unit with a sawmill located on the coast at either Sese or Lakemba, or the logs could be loaded into barges on the coast and drawn by tug to Lambasa.

PROPOSED ACCESS ROUTES

With the exception of the northern end of the Vatukaroa catchment, the forests of these catchments do not merit the building of a road either along the coast from Vunindongoloa or across the island from the north. If a road were to be built for other reasons, some pockets of forest rich in *kaudamu* would be worth exploiting.

PROPOSED TREATMENT OF FOREST TYPES

Non-commercial forest The total area of non-commercial forest is 15 500 ha (38 300 ac) which is 45% of the forest cover. A certain amount of the forest type S should be included in protection forest. The high proportion of poor quality forest seems to be due to cultivation in the past coupled with adverse conditions of climate and topography. Aspect too plays a part in determining the rate of regrowth. There seems nothing that can be done with these forest types at the present time. Plantations of forest trees or enrichment planting should not be undertaken until the reasons for the poorness of these forest types are known.

Production forest Production forest covers 33% of the forest cover and is mostly forest type G. This type has a variable stocking with a high proportion of *kaudamu* and not much *dakua* or *damanu*. It seems likely that this kind of forest will not attract exploiters in the near future as they are more interested in the softwood species (*dakua*) and the decorative hardwoods. The forest that lies west of Lakemba and Sese has a high potential having a reliable minimum estimate of nearly 60 000 m^3. (20 million Hsl ft).

Protection forest The area of protection forest is 7 500 ha (18 535 ac) which is 22% of the forest cover. This is made up mostly of forest type CS which has a stocking of about 60 m^3/ha (8 086 hsl ft/ac).

It seems likely that forest type S is the result of clearing forest in this type of country and that the shallow soil may in part be due to soil erosion following clearing. The population responsible for this clearing lived in the period prior to cession, possibly even prior to the entry of Europeans who brought with them so much illness and death. Clearing forest from these steep hills is not recommended.

PART 9. THE NASAVU AND VUNIVIA CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The Nasavu and Vunivia catchments lie at the extreme eastern end of Vanua Levu. The Nasavu River flows from south to north across the island rising very near the southern coast. The Vunivia catchment includes Undu Point.

The Nasavu catchment is divided in the middle and the Vunivia catchment along the watershed into Dongotuki Division in the north and Sanggani in the south of Mathuata and Thankaundrove Provinces respectively.

CLIMATE

The southern part of the area has a high rainfall and a very weak dry season. The highest rainfall 3 810 - 4 450 mm (150 - 175 in) falls on the southern and western watersheds of Nasavu catchment with rainfall tailing off towards the north-east. Thus the southern half of the Nasavu catchment has an annual rainfall of 3 180 - 3 810 mm (125 - 150 in) and the northern half has 2 540 - 3 180 mm (100 - 125 in) spreading out eastwards as far as Wainika Bay on Undu Point. The northern shoreline and eastern tip of Undu Point has an annual rainfall of 2 290 - 2 540 mm (90 - 100 in). Mean monthly rainfall figures are given in Table 27 for Vunikondi on the north coast of Undu Point. For boundaries of the climatic zones see Text Map 5, Volume 1.

TABLE 27 Mean monthly rainfall figures in millimetres and inches

location	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year
mm													
Vunikondi	282	296	283	255	122	117	86	124	141	139	326	248	2 420
in													
Vunikondi	11.12	11.66	11.13	10.04	4.82	4.60	3.38	4.87	5.57	5.48	12.82	9.76	95.29

The relative humidity at Vunikondi ranges from a high of 87% in January to a low of 80% in July. The annual mean relative humidity for Vunikondi is 84.5%.

The monthly mean maximum temperature ranges from 29°C (84°F) in January, February and March to 27°C (81°F) in June, July and August and rises gradually to reach 29°C (84°F) again in December. The montly mean minimum follows the same pattern falling from 24°C (74°F) in January to 22°C (72°F) in June, July and rising again to 24°C (74°F) in December.

GEOLOGY

Breccias, flows, grits and tuffs of the Natewa Volcanics Group underlie the southern and part of the western hill ranges, which form the watershed of the Nasavu catchment. The Vunivia catchment and the northern half of the Nasavu catchment are underlain by rocks of the Undu Volcanics groups. They form a sequence from south to north consisting of the Nasavu flows and tuffs, the Vunivia breccias and flows and the Malau formation of re-worked pumiceous sediments (Rickard, 1966)

LANDFORM AND SOILS

The Nasavu River flows in a wide open valley with gentle and moderate slopes nearly to the watershed. Long, very steep slopes occur along the western watershed spreading down to near the junction of the Valovoni and Nasavu Rivers. Very steep hills underlain by Vunivia Breccias occur along the northern watershed and in the north-east adjoining the Vunivia catchment. In the north-west of the Nasavu catchment, west of Vitina and Rauriko villages, lies an area of short, steep country underlain by Nasavu Dacite with no great rise in elevation from the river to the watershed. Here red-yellow podsolic soils have developed with a characteristic type of forest.

The Vunivia catchment is made up of steeper country than the Nasavu catchment. Expanses of moderately sloping country occur around the upper Vunivia and middle Vunivia Lailai Rivers, which are surrounded on all sides by steep hill masses. The Undu Peninsula is a narrow hill range falling steeply to the sea on the south side with a discontinuous shelf of flat land on the north side.

The main groups of soils are the humic latosols developed over the basic Natewa volcanic rocks in the south and the red-yellow podosols developed over the more acid rocks of the Undu Volcanics in the north. The boundary which seems to correlate with the vegetation occurs along an east-west line through Rauriko.

The widespread steepland humic latosol is Nailoca steepland bouldery clay (83e) a strongly weathered humic latosol of low base status. It is derived from basic andesites and shows 15 cm (6 in) of reddish brown friable stony clay on 20 cm (8 in) of red brown friable clay with a few stones overlying varicoloured rubbly clay containing much decomposing tuff and agglomerate. Auger points dug during the inventory agreed with this description of Twyford and Wright (1965). Closely allied to this soil and found on the easier slopes is Solevu clay loam and silty clay loam (27e). This soil type resembles Nailoca steepland soil but has no included matter in the surface horizon.

Nigrescent soils were mapped by Twford and Wright lying south of Nathula village. Although on the very steep slopes these proved to be lithosols, some profiles confirmed Twyford and Wright's description for Valovoni steepland soils (68b). They show 20 cm (8 in) of very dark grey friable to firm clay on 15 cm (6 in) of reddish yellow grading to pale brown, stony gritty firm clay, on pale brown stony and bouldery sandy clay.

The red yellow podsolic soils have been mapped as Dogotuki hill soils (40cH) and the rolling hills and Rauriko steepland stony sandy clay (92e) on the steep slopes. The former is described by Twyford and Wright as 10 cm (4 in) of black grading to dark brown, friable sandy clay, of moderately developed coarse nutty structure, on 20 cm (8 in) of dark brown friable fine sandy clay, with a weakly developed coarse and medium nutty structure, on 10 cm (4 in) of red friable clay slightly mottled riddish yellow, resting on 20 cm (8 in) of strong brown firm clay containing lumps of tuff. Auger points in this soil type dug along line 9 in the course of the survey showed soils with pale colours, pale red, pale yellow or pink, which did not reflect the topographic position, a loose consistence and weak structured grade. They are easily differentiated from humic latosols.

VEGETATION

Closed canopy tropical rain forest covers most of the area. In the south of the Nasavu catchment the forest is broken up by patches of partially closed canopy forest and poorly stocked low fringing forest. Throughout the southern half of the catchment the forest is for the most part moderately stocked with a high proportion of sa *(Parinari insularum)*. In the northern half the forest changes to an open forest dominated by *velau* and *yaka* on the ridges with broad-leaved species on the lower, middle and upper slopes. The Vunivia catchment has well stocked broad-leaved forest, which looks as though it has not been disturbed. Species of the family Sapotaceae are common.

Mixed shrub and grass occur in small areas near to villages. The areas tend to be large in the north where the strong dry season allows the vegetation to burn. Dry season effects are exacerbated by the lighter texture of the red-yellow podsolic soils.

A block of mixed shrub and grass occurs at the sharp bend in the Nasavu River north of Rauriko. Here erosion is taking place from continued burning. *Yaka* forms dense thickets at the edge of this area. The tip of the Undu Peninsula is covered with mixed shrub. This land is freehold and may have been cleared for coconut planting in the past.

Mangrove occurs along the north coast notably at the mouths of the Nasavu and Vunivia Rivers.

POPULATION AND LAND TENURE

A total of 1 848 people live in the area of whom 1 724 are Fijian, 31 are Indian and 93 are of other races. With the exception of Valovoni, Nathula, Vitina and Rauriko all the villages lie on the coast. Valovoni and Nathula lie at the southern end of the Nasavu catchment on the Valovoni and Nasavu Rivers respectively. Vitina and Rauriko lie on the Nasavu River about 10 km (6 mi) from its mouth.

There is a tendency throughout Fiji for the inland villages with no means of communication to become depopulated, whereas villages either on the coast, beside a main road or a navigable river tend to increase or maintain their populations. The accompanying Table 28 shows that the populations of the two coastal villages, Sanggani and Mbiaungunu, have increased since 1911 whereas those of the three inland villages have barely changed.

TABLE 28 Comparison of population figures for inland and coastal villages

Village	Census year			
	1911	1921	1956	1966
Sanggani*	20	37	81	117
Mbiaungunu*	74	76	113	109
Valovoni	62	49	36	44
Nathula	29	20	21	37
Nandongo*	33	35	44	42

* Not in this catchment group.

The nature of the vegetation cover however suggests that there was a much greater population inland in the past. This is indicated by species composition, low stocking and areas with partial cover. In many places the partial cover coincides with deserted village sites on the Native Land Commission maps, made between 1928 and 1936. According to the village head of Nathula, both Nawi and Vuniwai were deserted in 1907. The geologist Guppy in 1896 visited Nawi and stayed at Tembe on the western watershed near the hill Nailotha (Guppy, 1903). Five of the 6 village sites in Nasavu catchment fall in modified, partially closed canopy forest.

In the Nasavu catchment most of the forest is under Fijian ownership but not Native Reserve. In the Vunivia catchment the whole of the Undu Peninsula is under Native Reserve except the extreme tip which is freehold land. Native Reserve lies beside the Nasavu River in the vicinity of Rauriko and Vitina and again a small block surrounds Nathula and Valovoni. Another block lies to the west of the Nasavu River between the Naruru and Savurambarua Creeks. Apart from that at the tip of Undu Point, freehold land occurs to the east of the mouth of the Nasavu River and beside the Nasavu River in a small rectangular block called Ndreketi. Only one area of Crown land occurs and this lies to the west of the Nasavu River between Naruru and Nasauvou Creeks extending as far as the watershed.

This land tenure pattern shows similar tendencies to other areas with freehold land on or near the coast, where coconut plantations were possible. These areas were probably alienated before cession in 1874. Native Reserve occurs on all the land the Fijians are likely to use and Crown land exists where all member of a *Matanggali* or clan have died or disappeared.

PRESENT LAND USE

The Fijians derive their main source of income from coconut plantations, which occur along the coast and beside the inland villages. Coconuts do not flourish on the low fertility humic latosols that are found near to Nathula. Here the trees are short, yielding small bunches of small fruit. New planting of coconut are not extensive, the area of greatest activity being the north side of the Undu Peninsula.

Taro, *yaqona* and cassava are grown near the villages in small clearings. The area of cleared forest is not extensive.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

There has been one enumeration in the southern part of the Nasavu catchment and two interesting reconnaissance trips have taken place. The first was by J L d' Espeissis in 1941. He recognised a dry forest below Vitina in contrast to the rain forest to the south. He also walked about in the area of the Vunivia and Mbourewa Rivers and thought that the forest there was untouched. He recommended reservation for the dry forest to preserve it from cutting and burning. The second report is unsigned and dated February 1955. The route taken was along the lower Nasavu River and the coast round Undu Point. Diversions were made into the dry forest on both sides of the Nasavu River near Rauriko, where the main preoccupation seems to have been with *yaka* regeneration. A trip from Ndongotuki to Kendra and Tawake took in the lower Vunivia reaches but missed the well stocked forest that lies further south.

The only enumeration was carried out by J G Croome and Associates, Forestry consultants working for Fiji Forest Industries. They covered the southern half of the Nasavu catchment with a pattern of lines radiating from previously selected base camps. The figures for their enumeration are not available but their forest type map agrees broadly with that produced by this survey.

EXPLOITATION PAST AND PRESENT

This area like most of the rest of Vanua Levu is under option to Fiji Forest Industries. Except for a little pit sawing and extraction of *buabua* poles there has been no exploitation in this forest.

SAWMILLS

There are no sawmills in the area.

PLANTATION SPECIES AND AGE CLASS

No plantation or trial plots have been made in the area.

EXISTING ACCESS ROUTES

The main road from Lambasa travels up the northern side of the island turning due north near Nasasa village to follow the Wainikoro River. It crosses this river and stops at Numbu at the edge of the cane-growing area. This is the nearest that the road gets to the survey area with the result that the traveller must continue on foot either from Nasasa or Numbu.

The best acces to this area is by water along the coast and up the Nasavu and Vunivia Rivers. The Nasavu River is tidal as far as Vitina and navigable for 20 ton cutters to Rauriko. It is navigable by flat-bottomed punt with an outboard motor to the Naruru Creek (line 6,) about halfway between Vitina and Nathula. Sharks are common in the river and small ones were seen

in a pool above Titina. The Vunivia River is navigable by outboard motor punt for 3.2 km (2 mi) from its mouth at high tide and the Vunivia *lailai* (little Vunivia) for about 0.8 km (0.5 mi) beyond its junction with the Vunivia.

Nathula can be reached from Nasasa by a well graded footpath which goes in an easterly direction passing over the catchment boundary north of the Nailotha peak. An alternative route is to go from Nasasa to Nandongo and then turn east reaching Nathula through Valovoni. Paths connect Nathula with the north side of Natawa Bay going south-east to Mbiaungunu and east to Lakemba. Coconuts are carried along these paths for drying and shipment. The walk from Mbiaungunu to the watershed is steep but the gradient in the Nasavu catchment is easier. A path runs north beside the Nasavu River linking Nathula with the navigable river below Vitina. Rauriko is connected to Numbu by a path which runs east-west. Another track joins Ndongotuki, at the mouth of the Nasavu River, with Kendra and, across the Undu Peninsula, with Tawake.

THE ENUMERATION

LAYOUT OF SURVEY

The base line was chosen following the line of the upper Nasavu River, which runs parallel to the Vunivia River. Although the two catchments were originally combined they were computed separately because the Vunivia forest seemed different in nature to that found in the Nasavu catchment.

Lines were cut at right angles to the base line leaving gaps in line 3 to exclude broken forest cover, the dry forest type west of Vitina and the steep hills at the extreme northern end of both catchments. Both the dry forest and the steep hills were sampled by lines 9, 20 and 21.

TIMBER VOLUMES

Enumerated areas covered by the forest types in the 2 catchments are given in Table 29.

TABLE 29 Enumerated areas of forest types in the Vunivia and Nasavu Catchment Group (ha)

Forest type	Vunivia	Nasavu	Total enumerated area		% of total area
			ha	ac	
J	-	564	564	1 394	3
GD	54	1 621	1 675	4 139	8
S	74	1 120	1 194	2 950	6
V	-	113	113	279	1
Non-commercial	128	3 418	3 546	8 762	18
C1	2 019	3 141	5 160	12 750	26
E	-	270	270	667	1
G	210	4 612	4 822	11 915	24
Production	2 229	8 023	10 252	25 332	51
B	32	180	212	524	1
BS	-	283	283	699	1
CS	1 446	2 634	4 080	10 082	21
GSS	864	648	1 512	3 736	8
Protection	2 342	3 745	6 087	15 041	31
Total			19 885	49 135	

The forest types that cover extensive areas are GD, C1, G, CS and GSD. Forest type GD and GDS were not fully covered by the enumeration because they were not thought to be production forest types. As a result the enumerated area is much smaller than the total area.

The timber volumes of the forests of these two catchments are summarised in Table 30.

Table 30 Volume of timber from trees over 40 cm d.b.h., species groups 1-4, reliable minimum estimate and percentage errors by catchment and management category, Nasavu and Vunivia Catchment Group ('000 m^3)

Management and Catchment	Volume ≥40 cm s.g. 1-4	Sampling error >40 cm s.g. 1-4	Degrees of freedom	Confidence limits p<0.05	r.m.e. p<0.025	% error	Volume 40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Vunivia	3	-	2	1	2	33	1
Nasavu	70	9	20	19	51	27	23
	73				53		24
Production							
Vunivia	172	17	3	54	118	31	57
Nasavu	298	17	15	35	263	12	99
	470				381		156
Protection							
Vunivia	135	6	6	15	120	11	45
Nasavu	115	14	17	30	85	26	38
	250				205		83

The total timber volume in the production forest is 470 000 m^3 (156 million Hsl ft) with a Reliable Minimum Estimate of 381 000 m^3 (127 million Hsl ft). Of this 118 000 m^3 (39 million Hsl ft) are in the Vunivia catchment and 263 000 m^3 (88 million Hsl ft) in the Nasavu catchment. The non-commercial forest has a r.m.e. of 53 000 m^3 (18 million Hsl ft) and the protection forest 205 000 m^3 (68 million Hsl ft).

The sampling error percent for the production forest of the Nasavu catchment is low (12%), but high for Vunivia (31%) because of the few lines. The errors for non-commercial and protection forest are, in general, high because these categories were insufficiently sampled.

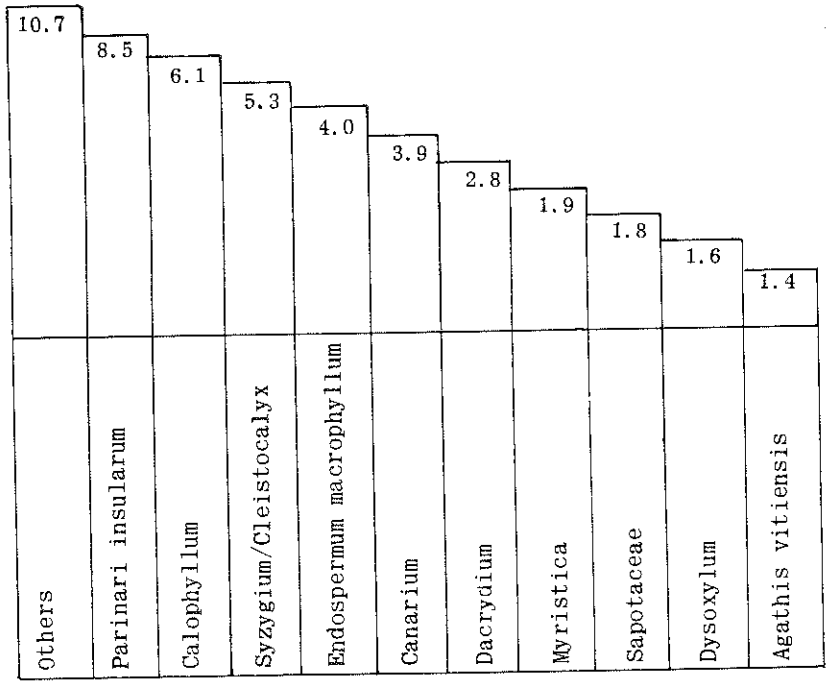
DESCRIPTION OF FOREST TYPES

In Table 32 the forest types are shown by management categories for the catchment together with the timber volumes, sampling errors, areas and stocking. The forest types that will be discussed more fully below are GD, C1, G, CS, and GDS.

Type GD: Moderately stocked *velau-yaka* dry-zone forest

This forest type has been described in broad terms in Part 3, Volume 1 'Description of the Forest Types'. The histogram below shows the stocking of the individual species. 'Others' include *velau* as well as species like *Pagiantha thurstonii, Elaeocarpus storckii* and *dulewa (Xylopia pacifica)*.

TABLE 31 Histogram showing volumes (m^3/ha): forest type GD



Three species of *yasiyasi* were present in this forest type, all three having trees over 35 cm d.b.h. They were *Syzygium rubescens* var. *rubescens*. *S. nidie* and *Cleistocalyx eugenioides*. Trees that are noticeable but do not have a high stocking are *buabua*, *duvula* and *vesi*. The *kauvula* in this kind of forest is *Endospermum macrophyllum* and not *E. robbieanum* which is the more usual species in the forests of Vanua Levu.

This forest type lies over red yellow podsolic soils of low fertility as described in the section 'Landform and Soils'.

The forest type is described as a dry-zone forest type on the basis of the severity and the length of the dry season. This part of Vanua Levu has a dry season of 6 months when the monthly rainfall is less than 15 cm (6 in).

Type C1: Well stocked mixed forest on moderate to steep short slopes

This forest type occurs in the middle of the Nasavu catchment and occupies the slopes halfway between the river and the watershed. In the Vunivia catchment it occurs on the easier slopes between the upper Vunivia and Vunivia Lailai Rivers. It covers 26% of the enumerated area.

Common trees are *yasiyasi*, *damanu*, *kaudamu*, *kauvula* and *dakua makadre*. The stockings of *sa* and 'others' are high (*sa* has a stocking of 14 m^3/ha (1 887 Hsl ft/ac) in Nasavu catchment). One tree included in 'others' which appears to be common in this area is *Buchanania vitiensis*. The Vunivia catchment contains many species of the family Sapotaceae which are difficult to identify. One interesting species collected called *bausagali* proved to be *Manilkara dissecta;* another species was identified as *Planchonella costata* var. *smithii*.

Type G: Moderately stocked mixed forest on moderate to steep short slopes

This forest type covers 24% of the enumerated area in the two catchments. It occurs in the southern half of the Nasavu catchment in a strip about 3.2 km (2 mi) wide either side of the Nasavu and Valovoni Rivers.

TABLE 32 Total volumes and sampling errors of forest types in the Nasavu and Vunivia Catchment Group ('000 m^3)

Catchment and forest type	Minimum diameter & sp. group (1) 35 cm 1-5	(2) 40 cm 1-5	(3) 40 cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (3)	Management category
Vunivia							
GD	8	5	3	0	1	55	Non-commercial
S	<1	<1	<1	<1	-	5	
Subtotal			3	<1	1	26	
C1	232	201	154	17	51	76	Production
G	20	20	18	0	6	86	
Subtotal			172	17	57	77	
B	1	1	1	0	0	31	Protection
CS	131	116	85	6	28	59	
GDS	59	56	49	0	16	57	
Subtotal			135	6	44	58	
Nasavu							
J	13	8	4	1	1	7	Non-commercial
GD	87	69	42	7	14	26	
S	31	26	21	4	7	19	
V	6	5	3	2	1	27	
Subtotal			70	9	23	20	
C1	303	252	165	15	55	53	Production
E	13	10	3	1	1	11	
G	260	212	130	9	43	28	
Subtotal			289	17	99	37	
B	5	4	2	1	1	111	Protection
CS	137	117	86	14	29	33	
GDS	32	27	20	3	7	31	
bS	9	8	7	0	2	25	
Subtotal			115	14	39	31	

In the Nasavu catchment, the species composition is typical of the type, *sa* and 'others' being the most abundant species with stockings of 12 and 8 m^3/ha, (1 617 and 1 678 Hsl ft/ac) respectively. The group 'others' includes *velau* which is common particularly on the ridges near the river. In the Vunivia catchment, this type has high stockings of *dakua makadre*, *yasiyasi* and *vesi* and a high overall stocking of 94 m^3/ha (12 667 Hsl ft/ac) of trees over 40 cm d.b.h. This high stocking is akin to a C1 forest but this is belied by the photographic appearance of the forest which is typical of type G.

The possibility exists that the forest type G in the Nasavu catchment with a high proportion of *sa* and 'others' represents a stage in succession towards mature forest after a period of clearing for cultivation in the distant past. It is known that more inland villages existed about 100 years ago and if this was the case there must have been more clearing of the forest than exists today.

Type CS: Moderately stocked forest on long, very steep slopes

Forest type CS covers 21% of the enumerated area occurring around the perimeters of the southern half of both the Nasavu and Vunivia catchments.

The type is characterised by a high stocking of 'others' which usually includes *vauceva (Firmiana diversifolia)*, *salato* and *mako* and a high stocking of *damanu*. In the Vunivia catchment the stocking of *damanu* is 30 m^3/ha (4 043 Hsl ft/ac).

Type GDS: Low-stocked dry-zone forest on long very steep slopes

Although it was not sampled extensively this forest type is important on the leeward side of Vanua Levu, occuring on the steep-sided hills that lie at right angles to the coast and separate the alluvial plains.

In the Vunivia catchment it contains 13 m^3/ha (1 752 Hsl ft/ac) of *dakua makadre*, 6 m^3/ha (809 Hsl ft/ac) of *yaka* and high stockings of *bau* and *bauvudi*. In the Nasavu catchment the species composition includes *bau*, *damanu* and *yasiyasi* with *dakua makadra* and *yaka* having stockings of 2 and 3 m^3/ha respectively (270 and 404 Hsl ft/ac).

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

From Lambasa eastwards the forest cover is either on very steep hills where exploitation is impractical or fringing forest too poorly stocked for commercial exploitation. The Nasavu and Vunivia catchments are the only tracts of forest at this end of the island on moderate slopes covering considerable areas. The reliable minimum estimate of timber in the production forest is 381 000 m^3 (127 million Hsl ft). This is for species groups 1-4 and therefore excludes the *sa* and *velau* which have unusually high stockings in the Nasavu catchment.

The well stocked forest of the Vunivia catchment would best be considered together with that of the Nasavu catchment.

PROPOSED ACCESS ROUTES

Two alternative routes exist for access to the southern half of the Nasavu catchment; one is to follow the Nandongo River as far as Nandongo and then go east over the watershed to Valovoni and Nathula. The more direct route, which would tap the stands of forest type C1 near the track, would be to go directly eastwards from Nasasa following the existing path that lies beside the Mbuthakoto Creek. Gradients are steep beside the Mbuthakoto Creek but in the Nasavu catchment they are easier.

The well stocked forest in the Vunivia catchment is blocked from the sea by steep hills. The best access to this forest is from the east in the vicinity of Rauriko. With the lower Nasavu navigable to sea-going ships, rafts of logs could be made up and towed out to a large tub outside the reef or loaded into barges at Rauriko

PROPOSED TREATMENT OF FOREST TYPES

Non-commercial forest Non-commercial forest covers 18% of the enumerated area because these forest types were only partly enumerated. However it covers a considerably bigger proportion of the total forested area. Forest type 9D is only marginally non-productive. The stocking of trees for all 5 species groups is 42 m^3/ha (5 660 Hsl ft/ac) but, when the species group 5 is subtracted, the stocking is only 26 m^3/ha (3 507 Hsl ft/ac). Although *yaka* is present its stocking of only 3 m^3/ha (404 Hsl ft/ac) does not merit cutting just for the *yaka*, many of which are small and branched nearly to the ground.

Twyford and Wright recommended that some forest cover should be kept on this red yellow podsolic soil type which is liable to erosion. An example of severe erosion can be seen at the bend in the Nasavu River below Rauriko (crossed by lin 19). If exploitation were carried out, replanting of pine might be successful on these acid infertile soils.

It would be worth preserving an area of this forest type as it represents a distinct community when compared with the fringing forest or more common mixed species forest.

Production forest Production forest covers 51% of the enumerated area of which 26% is well stocked and 24% moderately stocked. The high proportion of moderately stocked forest in the Nasavu catchment and the high proportion of *sa* mean that this area is not an attractive proposition from the point of view of logging. The production forest in the Vunivia catchment is of a better quality with a high stocking of *damanu, kaunicina* and *yasiyasi*. The reliable minimum estimate of the volume in the production forest in the Vunivia catchment is 118 000 m^3(39 million Hsl ft).

Protection forest This covers 31% of the enumerated area and contains a r.m.e. volume of 205 000 m^3 (68 million Hsl ft) of timber. It is recommended for protection because of the dangers of erosion and excessive run-off. Most of this forest is too steep and inaccessible for economic logging. Selective felling for valuable species such as the *dakua makadre* and *yaka* in forest type GDS is not recommended, because it is the logging skids and tracks that do the damage and because the rock is deeply weathered and crumbling and would erode all too easily if exposed.

PART 10. THE NATEWA PENINSULA CATCHMENT GROUP

THE ENVIRONMENT

LOCATION

The 3 catchments Navonu (28/1) Mbutha (29/1) and Mbangasau (30/1) make up the Natewa Peninsula, which lies to the east of Vanua Levu and is connected to the rest of the island by a narrow isthmus near Savusavu on the south central coast.

Navonu catchment consists of a west-facing coastal hill range with the drainage basin of the Navonu River in the middle. Mbutha is a broader area of land draining to the east and Mbangasau is a coastal strip of steeply rising hills along the south coast.

They fall into 3 administrative divisions: Savusavu, Thakaundrove and Tunuloa of Thakaundrove Province.

CLIMATE

The main range of hills lies in zone D (see Text Map 5), which has a 3 month period with less than 150 mm (6 in) of rain per month and an annual rainfall of 2 540 - 3 300 mm (100-130 in). The eastern part of the peninsula and the south-east promontory have lower hills and fall into climatic zone B with a long dry season and an annual rainfall of 1 948 mm (76 in). Mean monthly rainfall figures for the 3 stations Navonu, Tuvamila and Vunilangi are given in Table 33. Navonu and Tuvamila lie in climatic zone D whereas Vunilangi lies in zone B.

TABLE 33 Mean monthly rainfall figures in millimetres and inches

STATION	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
mm													
Navonu	396	737	249	142	123	108	40	35	52	167	278	218	2 558
Tuvamila	251	342	318	304	156	63	50	89	144	128	250	306	2 402
Vunilangi	258	218	245	251	106	74	77	82	102	113	233	170	1 948
in													
Navonu	15.61	29.03	9.80	5.59	4.83	4.26	1.58	1.37	2.05	6.57	10.95	8.57	100.69
Tuvamila	9.89	13.48	12.52	11.96	6.15	2.49	1.58	3.50	5.67	5.04	9.85	12.05	94.56
Vunilangi	10.15	8.60	9.67	9.89	4.31	2.93	3.04	3.24	4.01	4.44	9.16	6.70	76.71

Most of the Natewa Peninsula is underlain by breccias, flows, grits and tuffs of the Natewa Volcanics Group. The south-east promontory, the part nearest to Taveuni, is underlain by basalts of the Mbua Basalt Group. Narrow strips of sedimentary rock in the form of mudstones, sandstones and tuffs occur along the south and east coast extending inland along the Mbutha River.

LANDFORM AND SOILS

The main chain of hills which trends north-east to south-west runs near the western coast with elevations of over 610 m (2 000 ft) along the Mbutha watershed. Another line of hills runs east-west bending towards the south at the eastern end. Here the elevation is about 457 m (1 500 ft). The Navonu basin forms an embayment in the steep hills on the west coast about 1.6 km (1 mi) from the east coast. Recent uplift has caused down-cutting of previous mature river systems in the upper reaches of the Navonu and Mbutha Rivers (Adams, 1968). A subsidiary volcanic cone exists on the headland east of Viani Bay.

Along the eastern part, the ground rises steeply at a short distance from the coastline, forming a barrier to inland agricultural development.

The hill soils have been mapped by Twyford and Wright as humic latosols including Nailoca steepland bouldery clay (832) and Lobau steepland clay (83 f). The soils of the flat areas in the Navonu basin have been surveyed more recently by Adams (1968), who recognised a toposequence of lithosols, latosolic soils, humic latosols, alluvial soils and gley soils. The soil survey of Adams conforms fairly well with the forest types to the extent that both are classified on physiographic features. Thus forest types CS and BS are underlain by lithosols; latosolic soils are usually covered with secondary growth trees such as *waciwaci (Sterculia vitiensis)* and bamboo. The infertile humic latosols support a poor type of mixed coniferous and broad-leaved forest dominated by *dakua makadre* and *velau*. The alluvial and gley soils have on them a poor type of mixed species forest (forest type E).

Twyford and Wright have mapped steepland soils associated with nigrescent soils at the south-east end of the area and in the west along the isthmus joining Natewa Peninsula to the mainland.

VEGETATION

Closed canopy forest with a wide range of species covers most of the area. This has been divided on the basis of topography and species composition into 3 broad groups; the moderate or poorly stocked forest on very steep slopes usually with a mixed species composition: the well and moderately stocked forest on the steep or moderate slopes, covering appreciable areas, particularly in the Mbutha catchment: and the poorly stocked fringe forest, which probably represents regrowth after cultivation in the past. Forest with a partially closed canopy occurs along the southern coast on gently sloping land above the Hibiscus Highway.

Plantations of mature coconuts fringe the coastline and spread inland on the river flats. Higher up the valleys, beyond the coconuts, pockets of grass and mixed shrub occur. Mangrove occurs along the south coast at Naweni, Vunilangi, and Fawn Harbour.

POPULATION AND LAND TENURE

The total population of the area is 6 200 people of whom 4 965 are Fijian, 591 are Indian and 664 are of other races (Zwart, 1968). This last group refers mostly to other Pacific Island peoples. There are about 40 villages or settlements and a total of 1 011 households. The villages are scattered round the coast except for a few along the Hibiscus Highway and in the new settlement scheme on the upper Navenu River beside the road.

Deserted village sites are found mostly around the coast near to existing villages. There used to be a village called Navonu beside the road from Mbangason to Loa, about 2 km (1½ mi) west of the Commonwealth Development Corporation Oil Palm plot. Another interesting village site is Koroniyasatha a mile inland from Ndrekeniwai. This was visited by Horne and described as a town in the 1870s and mentioned in Guppy's journal in 1897 (Guppy, 1906) as being deserted. The site is now a coconut plantation.

The forested hill land that makes up most of the area is under Fijian ownership but not in Native Reserve. Some of the earliest settlement by Europeans occurred along this coast and in Natewa Bay with the result that large rectangular blocks of freehold land exist along the coast as coconut plantations. Along the south coast are the copra plantations Vunilangi, Lovonisikethi, Navuni, Nalovo, Navuo and Viani. Along the east coast are the copra plantations Natuvu, Nukundamu, Tuvamila, Ndevo and Kumbulau and beside Ndrekeniwai is the large rectangular estate called Valavala.

Crown land is of very limited extent and confined to one rectangular block opposite Fawn Harbour and a narrow strip that runs east-west across the land just north of Koroivonu.

Native Reserve occurs around the coast as a narrow strip extending one to two miles inland and further up river valleys. It also occurs to the south of the Hibiscus Highway where it runs inland between Fawn Harbour and Loa.

PRESENT LAND USE

The economy of this area centres around copra production both in private estates and in village communities.

Most of the coconuts are grown on raised coral terraces and alluvial flats. These sites are now fully taken up and new plantings, to get the coconut subsidy, are being made on the steep hills adjacent to the villages. New planting has been carried out to a small extent all round the coast most noticeably in the Ndakunimba and Viani areas.

A little cocoa is produced from trees planted under the coconuts. The trees look healthy and bear fruit. Interest in this cash crop is not great and is unlikely to increase while the price for copra remains high.

Oil palm trials have been laid out by the Commonwealth Development Corporation beside the road in the upper Navonu basin. The experiment looks promising.

Subsistence crops and *yaqona* are grown on the river plains and in small gardens on the hillsides above the villages, usually on cleared forest land.

Fishing is an important part of village life and the main source of protein.

With their farming on the coastal flats or forest fringe and their fishing the people have very little interest in the forest, compared, for instance, with people in the Rewa or Navua catchments. They do not know the vernacular names of the trees and soon get lost in the forest.

PRESENT FOREST MANAGEMENT

PREVIOUS ENUMERATIONS

No enumerations have been carried out in this area.

EXPLOITATION PAST AND PRESENT

The Mbutha concession of M J White lies in the south-west part of the Mbutha catchment. It follows the catchment boundary on the south and west sides and extends eastwards as far as the Koronikaivasi Falls. The northern limit lies roughly on the same latitude as Natewa.

Exploitation has occurred in two coupes adjacent to the mill and east of the road to it, but these had not been completely felled at the time of the survey.

Logging on a limited scale has been carried on outside the concession area. When given an order for *vesi* or *rosawa* Mr White transfers his activities to an area on the Nawi-Ndakunimba road near the catchment boundary. The big copra estates have cut timber in the past, usually *vesi*, for building purposes.

SAWMILLS

M J White's sawmill lies at the south-west end of the Mbutha catchment communicating by road with the Hibiscus Highway about 3 km (2 mi) west of Loa. The sawmill was started in about 1966 and is equipped with circular saws and a primitive drying kiln. Production from the mill is sporadic depending upon the orders for timber received. There are about 12 men employed at the mill.

PLANTATION SPECIES AND AGE CLASS

There are no plantations or species trials in the area.

EXISTING ACCESS ROUTES

One main road, picturesquely described as the Hibiscus Highway, serves the area. The road runs from Savusavu along the south coast of the isthmus as far as Mbangasau where it turns inland to follow the upper Navonu River crossing over the catchment boundary within one mile of Loa. From here a road runs down the coast as far as Nawi and crosses the hills to Ndakunimba. Another branch runs up the coast to serve all the villages on the eastern seaboard as far as the mission at Napuka.

The road serving the sawmill of the M J White Concession leaves the Hibiscus Highway beside the oil palm trial plots 3 km (2 mi) west of Loa. The section of road that climbs the escarpment to the higher elevation of the Mbutha catchment is too slippery after heavy rain for a land-rover to pass. This road would be better sited 1.5 km (1 mi) east along the watershed between the Navonu and Mbutha catchments.

The rivers are not navigable for logging operations.

A track runs from Tukavesi to Natewa but it is not used regularly. The people on the coast travel by sea rather than by land.

THE ENUMERATION

LAYOUT OF SURVEY

The Navonu survey covers the area from near Leya to a point just east of the Valavala estate and includes all the inland basin of the upper Navonu River. The lines run right across the catchment at right angles to this river.

In the Mbutha catchment the lines run at right angles to the eastern coast line and cover all the forested land that lies north of Loa village. For reasons of steepness and poor forest cover the coastal strip south of Loa was not enumerated.

There are two base lines for the Mbangasan coastal strip so that the enumeration lines run at right angles to the coast. The lines cover the forest as far as the Vunilangi estate in the west and Ndakunimba in the east.

TIMBER VOLUMES

Areas covered by the forest types in the 3 catchments are given in Table 34.

TABLE 34 Enumerated areas of forest types in Natewa Peninsula Catchment Group (ha)

Forest type	Navonu	Mbutha	Mbangasan	Total enumerated area		% of enumerated forest
				ha	ac	
H	-	74	77	151	373	1
J	178	-	572	750	1 853	3
S	780	315	1 242	2 337	5 775	8
Non-commercial	958	389	1 891	3 238	8 001	12
C1	419	6 282	816	7 517	18 575	26
C2	-	332	-	332	820	1
CDK	770	-	-	770	1 903	3
E	421	-	-	421	1 040	1
G	246	1 784	1 582	3 612	8 925	13
Production	1 856	8 398	2 398	12 652	31 263	44
B	9	293	82	383	946	1
BS	1 358	1 824	277	5 889	14 552	21
CS	998	4 589	493	6 080	15 024	22
Protection	2 365	6 706	852	12 352	30 522	44
Total				28 242	69 786	

In this group of catchments, non-commercial forest covers 12% and both production forest and protection forest 44% of the enumerated area.

TABLE 35 Volume of timber from trees over 40 cm d.b.h. species group 1-4, reliable minimum estimate and percentage error by catchment and management category, Natewa Peninsula Catchment Group ('000 m^3)

Management and catchment	Volume >40 cm s.g. 1-4	Sampling error >40cm s.g. 1-4	Degrees of freedom	Confidence limit p >0.05	r.m.e. p >0.025	% error	Volume 40 cm s.g. 1-4 (million Hsl ft)
Non-commercial							
Navonu	8	4	9	8	0	100	3
Mbutha	7	1	5	3	4	42	2
Mbangasau	12	2	17	6	6	57	4
Prod	27				10		9
Production							
Navonu	113	11	10	23	90	21	37
Mbutha	667	33	26	67	600	10	222
Mbangasau	98	11	13	23	75	23	33
Total	878				765		292
Protection							
Navonu	82	9	13	19	63	23	27
Mbutha	324	23	21	48	276	15	108
Mbangasau	83	8	11	18	65	22	28
Total	489				404		163

The volumes of standing timber in the enumerated forest are summarised in Table 35. The production forest contains an enumerated volume of 878 000 m^3 (292 million Hsl ft) and a r.m.e. of 765 000 m^3 (255 million Hsl ft). The protection forest too is well stocked with an enumerated volume of 489 000 m^3 (163 million Hsl ft). Much of this occurs in the CS forest type in Mbutha catchment.

The sampling error for the large volume of production forest in Mbutha catchment is very good with a percentage of only 10%. Percentage errors for Navonu and Mbangasau are 21 and 23% respectively which are near the 20% aimed at for the survey. The sampling error is reasonable for the protection forest but high for the poorly stocked non-commercial forest.

TABLE 36 Total volumes and sampling errors of forest types in the Natewa Peninsula Catchment Group ('000 m^3)

Catchment and Forest type	Minimum diameter & sp. group (1) 35cm 1-5	(2) 40cm 1-5	(3) 40cm 1-4	Sampling error for (3)	Volume (million Hsl ft) for (3)	Stocking (m^3/ha) for (2)	Management category
Navonu							
J	1	1	1	1	1	6	Non-Commercial
S	20	17	7	4	2	9	
Subtotal			8	4	3	8	
C1	55	48	41	5	14	98	Production
CDK	78	70	57	9	19	74	
E	22	18	11	0	4	26	
G	8	8	4	2	1	16	
Subtotal			113	11	38	61	
B	0	0	0	0	0	0	Protection
BS	67	61	31	5	10	23	
CS	86	75	51	7	17	51	
Subtotal			82	9	27	35	
Mbutha							
H	5	5	4	1	1	54	Non-Commercial
S	9	8	3	1	1	10	
Subtotal			7	1	2	18	
C1	780	709	577	31	192	92	Production
C2	24	22	18	4	6	54	
G	129	117	72	10	24	40	
Subtotal			667	33	222	79	
B	16	11	11	3	4	38	Protection
BS	106	93	65	9	22	36	
CS	363	327	248	21	83	54	
Subtotal			324	23	109	48	
Mbangasau							
J	8	7	4	1	1	7	Non-Commercial
H	1	1	1	>1	1	13	
S	12	11	7	2	2	6	
Subtotal			12	2	4	6	
C1	77	71	55	8	18	67	Production
G	76	69	43	7	14	27	
Subtotal			98	11	32	41	
B	1	1	0	0	0	0	Protection
BS	100	91	58	8	19	21	
CS	35	32	25	2	8	51	
Subtotal			83	8	27	25	

DESCRIPTION OF FOREST TYPES

The important forest types in this group of catchments are S, C1, G, BS and CS. The volumes and sampling errors are given in Table 36.

Type S: Low-stocked open woodland

This forest type covers a total of 2 337 ha (5 775 ac) of which over half occurs in the Mbangasau catchment. It covers flat land in the area north-west of Mbangasau village but also occurs to some extent on steep country east of this village and in the Mbutha catchment. At the time this area was enumerated the distinction between open canopied forest on flat or gently undulating country and that on very steep slopes had not been made. The result is that the forest on some very steep slopes is included in this category.

The important species in this locality are *kaudamu*, *koka*, *vesi* and *dawa* as well as 'others' which includes *bo*, *mako*, *doi* and *yaro*.

Type C1: Well stocked mixed forest on moderate to steep short slopes

This type has the largest cover in this group of catchments extending over 7 517 ha (18 575 ac) or 26% of the enumerated area. Of this area 6 282 ha (15 523 ac) lies in the Mbutha catchment with the big block at the western end of the catchment falling into the concession of M J White. The Tuvamila estate freehold has a sizeable area of forest of this type.

Dakua makadre, *kaudamu* and *yasiyasi* have the highest stockings with 15, 13, and 12 m^3/ha respectively (2 021, 1 752 and 1 617 Hsl ft/ac), in the Mbutha catchment.

Vesi has a high stocking, 10 and 9 m^3/ha (1 348 and 1 213 Hsl ft/ac) in the Navonu and Mbutha catchments respectively, but only 1 m^3/ha (135 Hsl ft/ac) in the Mbangasau catchment. The stocking of *damanu* is low compared with Viti Levu forests, being about 5 m^3/ha (674 Hsl ft/ac).

In the Mbutha catchment the general impression is that this forest is overmature. The trees, particularly the *yasiyasi*, grow to huge sizes with spreading crowns showing signs of dieback. This over-maturity is indicated by the size class distribution of the trees which shows 20% of the trees in the 35-39 cm (14-15 in) class, 37% in the 40-49 cm (16-19 in) class and 43% in the 50 cm and over (20 in) class. In the Nambukelevu South-West catchment the equivalent figures are 29, 40 and 31%.

Type G: Moderately stocked mixed forest on moderate to steep short slopes

This forest type covers 3 612 ha (8 925 ac), 31% of the enumerated area, with areas of over 1 000 ha (2 471 ac) in the Mbutha and Mbangasau catchments. The type occurs at the edge of the forest or in patches in the middle as in Mbutha, never occupying very big areas. As in forest type C1, *kaudamu* and *yasiyasi* are the commonest trees but the group 'others' has the same stocking here as it does in C1 and is therefore relatively more abundant.

Type BS: Low-stocked forest on very steep or precipitous slopes

This covers 5 889 ha (14 552 ac), 21% of the enumerated area, and is a major constituent in all 3 catchments. It occurs near the coast in the Mbutha catchment where recent uplift has caused the hills above the coast to be a series of tumbling rock faces. The Mbangasau catchment has this type east of Mbangasau village, where the underlying basalt and breccia cause rugged topography.

Common species in this forest type are *vesi* which has a stocking of 6 m^3/ha (809 Hsl ft/ac) in all 3 catchments, *kaudamu*, *sasauwira*, *koka*, *moivi* and *dawa*.

The profuse white flowers of the *moivi* (*Maniltoa grandiflora*) are conspicuous, covering whole hillsides with white crowns in the month of June.

Overall stocking of trees over 40 cm d.b.h. is 45, 51 and 34 m^3/ha (6 064, 6 873 and 4 582 Hsl ft/ac) for Navonu, Mbutha and Mbangasau catchments respectively. Of this 11 to 19 m^3/ha (1 482-2 560 Hsl ft/ac) is made up of the group 'others'.

Type CS: Moderately stocked forest on long, very steep slopes

This type covers 6 080 ha (15 024 ac) or 22% (nearly the same proportion as BS) of the enumerated area. In Mbutha catchment there are 4 589 ha (11 339 ac) of this type which makes up the main back-bone of hills running down the peninsula. The type merges into BS but the main distinction between them is that CS has a developed pattern of ridges and gulleys radiating from a high hill mass whereas BS consists of tumbling rocks falling away in one plane.

Dakua makadre has a high stocking in the Navonu and Mbangasau catchments of 10 m^3/ha (1 348 Hsl ft/ac) but low in the Mbutha catchment (3 m^3/ha, 404 Hsl ft/ac). Common species are *kaudamu, yasiyasi* and *damanu*, which have stockings of 5 to 10 m^3/ha (674-1 348 Hsl ft/ac).

The overall stocking of trees over 40 cm d.b.h. is 75, 71 and 64 m^3/ha (10 107, 9 568 and 8 625 Hsl ft/ac) in Navonu, Mbutha and Mbangasau catchments respectively.

RECOMMENDATIONS

POSSIBLE COMBINATION WITH ADJACENT AREAS

The bulk of the production forest is in the Mbutha catchment a large proportion of which lies in the existing concession area of M J White.

If the need arose to clear the forest in the Navonu basin for oil palm planting, the operation would be lucrative for a sawmiller because the forest contains a high proportion of *dakua* for which there is always a demand.

Combining the catchments is unlikely to be a practicable proposition because the land that is not in Mr White's concession is under option to Fiji Forest Industries.

PROPOSED ACCESS ROUTES

The inadequacy of the present route to Mr White's mill and a possible alternative have been mentioned already (see existing access routes).

Access to the block of C1 forest inland from Koroivonu in the Mbutha catchment would best be made by following Nala River as it sweeps southwards. This river is not big enough for floating logs.

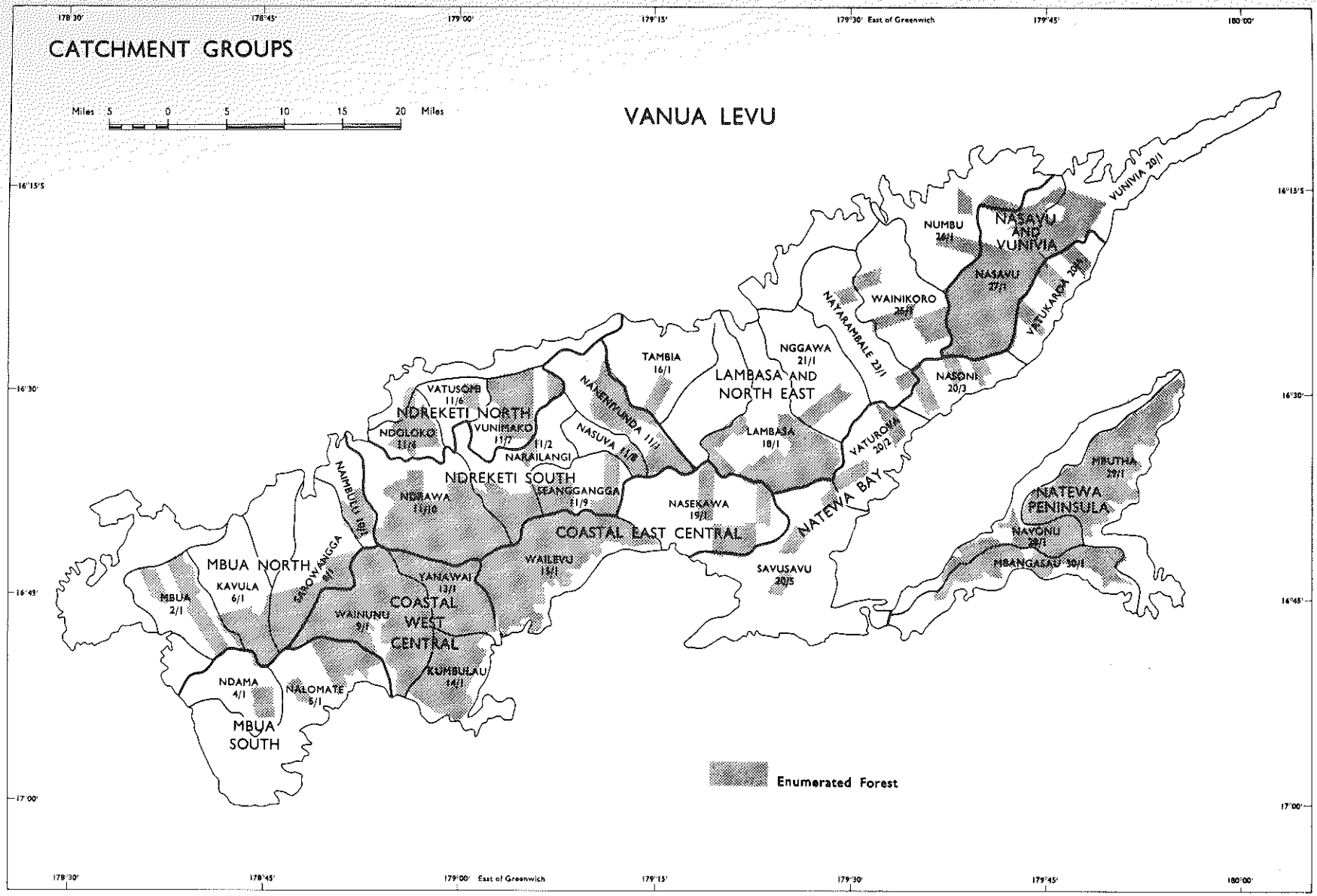
Access to the block of C1 forest in the Mbangasau catchment may be gained by branching westwards from the Vunikura to Ndakunimba road just west of Nawi.

The upper Navonu is already served by the main road. The area further from the road east of Ndrekeniwai may be reached by the path which at present serves Ndrekeniwai. It is a well graded alignment. A bridge would have to be built over the river which is liable to flood.

PROPOSED TREATMENT OF FOREST TYPES

Production forest This covers an area of 12 652 ha (31 263 ac) with a reliable minimum estimate of timber volume of 765 000 m^3(255 million Hsl ft). The forest type C1 has a high stocking of around 100 m^3/ha (13 476 Hsl ft/ac, trees over 40 cm d.b.h.). The forest type CDK in Navonu has a lower stocking (74 m /ha, 9 837 Hsl ft/ac) but contains valuable species such as *dakua makadre*.

Protection forest The forest on very steep slopes covers nearly as great an area as the production forest, 12 352 ha (30 522 ac) as against 12 652 ha (31 263 ac). In view of the slope and the structure of the forest, forest type BS would not be an economic proposition for timber exploitation. Forest type CS has a better stocking of about 50 m^3/ha (6 738 Hsl ft/ac) with valuable species such as *dakua makadre, kaudamu, yasiyasi* and *damanu*. Felling of this forest is not recommended because it plays an important role in holding the soil and rock scree as well as in controlling run off.



D.O.S. 3105

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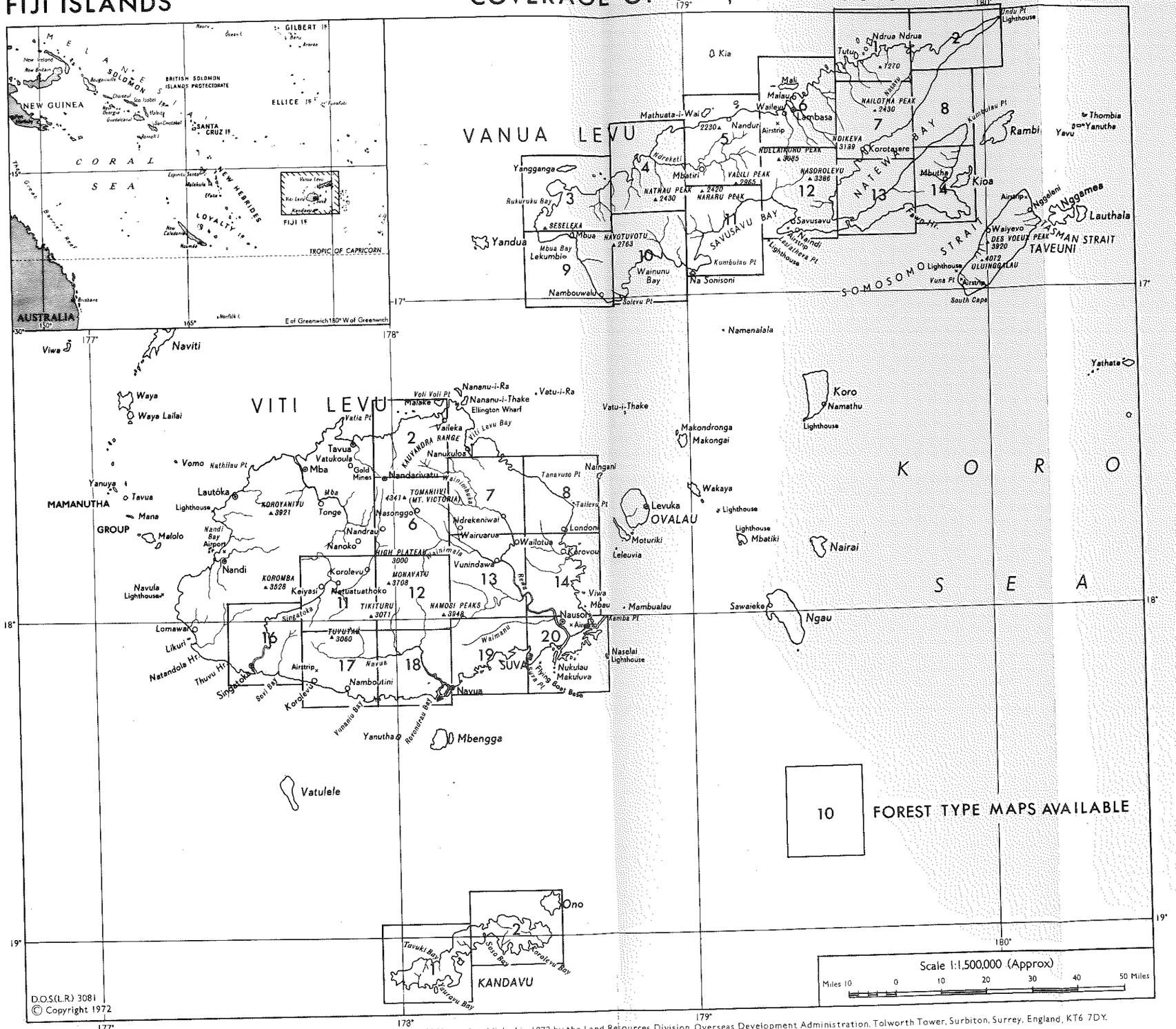
FIJI ISLANDS

COVERAGE OF 1:50,000 MAPS OF FOREST TYPES



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PUBLICATIONS OF THE LAND RESOURCES DIVISION

These publications have a restricted distribution and are not available to booksellers. The Division makes a report on each completed project. The report is published as a *Land Resource Study* or *Technical Bulletin* only with the consent of the government concerned. The abbreviated titles of the reports in the style of the 'World List of Scientific Periodicals' are *Land Resour. Stud.* and *Tech. Bull. Land Resour. Div. overseas Dev. Admin.*

BAWDEN M G and LANGDALE-BROWN I	1961	An aerial photographic reconnaissance of the present and possible land use in the Bamenda Area, Southern Cameroons.*
BAWDEN M G and STOBBS A R	1963	The land resources of Eastern Bechuanaland.
LANGDALE-BROWN I and SPOONER R J	1963	The land use prospects of Northern Bechuanaland.
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