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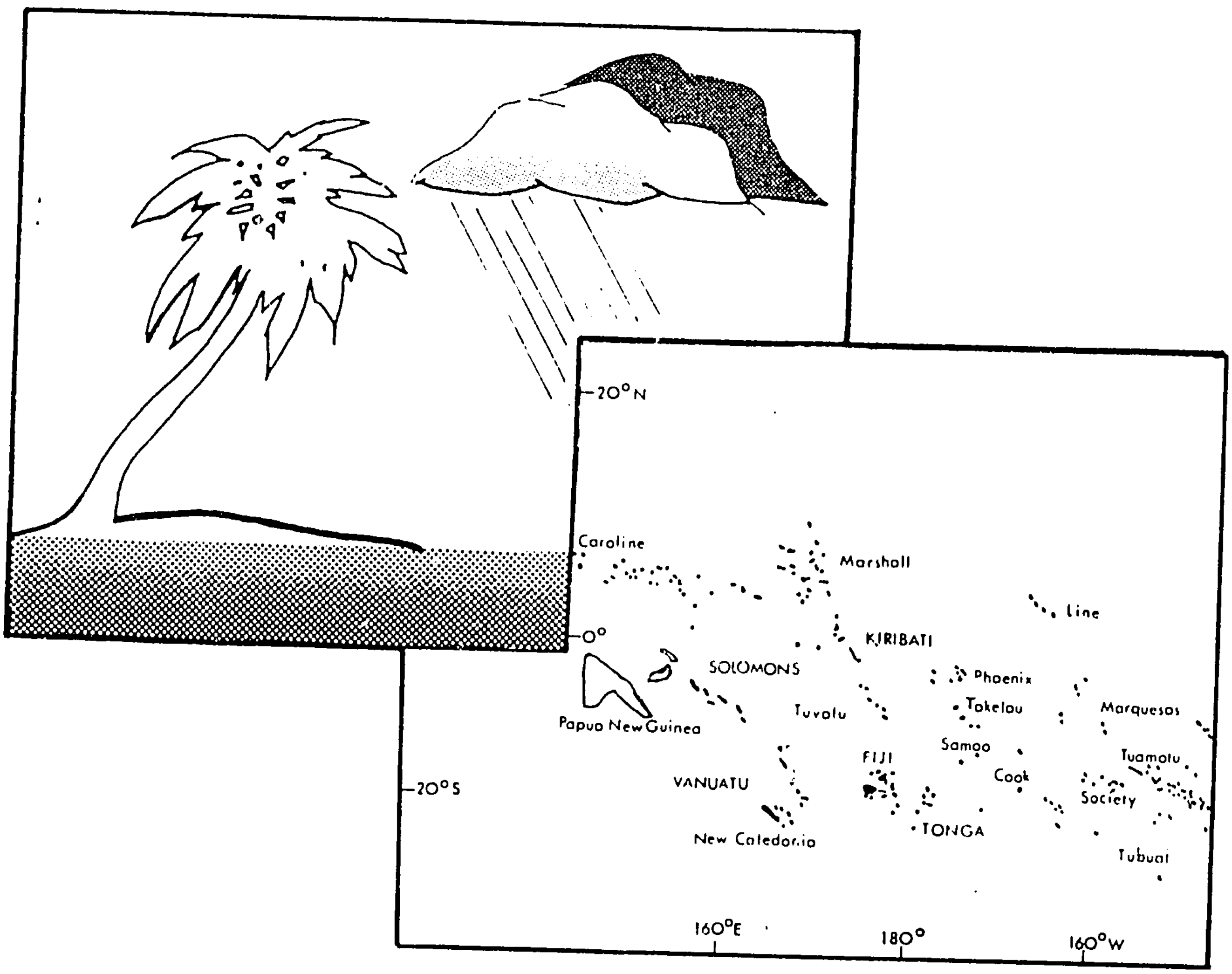
AGROCLIMATIC METHODS TO ASSESS CLIMATE/FOOD SECURITY CONDITIONS IN THE SOUTH PACIFIC

EARLY WARNING PROGRAM



MAY 1984

AGROCLIMATIC METHODS TO ASSESS CLIMATE/FOOD SECURITY CONDITIONS IN THE SOUTH PACIFIC[1]

to

International Development Cooperation Agency
Agency for International Development
Office of U.S. Foreign Disaster Assistance
Washington, D.C.

by

National Oceanic and Atmospheric Administration
National Environmental, Satellite, Data and Information Service
Assessment and Information Services Center
Climatic Impact Assessment Division-Models Branch
Columbia, Missouri

and

Atmospheric Science Department
University of Missouri-Columbia; Columbia, Missouri

prepared by
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EXECUTIVE SUMMARY
PROPOSED AGROCLIMATIC METHODS TO ASSESS CLIMATE/FOOD SECURITY CONDITIONS IN THE SOUTH PACIFIC

by V. Rao Achutuni, Judy L. Trujillo and Louis T. Steyaert[1]

The Agency for International Development (AID) needs reliable early warning of potential food shortages to make decisions affecting many of its programs for disaster preparedness, relief assistance and food security in the South Pacific. These island economies are highly vulnerable to climate variability. Severe cyclonic, hurricane, flood and drought activities have historically led to crop failures and economic losses. For these reasons, the USAID/Office of U.S. Foreign Disaster Assistance sponsored this project, "Agroclimatic Conditions and Assessment Methods for Drought/Food Shortages in the South Pacific", which covers the Solomon, Vanuatu, Kiribati (Gilbert Islands), Fiji and Tonga island groups.

The objectives of the project were accomplished. An inexpensive Early Warning program was developed to provide reliable, timely information on potential food shortages triggered by climatic events. Computerized data bases were assembled and used to determine historical relationships between climate anomalies, crop failures and causes of abnormal food shortages.

The Early Warning Program is based on a combination of 1) bi-weekly weather assessments and 2) monthly crop condition assessments. Weather assessments begin with an analysis of precipitation amount, the most

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important element influencing crop productivity in the tropics. Weekly and monthly rainfall estimates are determined from ground station reports received through the World Meteorological Organization's Global Telecommunications Network. Satellite cloud data are used to improve the accuracy of precipitation estimates, particularly in those regions where weather data are sparse and unreliable. Weather data are then interpreted by applying cumulative rainfall indices to identify the potential problem areas and crops impacted during the assessment period. Currently, monthly crop condition assessments and bi-weekly weather assessments are being issued by NOAA/NESIDS/AISC on an operational basis. These assessments should benefit the USAID Office of Foreign Disaster Assistance in providing food security for the South Pacific island groups.

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CHAPTER I

INTRODUCTION

The Agency for International Development (AID) needs reliable early warning of potential food shortages to make decisions affecting many of its programs for disaster relief, preparedness and food security in the South Pacific. These island economies are highly vulnerable to climate variability which has historically led to crop failures and economic loss. For these reasons, the USAID/Office of Foreign Disaster Assistance (OFDA) sponsored this project: "Agroclimatic Methods to Assess Climate/Food Security Conditions in the South Pacific."

This project covers five island groups including Solomon, Vanuatu, Kiribati (Gilbert), Fiji and Tonga (Figure 1.1). The objectives of the project were:

1. To study the existing agroclimatic conditions, agricultural practices and food security in each island group.
2. To collect and compile a meteorological data base for the South Pacific island groups.
3. To study the relationships between climate and crop production.
4. To develop a timely, reliable, yet inexpensive Early Warning Program for operational assessments of the current agrometeorological conditions, crop conditions and the potential for food shortages due to anomalous weather events.

Included in this report is information on the physical geography, climate, agriculture, economy and episodic events for each island group. Figures and tables for each island group are provided.

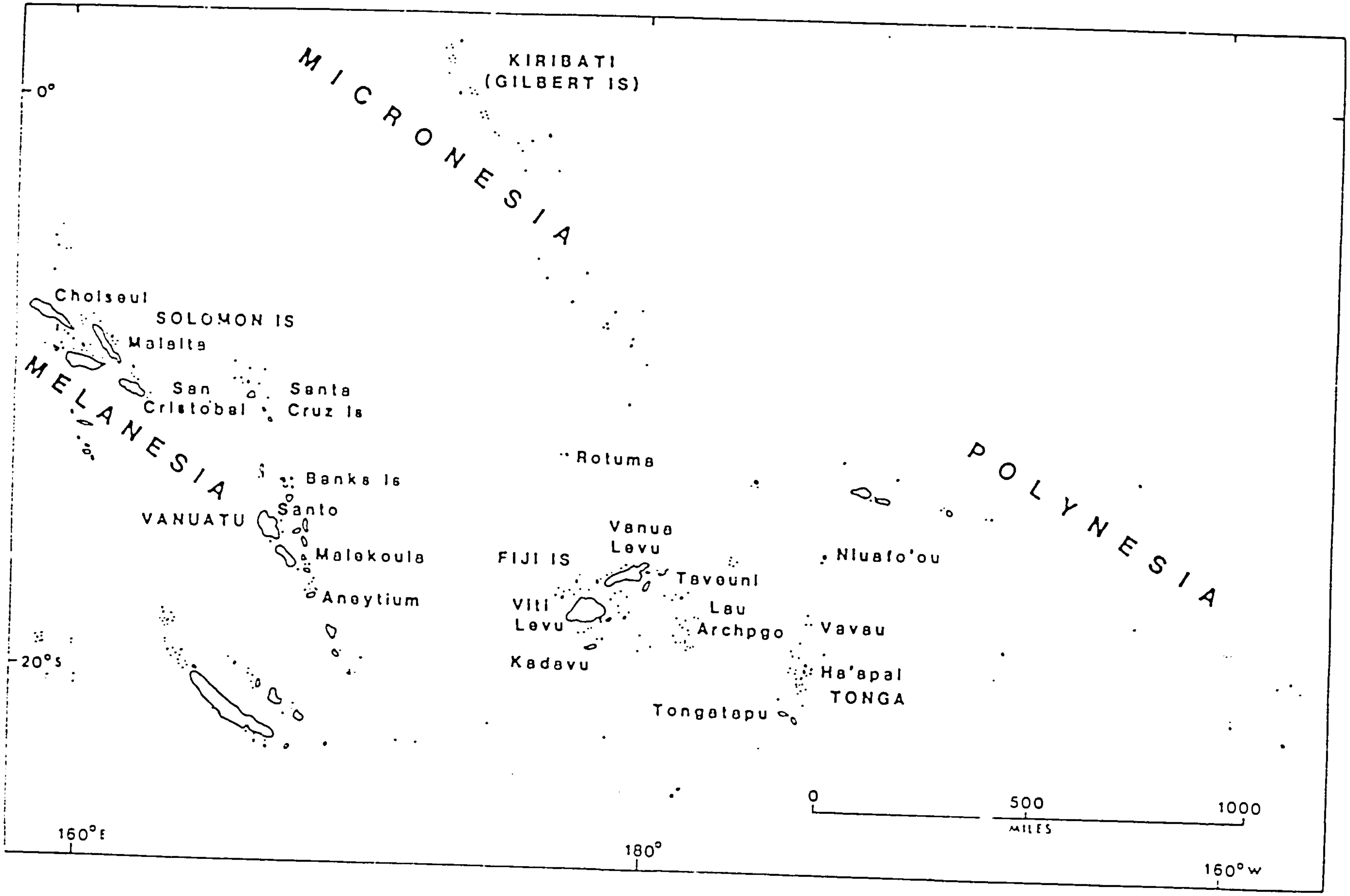


Figure 1.1 South Pacific Island Groups Used in This Study.

The findings of this project are expected to aid agrometeorologists and agronomists, as well as policy and decision makers, in understanding the weather/agriculture relationship. This will in turn help achieve short and long term goals for increasing food security in these South Pacific island groups.

CHAPTER II

REGIONAL OVERVIEW

A. Physical Environment

The five island groups covered in this study include Solomon, Vanuatu, Kiribati, Fiji and Tonga. These island groups are of volcanic origin, atolls and raised or lowered coral reefs. Some are geologically active and tremors are frequent.

Fiji and the Solomon Islands are by far the most populous island groups, however Tonga and Kiribati have the largest population densities. The bulk of the population in all the island groups is rural (Table 2.1).

B. Climate

The five island groups enjoy a tropical maritime climate influenced by the trade winds. The position of the South Pacific Convergence Zone (SPCZ) primarily determines the areas of heavy rainfall. In turn, the position of the SPCZ is determined by the large scale circulation patterns involving the Southern Oscillation and Sea Surface Temperature (SST) anomalies in the equatorial Pacific (Rasmusson and Carpenter, 1982).

The mean annual rainfall pattern for the equatorial Pacific is shown in Figure 2.1. The rainfall amounts vary from 1,000 to 6,000 millimeters. Mean monthly rainfall amounts for equatorial Pacific can be found in Appendix A. Generally speaking, December to April can be considered the rainy season. The prevailing trade winds and orography determine the seasonality and distribution of rainfall.

According to Revell (1981) tropical cyclones occur in the South Pacific between the months of October and June. January and February are the two months having peak cyclonic activity. Revell examined the tracks of tropical cyclones

TABLE 2.1 POPULATION STATISTICS IN THE SOUTH PACIFIC

Island Groups	Area (Sq.km.)	Population (Year)	% Urban Population	% Rural Population	Population Density
Solomon	28,530	233,000(1981)	9	91	8
Vanuatu	11,880	120,000(1981)	17	83	10
Kiribati	690	53,835(1978)	36	64	78
Fiji	18,272	676,000(1983)	37	63	37
Tonga	699	97,400(1980)	26	74	139

Adapted from "Disaster Preparedness and Disaster Experience in the South Pacific", Franco, A.B, Hamnett, M.P., Makasiale, J.; August 1982. East-West Center, Honolulu, Hawaii. Sponsored by AID.

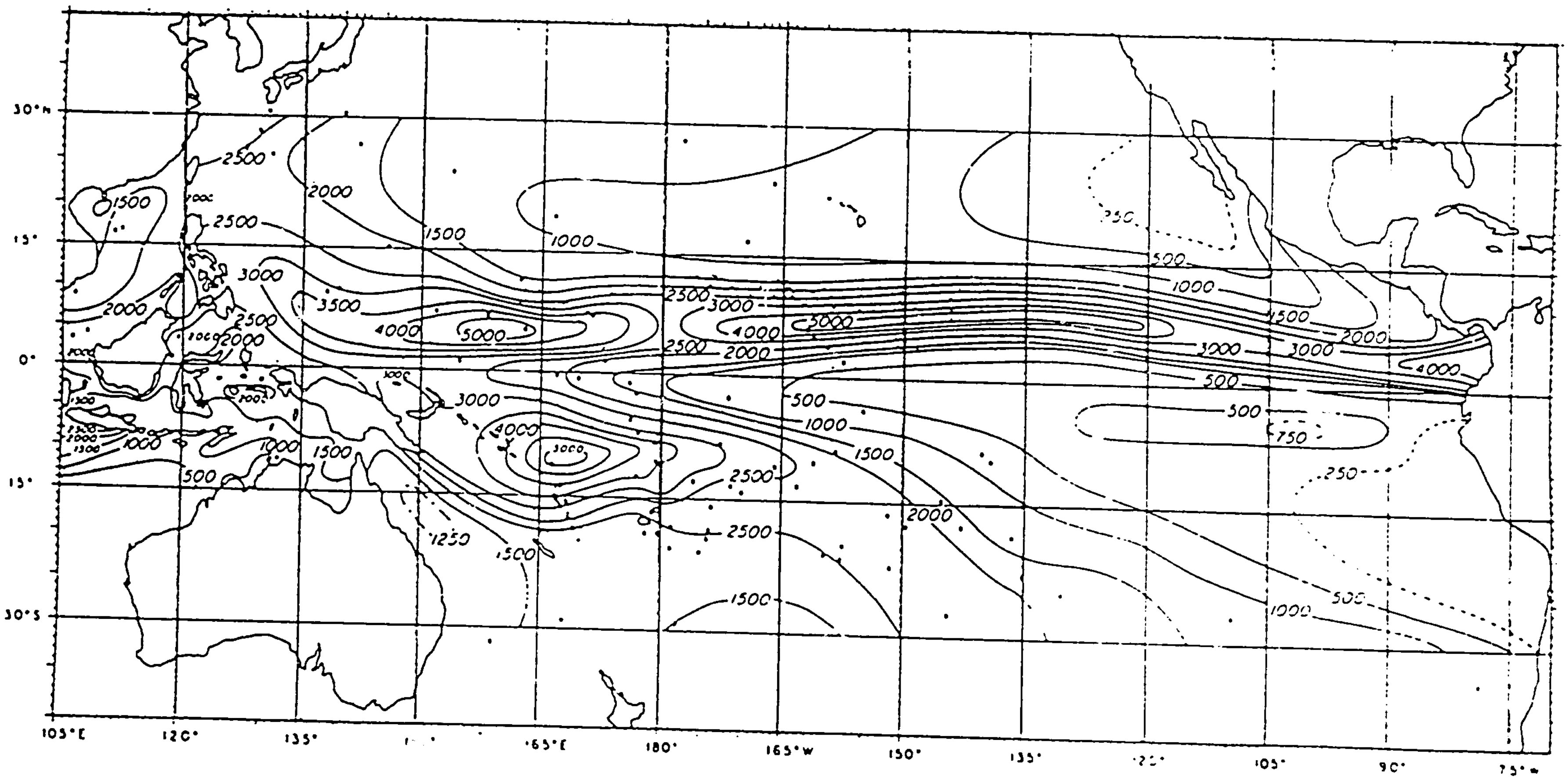


Figure 2.1 Distribution of mean annual rainfall (mm) in the equatorial Pacific (Adapted from Taylor, 1973).

in the southwest Pacific. The seasonal distribution of all tropical cyclones, by intensity classes, is shown in Figure 2.2. The frequency of tropical cyclones in the South Pacific (5°-25°S latitude and 150°E to 155°W longitude) is shown in Figure 2.3. Vanuatu, New Caledonia, Fiji and Tonga have a higher frequency of cyclones than the other island groups. Kiribati, being close to the equator, generally does not experience any cyclones. The percentage of tropical storms that became hurricanes is indicated in Figure 2.4. Revell's analysis suggests that the highest percentage frequency of hurricanes is near the Cook Islands. The majority of the few tropical cyclones that do hit this island group become hurricanes. The hurricanes conversion rate of New Caledonia, Fiji, Vanuatu and Tuvalu is between 17-29 percent.

The mean monthly air temperature values for select stations in the South Pacific are shown in Table 2.2. The monthly variation in temperature is generally less than 2°C and seldom exceeds 5°C.

The mean monthly relative humdity for select stations in the South Pacific is shown in Table 2.3. The humidity is high throughout the year.

C. Agriculture

A majority of the South Pacific islanders are engaged in farming although arable land is generally a scarce commodity. Table 2.4 shows the land use for the Solomon, Kiribati, Fiji and Tonga island groups.

Coconut, copra, cacao, bananas and sugarcane are the principal cash crops. Rice, sweet potato, cassava and taro are some other crops of importance. The area, production and yield statistics for some of the principal crops are shown in Table 2.5. The negligible level of yield increases over the period 1969-1979 is indicative of subsistence level farming in these island groups.

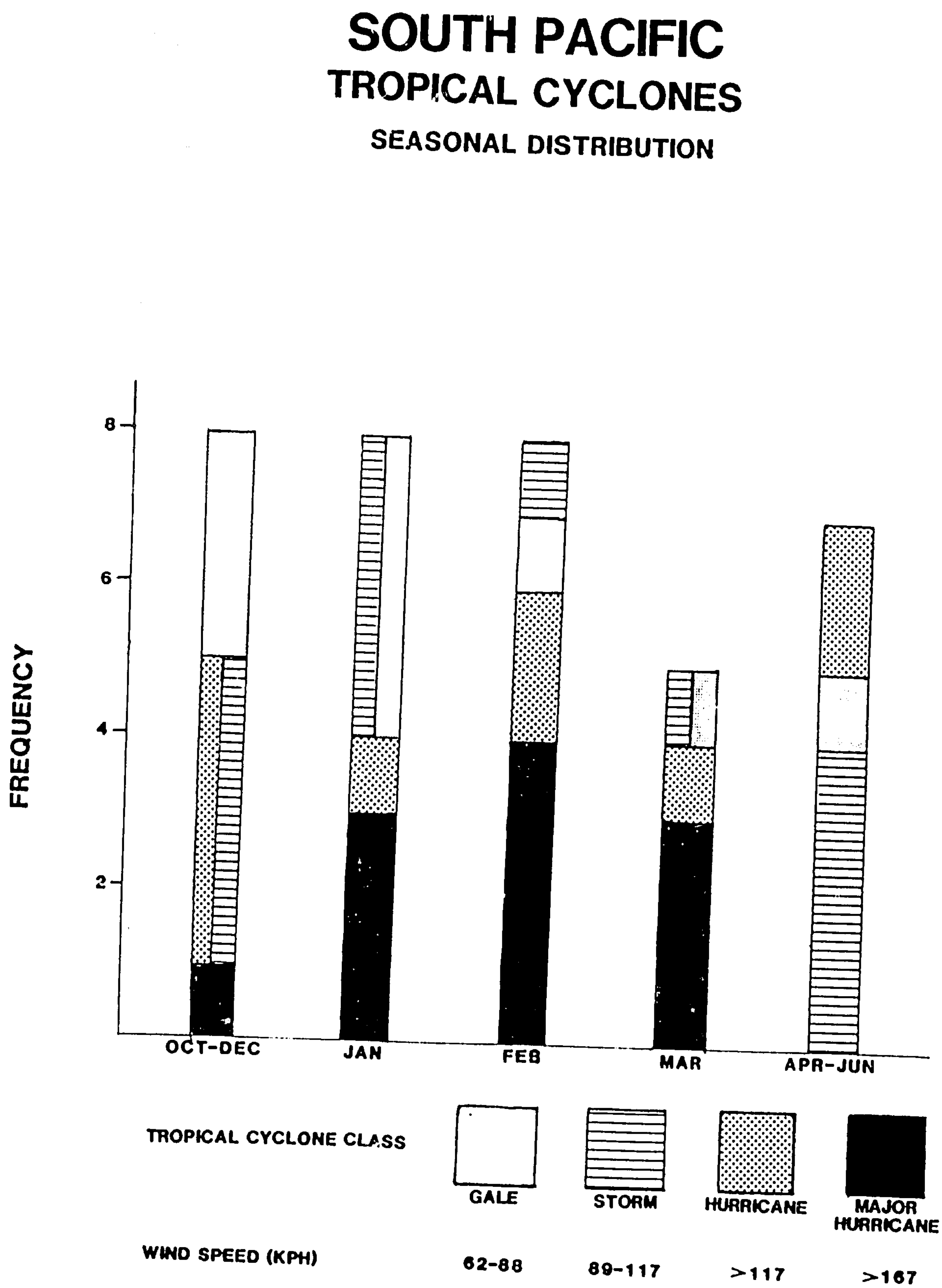


Figure 2.2 The seasonal distribution of tropical cyclones in the South Pacific (adapted from Revell, 1981).

SOUTH PACIFIC CYCLONES FREQUENCY

NOVEMBER 1969 - APRIL 1979

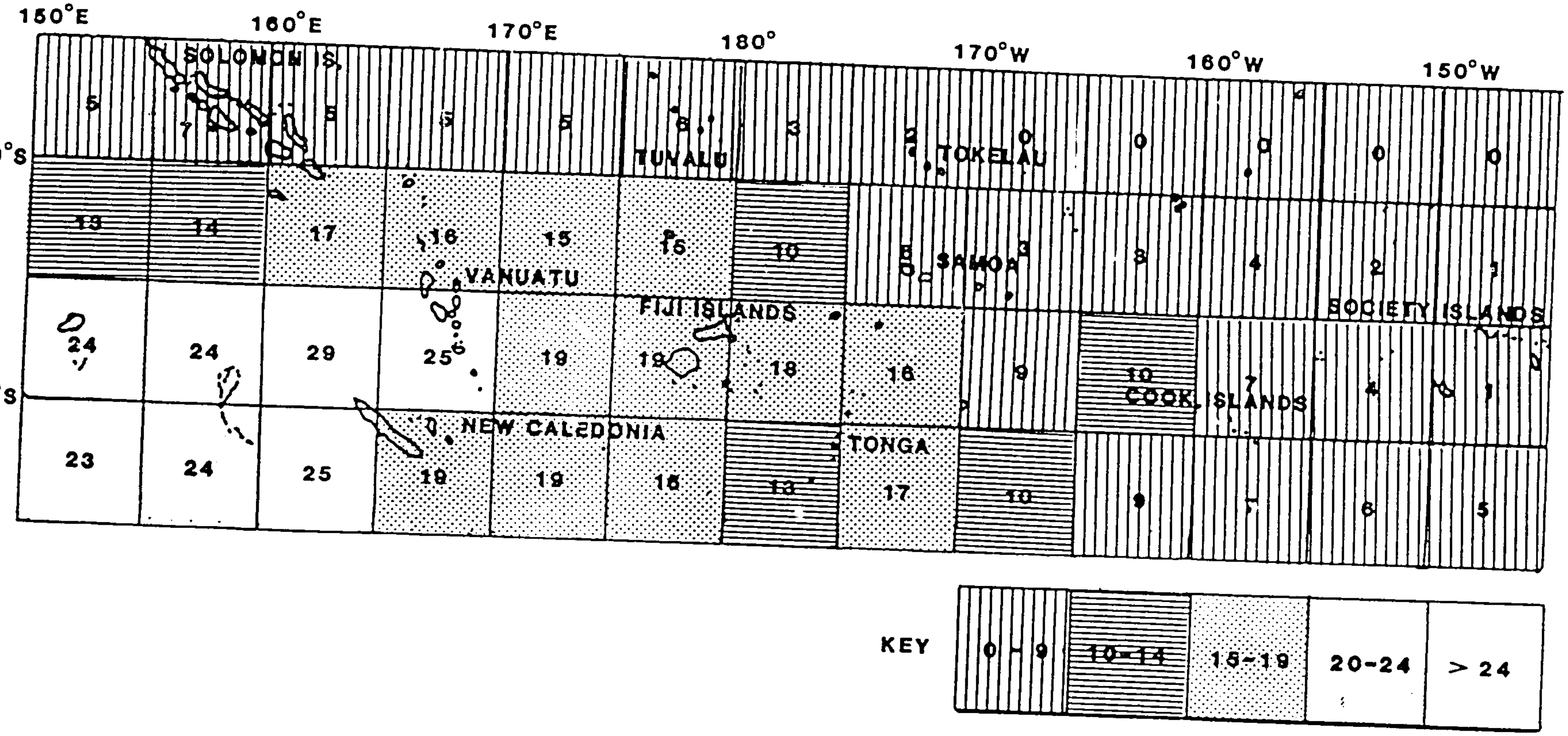


Figure 2.3 Frequency of tropical cyclones of all classes in the South Pacific for each five degree square) (adapted from Revell, 1981)

SOUTH PACIFIC
HURRICANES (WIND SPEED>117 KPH)
PERCENTAGE FREQUENCY

NOVEMBER 1969 - APRIL 1979

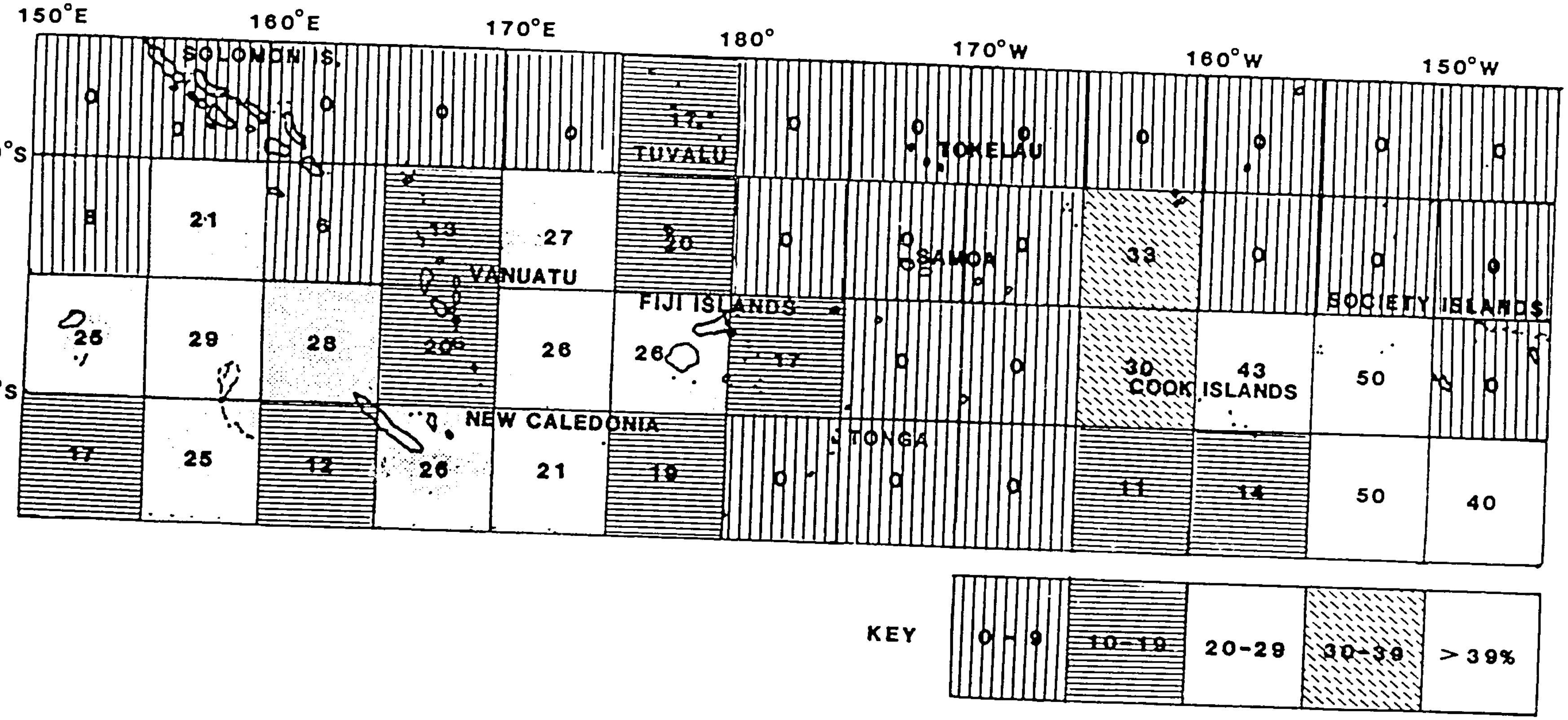


Figure 2.4 Percentage frequency of tropical cyclones in the South Pacific that became hurricanes (wind speed >117 KPH) at each five degree square (adapted from Revell, 1981).

TABLE 2.2 MEAN MONTHLY AND ANNUAL AIR TEMPERATURE (°C) AT SELECTED STATIONS IN THE SOUTH PACIFIC

Island Group	Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Solomon	Honiara	26.8	26.7	26.5	26.6	26.7	26.4	26.2	26.3	26.5	26.7	26.8	26.7	26.6
	Tulaghi	27.7	27.7	27.7	27.7	27.5	27.1	27.1	27.0	27.2	27.4	27.8	28.1	27.5
Vanuatu	Aneityum	26.0	26.6	26.0	24.9	23.4	22.5	21.5	21.4	22.0	23.1	24.2	25.3	23.9
	Lugan-ville	25.5	25.8	25.4	25.3	24.1	23.6	22.8	23.3	23.8	24.1	24.8	25.4	24.5
	Port-Patterson	26.6	26.9	26.6	26.3	26.1	25.8	25.2	25.2	25.5	25.7	26.1	26.6	26.1
	Vila	26.4	26.8	26.1	25.2	24.0	23.2	22.4	22.7	23.2	23.9	25.0	25.9	24.6
Kiribati (Gilbert)	Arorae	28.8	28.9	29.1	28.9	29.1	28.8	28.6	28.8	28.9	29.0	29.0	29.0	28.9
	Beru	28.2	28.3	28.3	28.3	28.5	28.4	28.2	28.0	28.6	28.5	28.4	28.4	28.3
	Tarawa	28.2	28.1	28.1	28.2	28.4	28.3	28.2	28.3	28.4	28.6	28.3	28.3	28.3
Fiji	Labasa Mill	26.8	26.8	26.6	26.2	25.3	24.4	23.8	24.2	24.7	25.4	25.9	26.4	25.5
	Lambasa AP	26.8	26.7	26.6	26.3	25.1	24.3	23.4	23.9	24.8	25.4	25.7	26.3	25.4
	Lauthala Bay	26.3	26.3	26.1	25.7	24.7	23.9	22.9	22.9	23.5	24.2	24.9	25.8	24.8
	Lautoka Mill	27.2	27.3	26.9	26.6	25.6	24.6	24.0	24.3	24.8	25.7	26.2	26.8	25.8
	Lautoka PO	26.8	26.8	26.7	25.9	25.1	24.0	23.3	23.7	24.3	25.0	25.6	26.3	25.3
	Matuku	26.8	27.0	26.8	26.3	25.1	24.1	23.1	23.6	24.2	25.0	25.7	26.4	25.3
	Nacoco-levu	26.4	26.5	26.2	25.6	24.0	22.9	22.1	22.5	23.3	24.1	25.1	25.9	24.6
	Nambou-walu	26.9	27.1	26.7	26.3	25.5	24.7	23.9	24.0	24.4	25.2	25.4	26.3	25.5
	Nandari-vatu	21.6	22.0	21.5	21.0	20.0	18.9	18.3	18.8	19.0	20.1	20.6	21.1	20.2
	Nandi	27.0	26.9	26.7	26.2	25.0	24.0	23.3	23.8	24.5	25.2	25.9	26.6	25.4
	Nausori Mill	26.2	26.5	26.4	25.6	24.3	23.3	22.6	22.6	23.1	23.9	24.7	25.6	24.6
	Ono-I-Lau	26.3	26.6	26.4	25.7	24.3	23.4	22.4	22.4	22.7	23.6	24.5	25.3	24.5
	Penang Mill	27.6	27.6	27.3	26.8	25.9	24.9	24.2	24.6	25.1	25.9	26.6	27.1	26.1
	Rarawai Mill	27.2	27.1	26.9	26.5	25.3	24.1	23.3	23.8	24.7	25.5	26.1	26.6	25.6
	Rotuma	27.4	27.3	27.2	27.4	27.2	26.8	26.4	26.5	26.7	26.8	27.0	27.2	27.0
	Suva	26.8	26.9	26.8	26.1	24.8	23.9	23.1	23.2	23.7	24.4	25.3	26.2	25.1
	Undo Pt.	26.6	26.7	26.6	26.3	26.0	25.3	24.6	24.7	25.0	25.6	25.9	26.6	25.8
	Vunisea	26.4	26.8	26.1	25.4	24.2	23.2	22.4	22.6	23.1	23.9	24.7	26.1	24.6
	Yasawa-I-Rara	27.0	26.9	26.6	26.4	26.0	25.3	24.6	24.8	25.1	25.7	26.1	26.7	25.9
Tonga	Nukualofa	25.6	25.9	24.1	23.2	21.4	21.3	21.4	21.7	22.4	23.8	24.8	25.4	23.4
	Vavau	26.4	26.7	26.0	24.8	24.2	23.2	23.1	23.7	24.3	25.1	25.9	26.0	25.0

TABLE 2.3. MEAN MONTHLY RELATIVE HUMIDITY (%) AT SELECTED STATIONS IN THE SOUTH PACIFIC

Island Group	Station Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Solomon	Honiara	77	77	80	79	75	75	74	73	73	75	77	77
	Mbarakoma	85	87	88	88	88	87	87	88	86	86	85	84
	Munda	85	87	88	88	88	87	87	88	86	86	85	84
Vanuatu	Aneityum	83	85	84	83	82	80	79	78	78	78	80	81
	Baurfield	84	86	86	86	86	85	84	82	81	81	81	83
	Burton-field	84	85	85	84	80	81	81	76	79	80	80	83
	Erromango	85	85	86	84	85	83	81	79	80	78	80	82
	Lugan-ville	85	85	88	86	83	80	81	80	83	81	82	81
	Vila	84	86	86	86	86	85	84	82	81	81	81	83
Kiribati (Gilbert)	No data available												
Fiji	Labasa Mill	80	80	83	82	78	78	74	73	73	75	73	78
	Matei	76	78	79	79	81	78	77	77	76	75	75	76
	Nandi	80	80	83	82	78	78	74	73	73	75	73	78
	Nausori Mill	76	78	79	79	81	78	77	77	76	75	75	76
	Savusavu Airport	76	78	79	79	81	78	77	77	76	75	75	76
	Suva	74	76	76	77	79	74	73	74	73	73	74	74
Tonga	Fua'amotu	77	78	79	76	78	77	75	75	74	74	73	75
	Nukualofa	77	78	79	76	78	77	75	75	74	74	73	75

TABLE 2.4 LAND USE IN THE SOUTH PACIFIC - 1978
(Thousand Hectares)

Land Use	Solomon	Vanuatu	Kiribati	Fiji*	Tonga
Agricultural Area:					
Arable land and land under permanent crops	54	NO DATA AVAILABLE	36	233	53
Permanent meadows and pastures	39		-	65	4
Forests and woodlands	2560		2	1185	8
Other lands	101		33	344	2

*1977 data.
Adapted from Statistical Yearbook for Asia and the Pacific, 1979.

TABLE 2.5 AREA, PRODUCTION AND YIELD UNDER PRINCIPAL CROPS IN THE SOUTH PACIFIC

Island Group	Crop	1969			1979		
		Area (thous. ha.)	Production (thous. met.tons)	Yield (met. tons / ha.)	Area (thous. ha.)	Production (thous. met.tons)	Yield (met. tons / ha.)
Solomon	Coconut	-	183	-	-	200	-
	Copra	-	25	-	-	28	-
	Cacao	-	97	-	-	110	-
	Sweet Potato	5	46	9.2	5	50	10.0
Vanuatu	No Data Available						
Kiribati	Coconut	-	55	-	-	86	-
	Copra	-	7	-	-	11	-
Fiji	Rice (Paddy)	10	17	1.7	18	33	1.8
	Sugarcane	47	2377	50.6	60	3850	64.2
	Sweet Potato	1	7	7.0	1	8	8.0
	Cassava	7	84	12.0	8	93	11.6
	Banana	4	6	1.5	5	4	0.8
	Coconut	-	282	-	-	280	-
	Copra	-	34	-	-	25	-
Tonga	Sweet Potato	5	72	14.4	6	79	13.2
	Cassava	2	10	5.0	2	13	6.5
	Banana	2	9	4.5	2	4	2.0
	Coconut	-	105	-	-	100	-
	Copra	-	12	-	-	13	-

Adapted from Statistical Yearbook for Asia and the Pacific, 1979.

D. Economy

The agricultural sector is the backbone of the economy of the South Pacific island groups. The large rural population combined with limited natural resources makes their economies particularly dependent on the weather. Severe economic pressure can be created by the occurrence of tropical cyclones and floods when crops are heavily damaged. Copra, cacao and banana exports are the principal foreign exchange earners of these economies. Natural disasters can drastically reduce the foreign exchange needed for importing processed food stuffs. Some of these island groups are expanding their fishing industries and promoting tourism to improve their balance of trade. (Table 2.6)

TABLE 2.6 TRADE STATISTICS IN THE SOUTH PACIFIC; 1980
(US $ Millions)

Island Group	Export	Imports	Balance of Trade
Solomon	67.3	68.0	- 0.7
Vanuatu	35.2	71.5	- 36.3
Kiribati	2.7	18.9	- 16.2
Fiji	368.0	522.5	-154.5
Tonga	7.6	33.7	- 26.1

Adapted from "Disaster Preparedness and Disaster Experience in the South Pacific", Franco, A.B., Hamnett, M.P., Makasiale, J.; August 1982. East-West Center, Honolulu, Hawaii. Sponsored by AID.

CHAPTER III

SOLOMON ISLANDS

A. Physical Environment

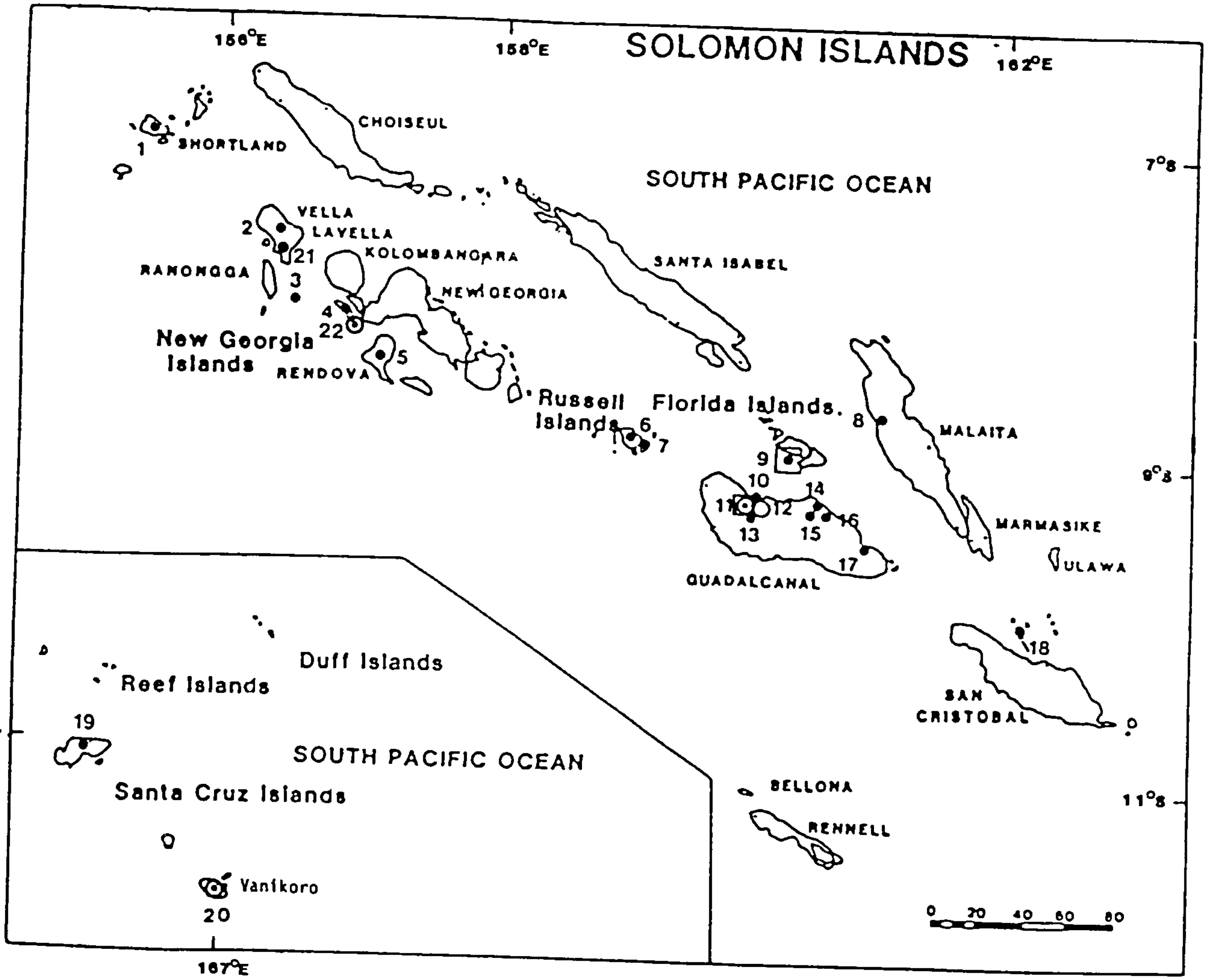
The Solomon Islands consist of six large islands and hundreds of small unnamed islands that stretch 1,450 km from Papua New Guinea across the Coral Sea to Vanuatu. This archipelago lies between 5^oS and 10^oS latitude and 157^oE and 162^oE longitude with a total land area of 29,785 sq. km. (Figure 3.1). Population as of 1981 was 233,000 with an annual growth rate of 3.2 percent.

The six main Solomon Islands are Choiseul, New Georgia, Santa Isabel, Guadalcanal, Malaita and San Cristobal. They consist of volcanic mountain ranges, deep narrow valleys and coastal belts lined with reefs (Figure 3.2). The smaller islands are also mostly volcanic with a few coral atolls as shown in Figure 3.3. All of the Solomon region is geologically active and tremors are frequent.

More than 90 percent of the land area is forested. On the larger islands two natural regions can be distinguished; the heavily forested interior uplands and the discontinuous coastal plains which are relatively free of vegetation except for a few coconut palms. The smaller islands are sparsely vegetated.

B. Climate

The Solomon Islands have a maritime equatorial climate with annual rainfall ranging from about 1,900 mm to 6,000 mm. The mean monthly rainfall pattern varies greatly due to the small island sizes and the different locations (Figure 3.4a and b). In general, the wet season occurs from December to April with two major exceptions. Shortland Island, located northwest of the group, has a more even rainfall distribution throughout the year, peaking during July or August. Annual rainfall in the southeast islands, including Kaoka, Three Sisters and Vanikoro, averages from 4,500 mm to 5,000 mm with the peak anywhere from June to August (Figure 3.4b).



NO.	STATION
1.	Alu
2.	Vella Lavella
3.	Gizo
4.	Kohinggo
5.	Rendova
6.	Pipisala
7.	Mbanika
8.	Auki
9.	Tulagi Island
10.	Lungga
11.	Honiara
12.	Honiara/Henderson
13.	Kukum
14.	Ruavatu
15.	Tenaru
16.	Aola
17.	Kaoka
18.	Three Sisters
19.	Santa Cruz
20.	Vanikoro
21.	Mbarakoma
22.	Munda

Key

- O Historical Station
- • Wernstedt Precipitation Station
- ☐ Wernstedt Temperature Station

Figure 3.1 Solomon Islands historical and normal stations.

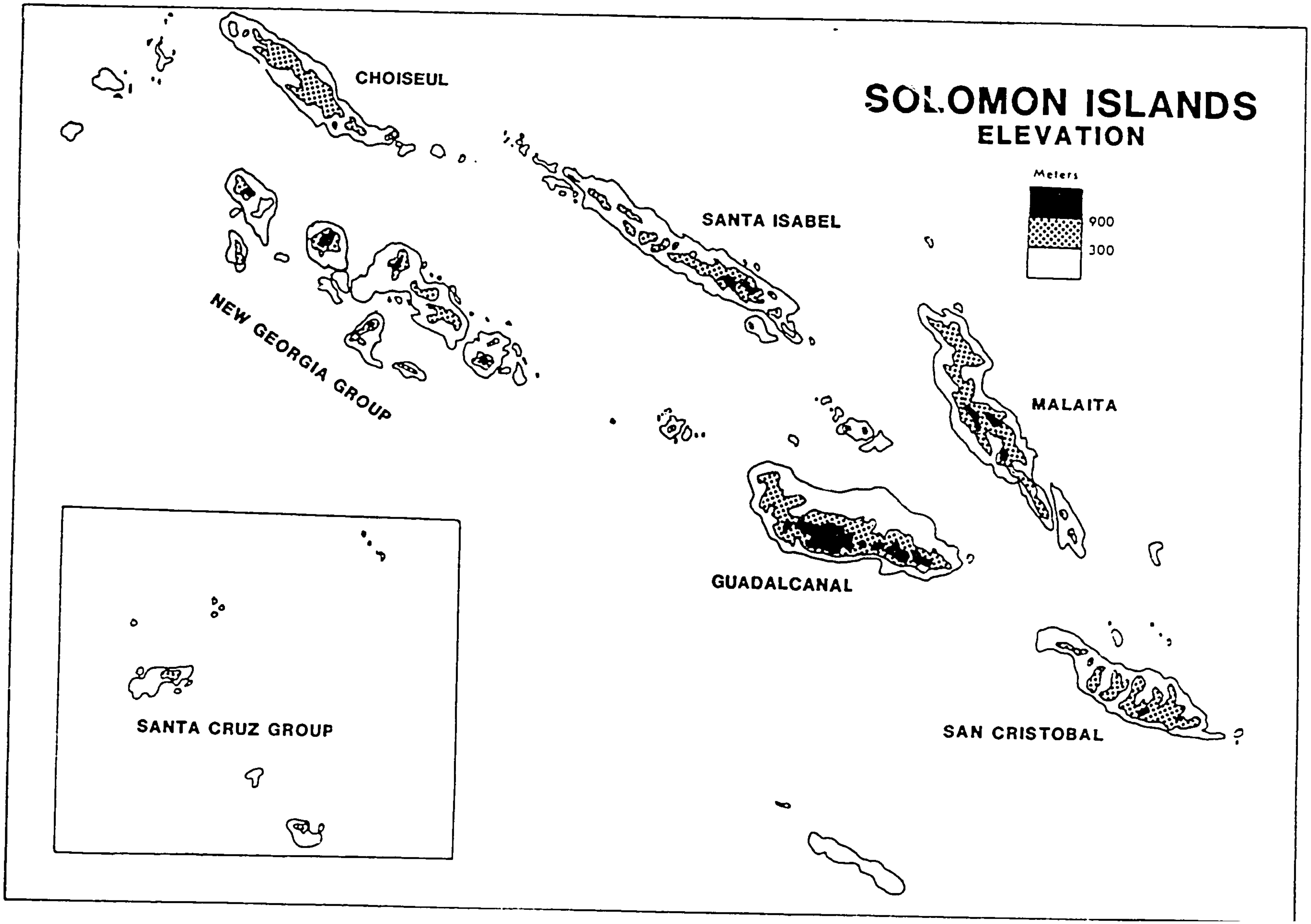


Figure 3.2 Elevation map of the Solomon Islands.

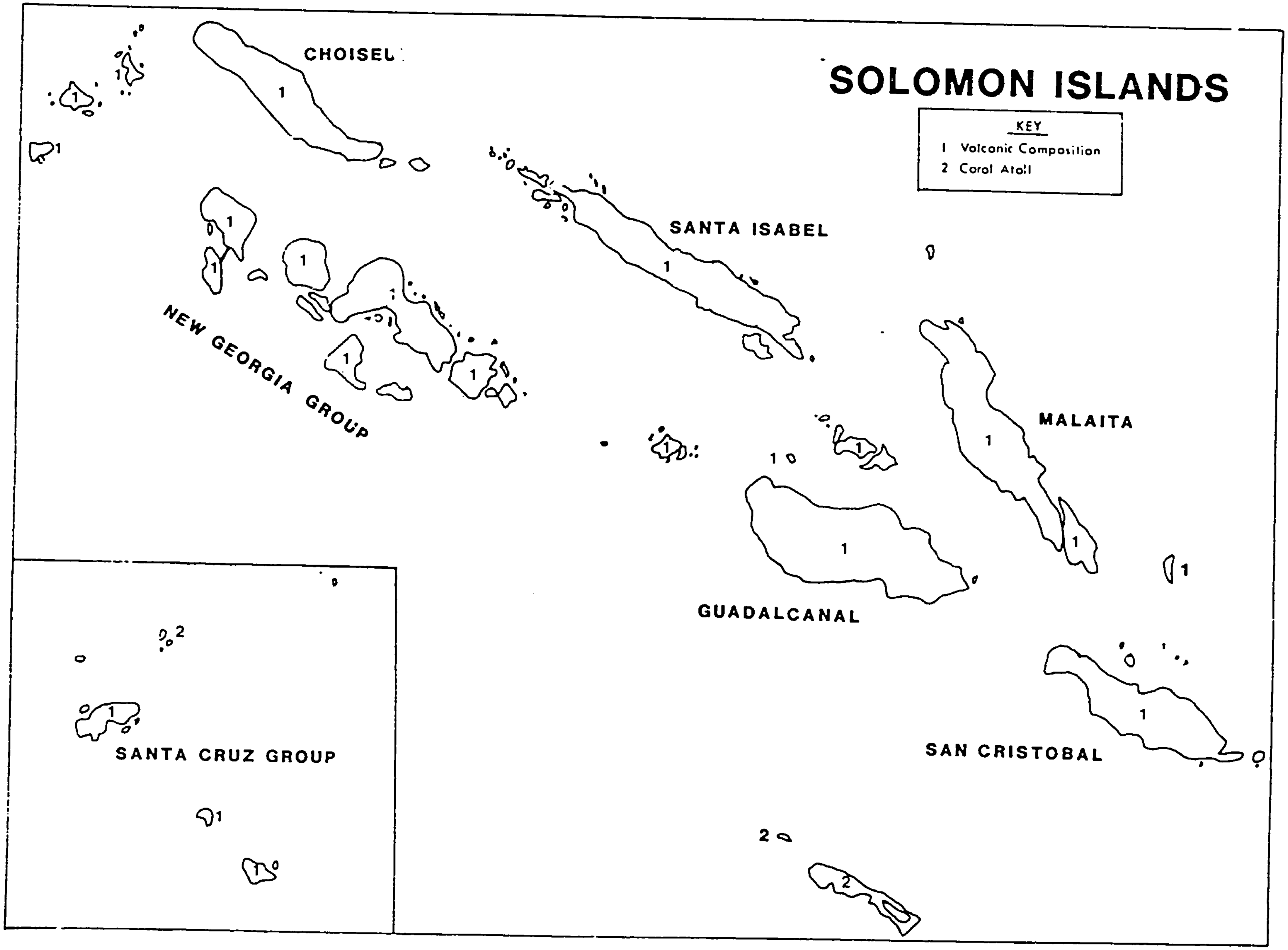


Figure 3.3 Composition map of the Solomon Islands.

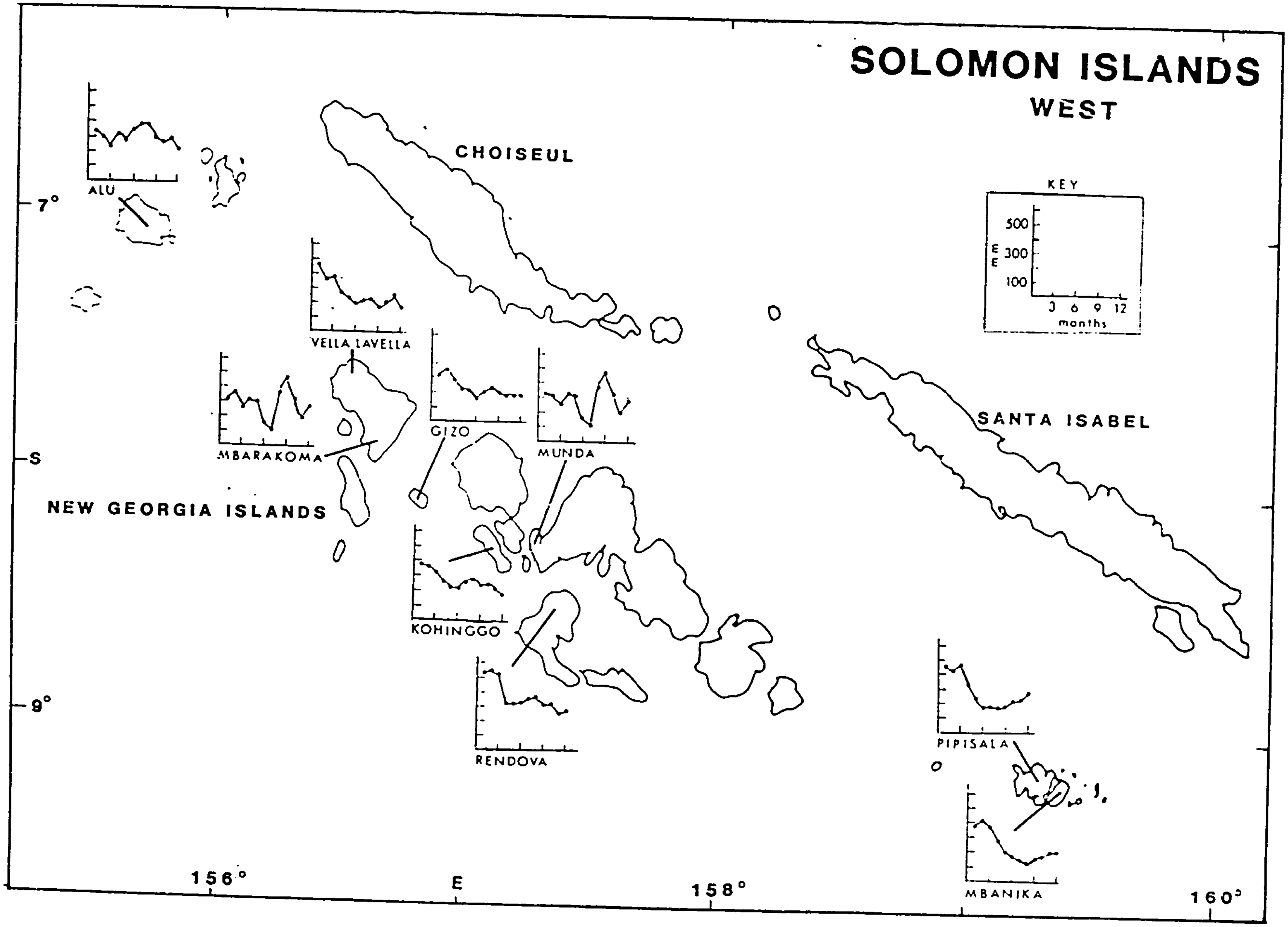


Figure 3.4a Mean monthly rainfall (mm) histograms for selected stations in West Solomon Islands.

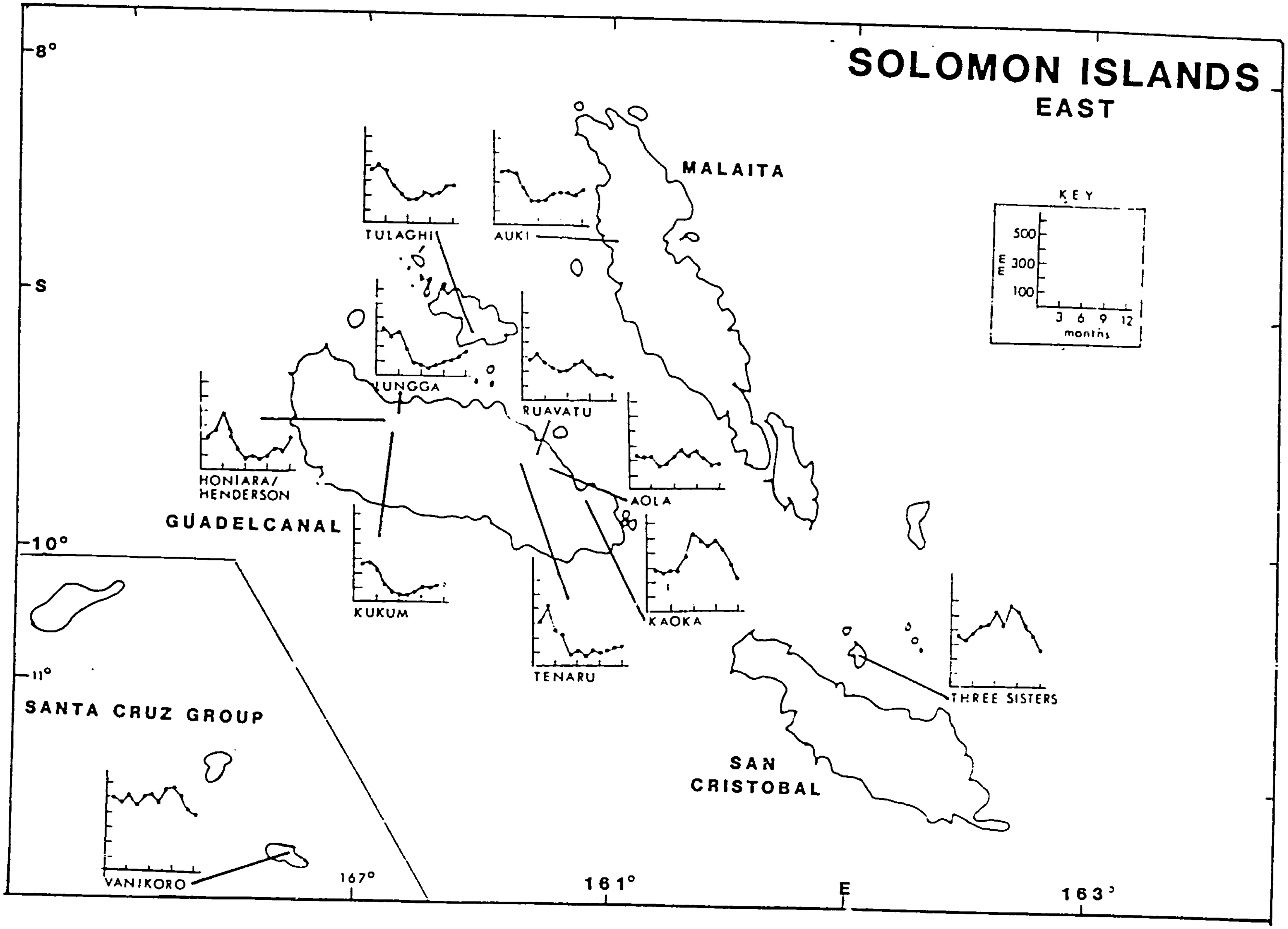


Figure 3.4b Mean monthly rainfall (mm) histograms for selected stations in East Solomon Islands.

Temperatures vary little over the Solomon Islands with the monthly deviations generally remaining within one degree Celsius (Table 2.2). Relative humidity is high year-round, ranging from 70-90 percent (Table 2.3).

Although the seasons are not well pronounced, the winds blow from the northwest November to April bringing more frequent rainfall and slightly higher temperatures. Weather is unpredictable during this period and cyclones are apt to occur. The southeast trade winds occur from late April to October and somewhat modify the climate.

Natural disasters common to the Solomon Islands besides cyclones are earthquakes, hurricanes, tsunamis and volcanic eruptions. (See Appendix B for 1951-82 episodic events.)

C. Agriculture

Nine of ten households are engaged in either commercial or subsistence agriculture. As much as 96 percent of the total land area is used for bushlands, producing wildcrops that are gathered by natives, and small subsistence gardens or village lands used for village gardens and commercial crops. The land use in the Solomon Islands is shown in Figure 3.5. The climate and generally fertile soils, along with low population density, allow most tropical crops to be grown.

Coconut, in the form of copra and some oil, is the most valuable commercial crop in the Solomons. Most of the plantations are on coastal land and are owned by European growers, although native production in village gardens is increasing. The coconuts are produced year-round.

Cacao is another important commercial crop. The largest producing areas are Guadalcanal, producing 29 percent of the total; Central Islands, 27 percent; Malaita, 24 percent; and the Western District, producing far less at 12 percent. A very important development in cacao production came in the late 1970's when yields were tripled with the introduction of a disease-resistant variety suited

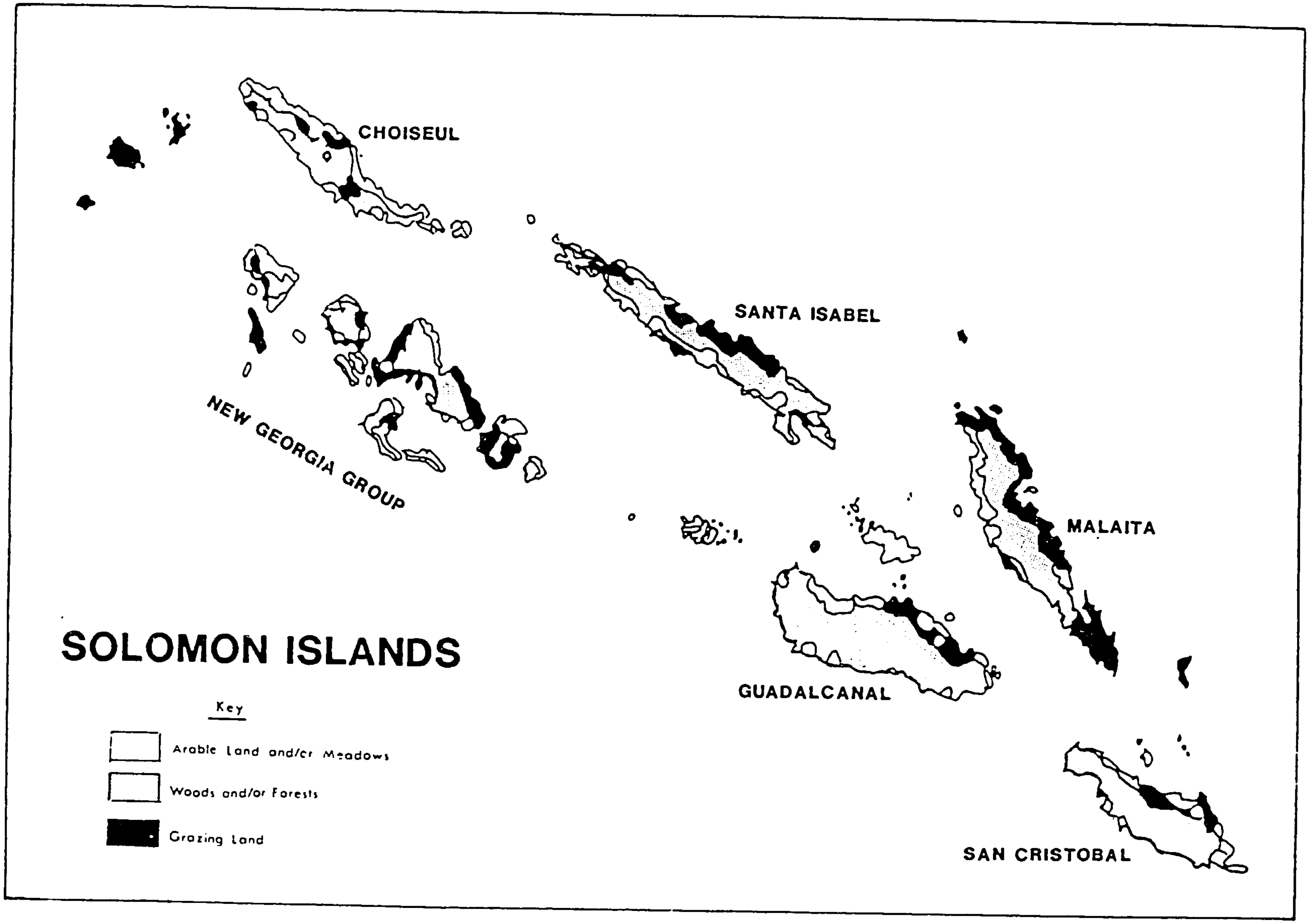


Figure 3.5 Land use in the Solomon Islands.

to local soils. Since then small holders have increased their share of total production from 29 to almost 50 percent.

Oil palm and rice are cultivated successfully on large scale plantations and are becoming increasingly important exports. Oil palm is generally planted during November and December and harvested from April to May. Rice is irrigated and two crops are grown each year. The main crop is planted in March and April and harvested during August and September while the secondary crop is planted in September and October and harvested in February and March. The major growing area for both crops is Guadalcanal. Other crops grown on a smaller scale for export include turmeric, ginger, cinnamon, tabasco, and allspice.

Subsistence crops are grown on two types of plots: 1) garden plots which are cultivated by natives and used exclusively for local food crops, and 2) larger village plots which produce both subsistence and commercial crops. The major crops grown for domestic consumption are sweet potatoes, harvested May to December; yams, harvested February to June; taro, harvested June to December; corn, harvested March and April; and green vegetables of all kinds. Bananas and cassava are grown year-round, also on a small scale (Table 3.1).

D. Economy

The economy of the Solomon Islands is primarily based on three major industries. They are agriculture, timber and fisheries.

Agricultural production is extremely important to the Solomon economy in both commercial exports and subsistence agriculture (which alone accounts for 40 percent of the Gross Domestic Product). Copra, making up 34 percent of all exports, and to a lesser extent, cacao, oil palm, rice and spices are the main agricultural inputs to the economy.

TABLE 3.1

ESTIMATED CROP CALENDAR FOR SOLOMON ISLANDS

///Planting, —— Transplanting, 000 Harvesting

Crop	J	F	M	A	M	J	J	A	S	O	N	D
Banana	000	000	000	000	000	000	000	000	000	000	000	000
Coconut	000	000	000	000	000	000	000	000	000	000	000	000
Taro	///	///	///	///		000	000	000	000	000	000	000
Cassava	000	000	000	000	000	000	000	000	000	000	000	000
Corn			000	000								
Sweet Potato	///	///	///	///	000	000	000	000	000	000	000	000
Yams		000	000	000	000	000	///	///	///	///	///	
Rice (Irrigated)												
1st Crop			///	~~///~~——	——			000	000			
2nd Crop		000	000						///	~~///~~——	——	

Major timber operations on Kolombangara, New Georgia, Santa Cruz, Guadalcanal and Shortland Islands account for 31 percent of all exports. Major replanting in 1980 helped diversify the economy making it less vulnerable to rapid changes in a single commodity price.

The fishing industry is also being used as a diversification in the economy and accounts for 33 percent of all exports. Commercial fishing operations are generally conducted near the major population centers of Honiara, Guadalcanal, Auki, Malaita and Gizo. Other marine export products include shells and green snails.

CHAPTER IV

VANUATU

A. Physical Environment

Vanuatu, earlier known as New Hebrides, attained independence on July 30, 1980. It is a double chain of twelve main islands and about seventy smaller islets. Vanuatu is located between 12°S and 21°S latitude and 166°E and 171°E longitude with a total land area estimated at about 14,763 sq.km. (Figure 4.1). The population in 1981 was 120,000.

Vanuatu is characterized by a diverse relief (Figure 4.2). The islands range from rugged mountains and high plateaus to rolling hills and low plateaus with coastal terraces. Half of the islands are simply islets and rocky volcanic outcrops (Figure 4.3). Sedimentary and coral limestones or volcanic rocks are predominant and frequent earthquakes indicate structural instability. A number of active volcanoes erupt on the islands periodically.

The islands are densely forested with a thick undergrowth of tall trees, vines and ferns. The high plateaus on the larger islands have a savannah - like vegetation, particularly on the leeward side. Kauri, pine, teak, and sandlewood are also abundant in Vanuatu.

B. Climate

The climate of Vanuatu is hot and humid, quite typical of the area. Annual rainfall ranges from 1,800 mm in the south to over 4,000 mm in the north and from 1,700 mm in the west to over 3,000 mm in the east. The rainy season generally extends from January to April with the peak rainfall occurring in March. The dry season usually lasts from June to October (Figure 4.4).

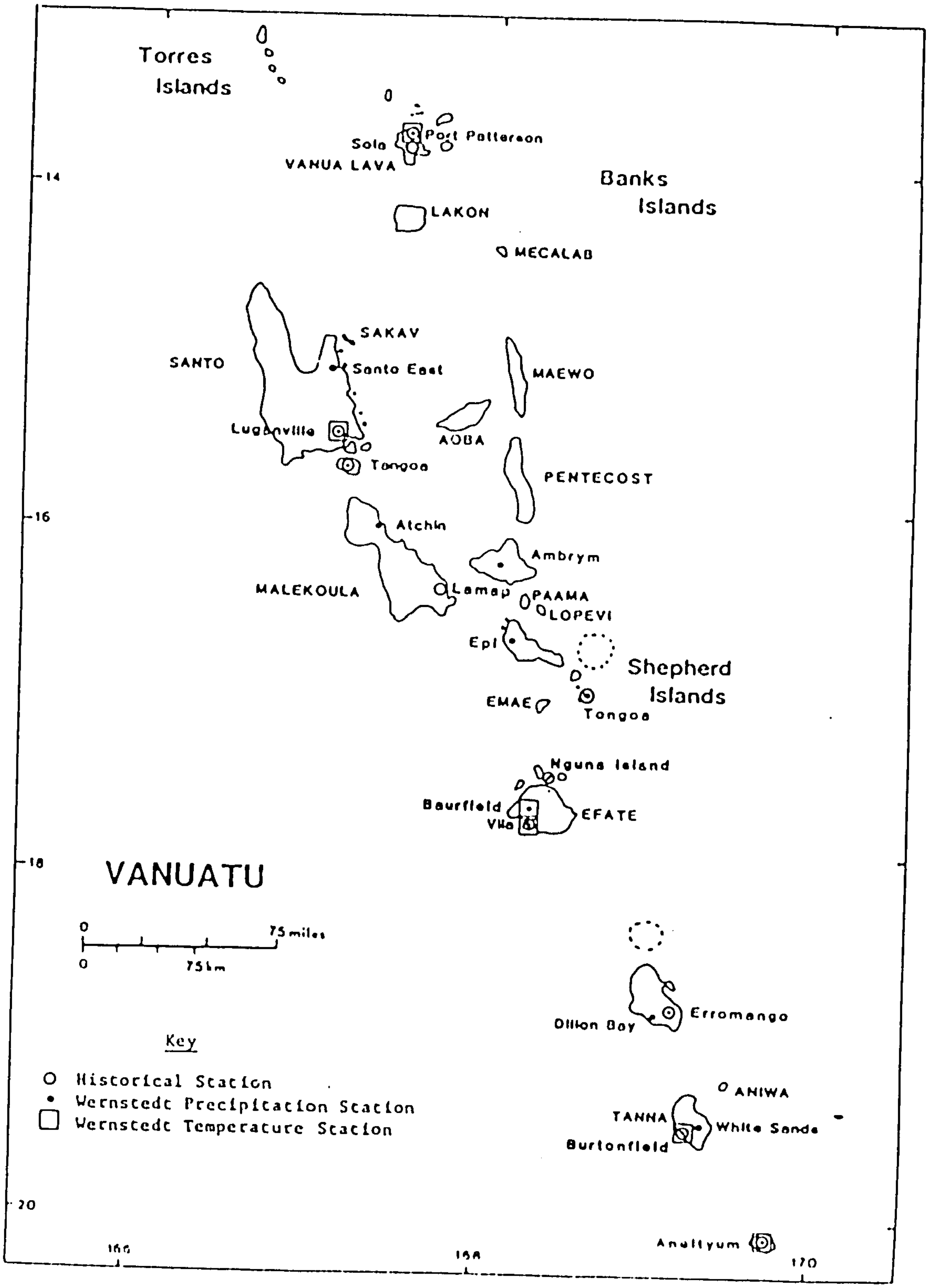


Figure 4.1 Vanuatu historical and normal stations.

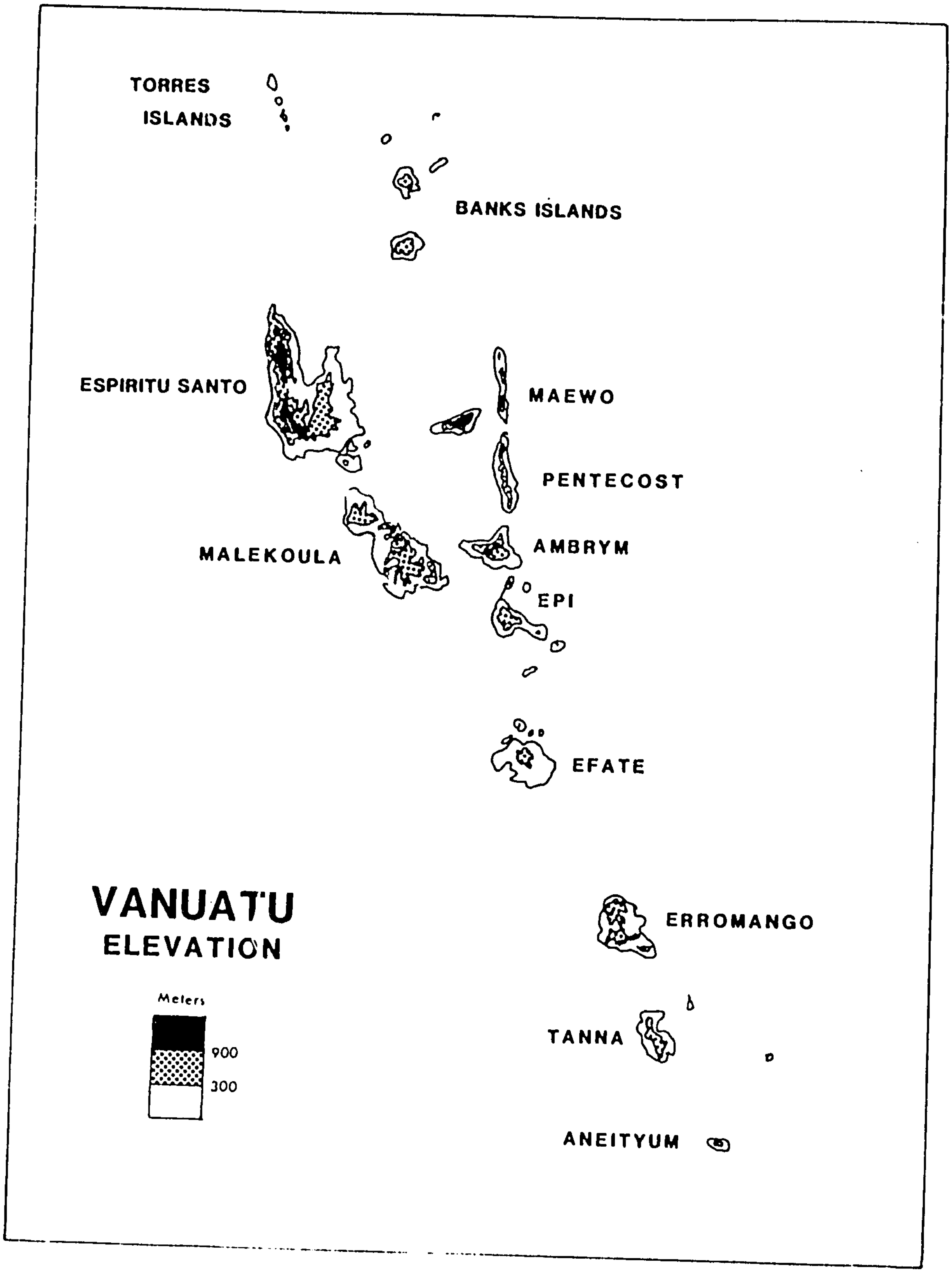


Figure 4.2 Elevation map of Vanuatu.

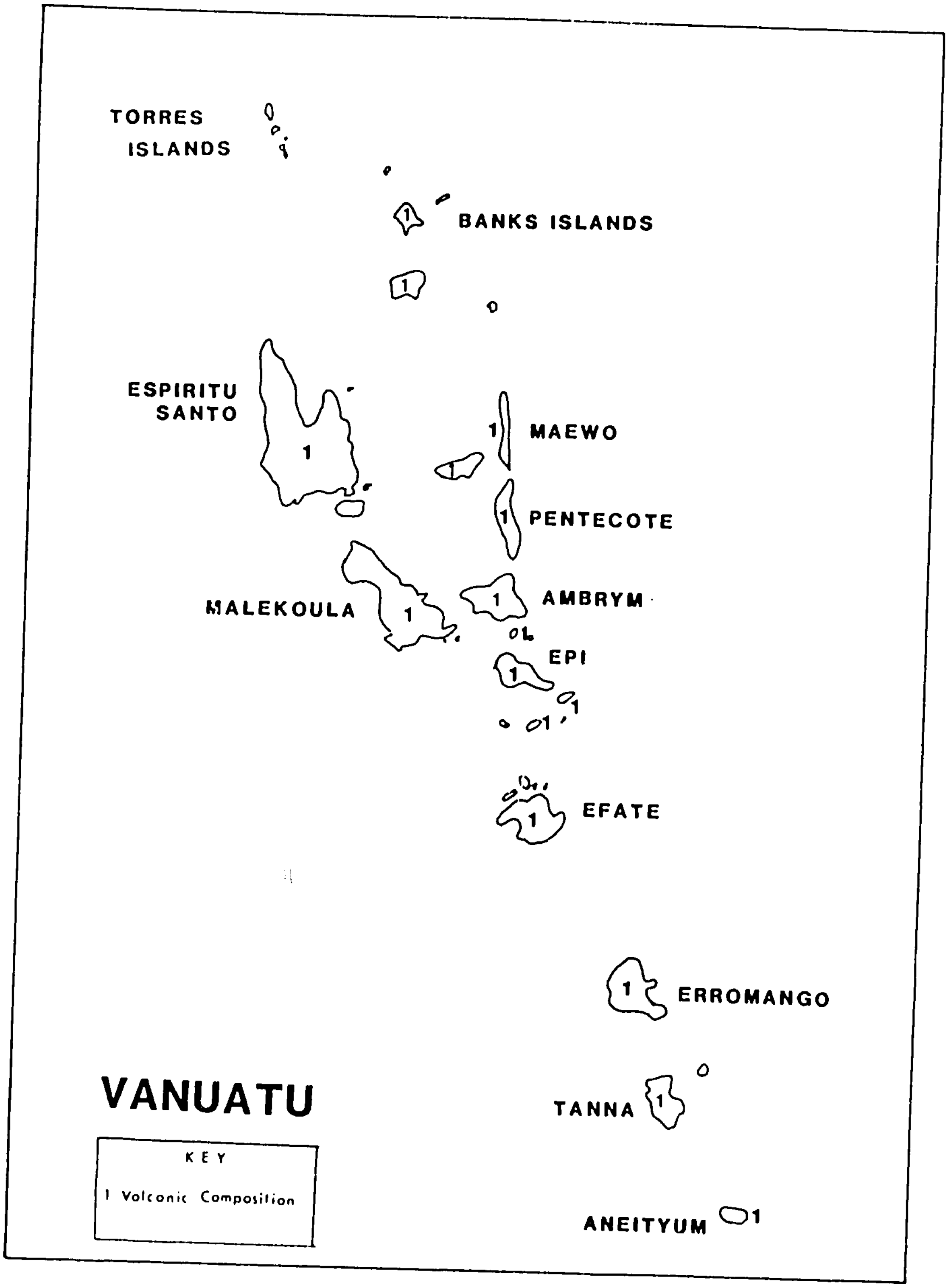


Figure 4.3 Composition map of Vanuatu.

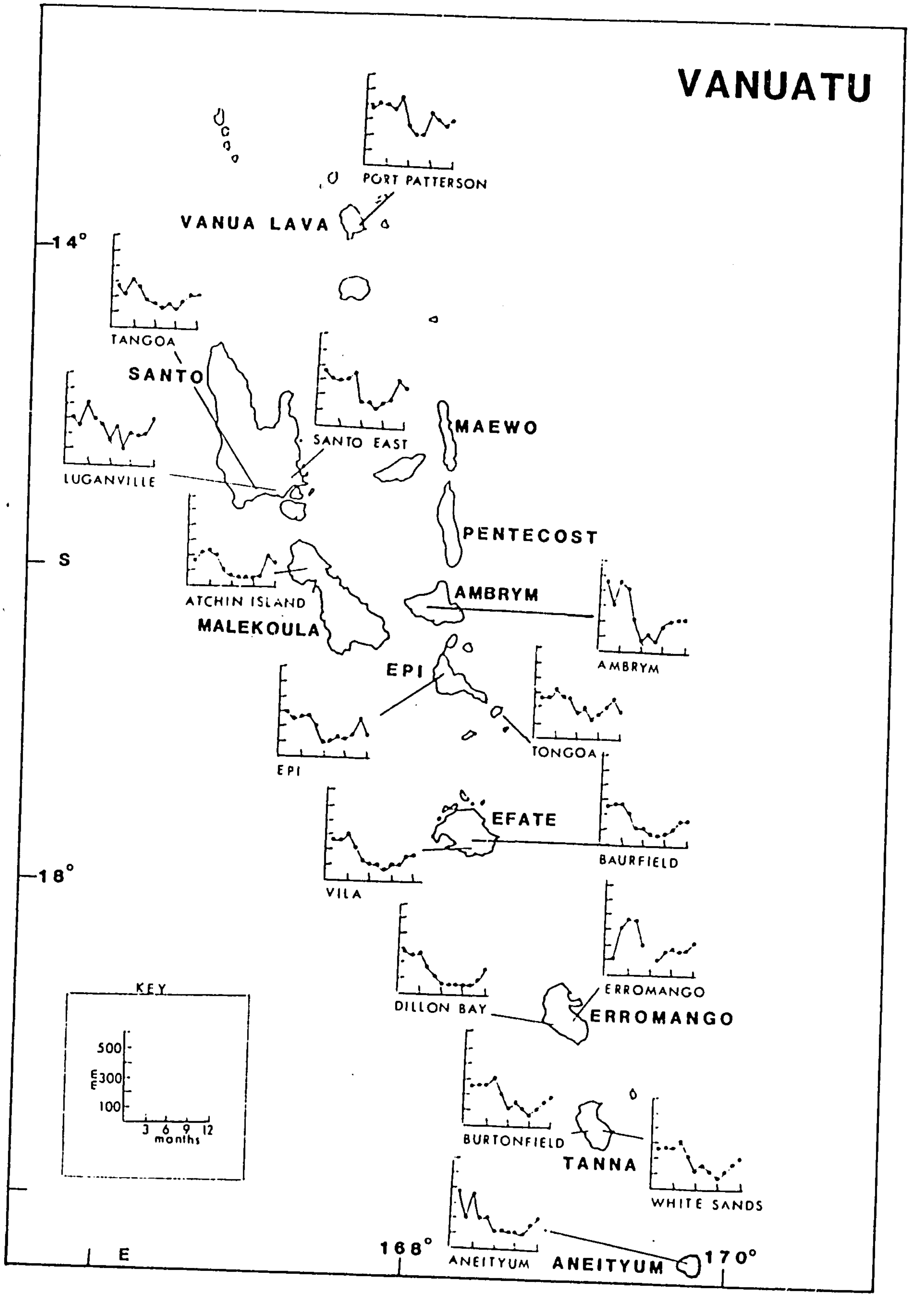


Figure 4.4 Mean monthly rainfall (mm) histograms for selected stations in Vanuatu.

The annual average temperature also increases from south (24°C) to north (26°C). The hot season lasts from December to March with the cool season lasting from July to August (Table 2.2).

The prevailing southeast trade winds temper the hot climate. However, frequent calms can be followed by winds from northeast, bringing rain. Annual average humidity is 83 percent, ranging from about 78-85 percent (Table 2.3).

Vanuatu lies within the hurricane zone and once or twice a year, normally during December to April, the islands are struck. Other natural disasters include earthquakes, volcanic eruptions, tsunamis, sea swells, droughts and floods. (See episodic event data in Appendix B, 1951-82.)

C. Agriculture

As in most of the South Pacific, agriculture is important to Vanuatu. The bulk of the population is engaged in some aspect of agriculture either in commercial production for export or subsistence production for local consumption. Land use in Vanuatu is shown in Figure 4.5. Forests and grazing lands exceed arable land at present. This can change in the future to accomodate population pressure.

Coconut, processed into copra and coconut oil, is the most important commercial crop grown. The soil and climate are particularly favorable on coastal plantations found on Espiritu Santo, Malakula, Pentecost and Efate Islands. The coconuts are grown and harvested year-round. Yields are low and cultivation methods are poor but due to extensive replanting copra is the largest export commodity.

Cacao and coffee are the other two major commercial crops. These crops are not as well suited to the coral coastal soils and production has fluctuated during recent years with little replanting. European growers produced most of the cacao and coffee before World War II, but the Department of Agriculture has

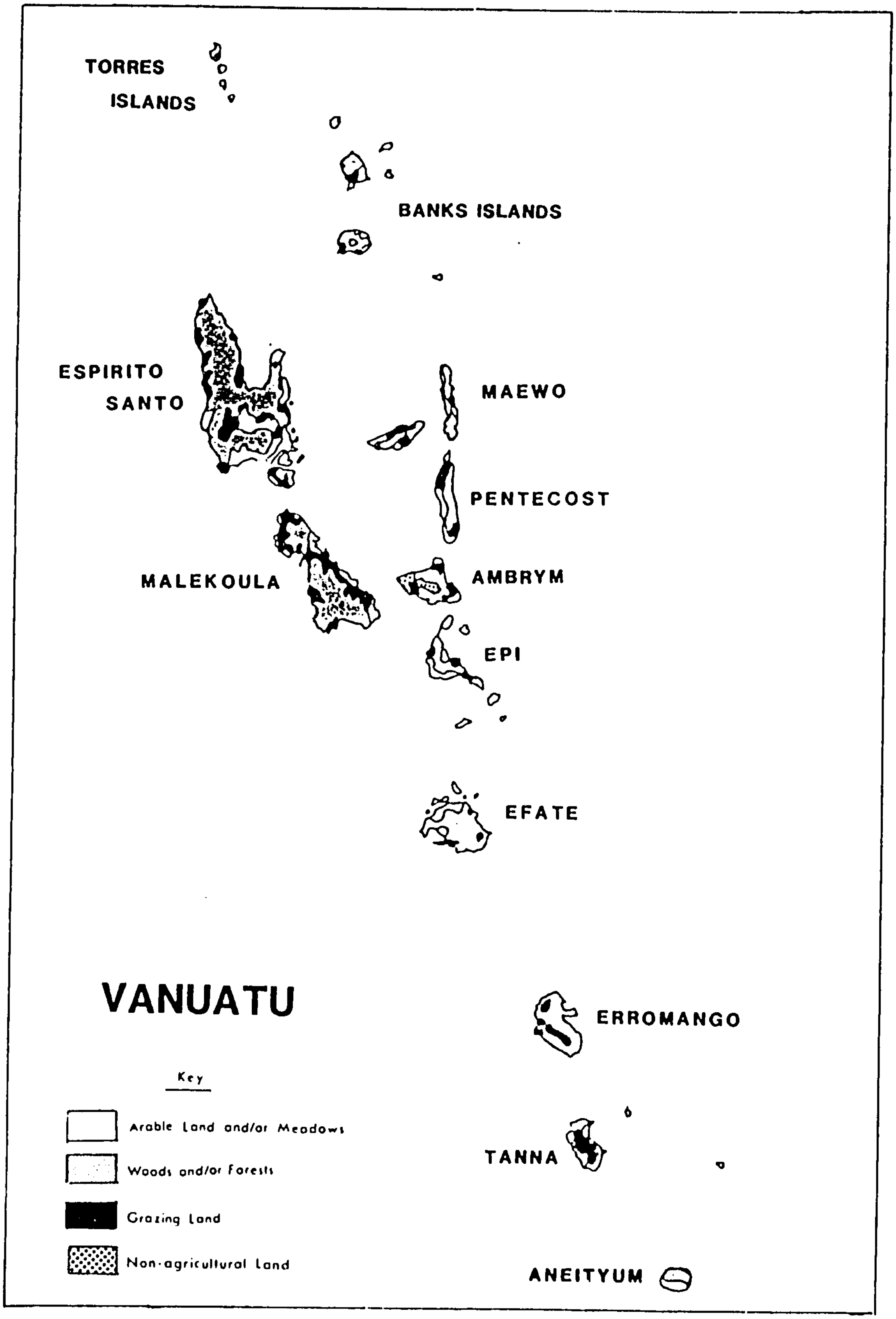


Figure 4.5 Land use in Vanuatu.

tried to encourage native production in recent years with only moderate success.

Subsistence crops for local consumption generally include taro, harvested June to November; sweet potato, harvested March to November; yams, harvested February to July; and corn, harvested February and March. Bananas and cassava are also grown, with harvesting occurring year-round (Table 4.1). A form of shifting agriculture is practiced on these crops, which are cultivated mainly on coastal plains.

Surveys have shown that higher elevations are fertile and suitable for both commercial and subsistence tropical crops. However, population pressure has not yet been great enough to force the use of this land.

D. Economy

The production of coconuts, fish and beef are the main contributors to the Vanuatu economy. These industries total 95 percent of all exports.

The second most important industry, at least in future terms, is tourism. It is a great hope for Vanuatu and the opening of two resort hotels have increased the significance of tourism. The future importance of this industry rests mainly with improved regional air links.

Currently, mining adds little to the economy with the exception of manganese which is produced on the east coast of Efate at Furari and is exported to Japan. However, there is a possibility of economic growth in mining due to new deposits of manganese, discovered on Erromango, and pozzalan extractions (volcanic ash used in making cement).

Timber shows little promise of great economic progress. Only Erromango, Efate and Aneityum have useful timber stands and the kauri stands on Erromango have already been exploited.

Other small industries which contribute to the economy are cacao and coffee exports, trochus and green-snail shell export and small scale manufacturing

TABLE 4.1

ESTIMATED CROP CALENDAR FOR VANUATU ISLANDS

///Planting, —Transplanting, 000 Harvesting

Crop	J	F	M	A	M	J	J	A	S	O	N	D
Banana	000	000	000	000	000	000	000	000	000	000	000	000
Coconut	000	000	000	000	000	000	000	000	000	000	000	000
Taro	///	///	///	///		000	000	000	000	000	000	///
Cassava	000	000	000	000	000	000	000	000	000	000	000	000
Sweet Potato	///	///	///	///	000	000	000	000	000	000	000	
Yams		000	000	000	000	000	000		///	///	///	///
Corn		000	000								///	///

CHAPTER V

KIRIBATI (GILBERT ISLANDS)

A. Physical Environment

Kiribati (Gilbert Islands) consists of 17 islands which lie from 27°S to 3.3°N and 172.9°E to 176.8°E longitude (Figure 5.1). Banaba, now officially part of Kiribati, lies just to its west at 9°S latitude and 169.5°E longitude. The land area is estimated at 278 sq. km. with a population of 53,835 (as of December, 1978).

The islands are all low coral atolls, no more than 5 meters high, with the exception of Banaba which is a raised atoll (Figure 5.2). These coral rocks are covered with up to 2.5 m of hard sand and scanty soil that is incapable of retaining moisture. Native land vegetation is limited including only seaside scrub, pandanus and coconuts.

B. Climate

While Kiribati (Gilbert Islands) lies in the South Pacific, its climate varies from the other island groups. The climate is less trying, and drought, rather than cyclonic activities, is the primary concern.

Rainfall varies considerably from island to island as well as from year to year. The northern islands receive the most rainfall, from over 1,350 mm to 2,300 mm. The north-central islands of Aranuka and Abemama receive slightly less at about 1,000 mm to 1,100 mm while the south-central islands of Kuria, Nonouti, Beru, and Nukunau receive the least rainfall ranging from 850 mm to almost 1,000 mm. Tabiteuea, Onotoa, Tamana and Arorae (the southern islands) receive moderate rainfall from just over 1,000 mm to 1,300 mm.

The rainy season lasts from November to March, with a definite peak in January. The dry season generally lasts from April to October, although

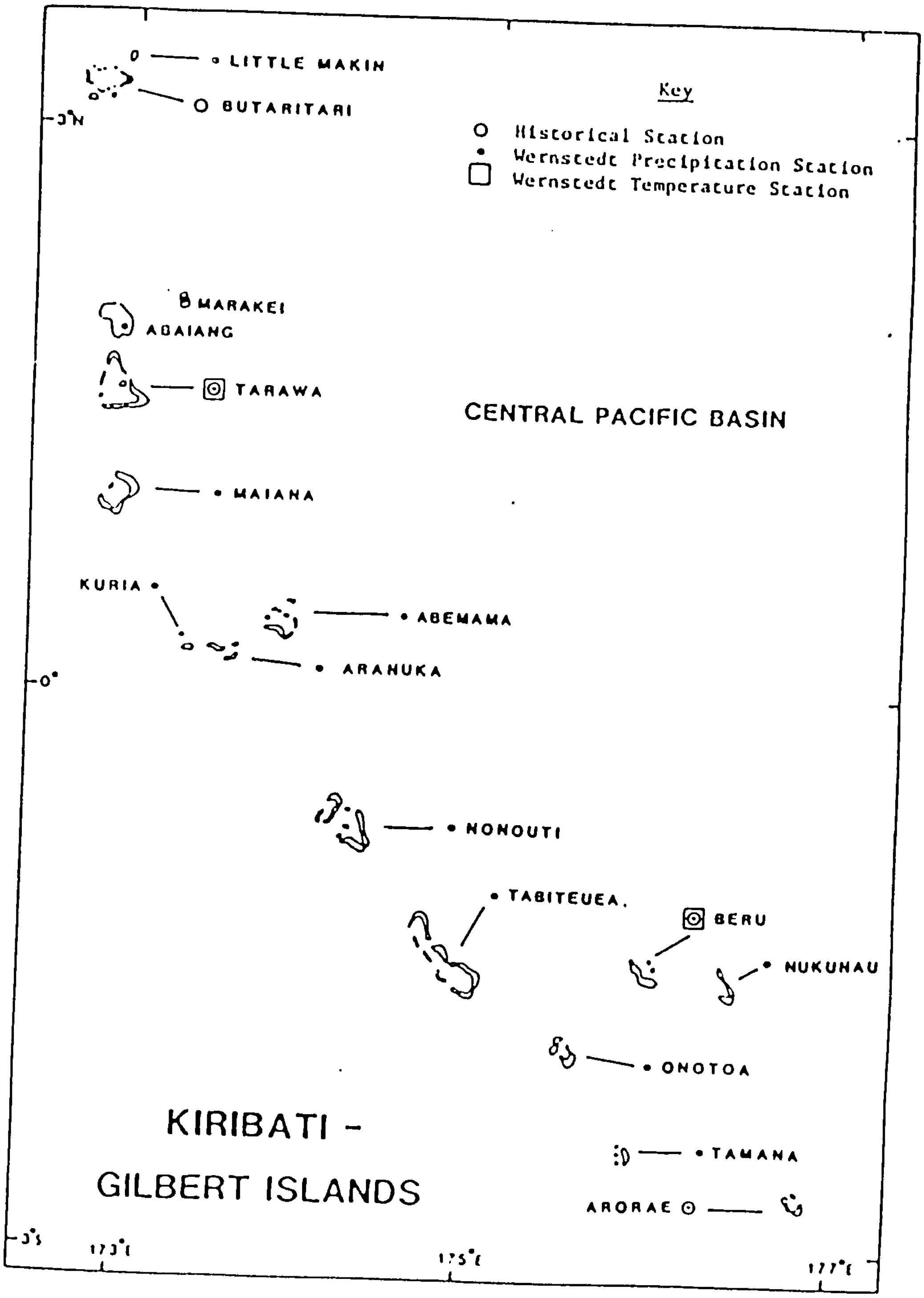


Figure 5.1 Kiribati (Gilbert Islands) historical and normal stations.

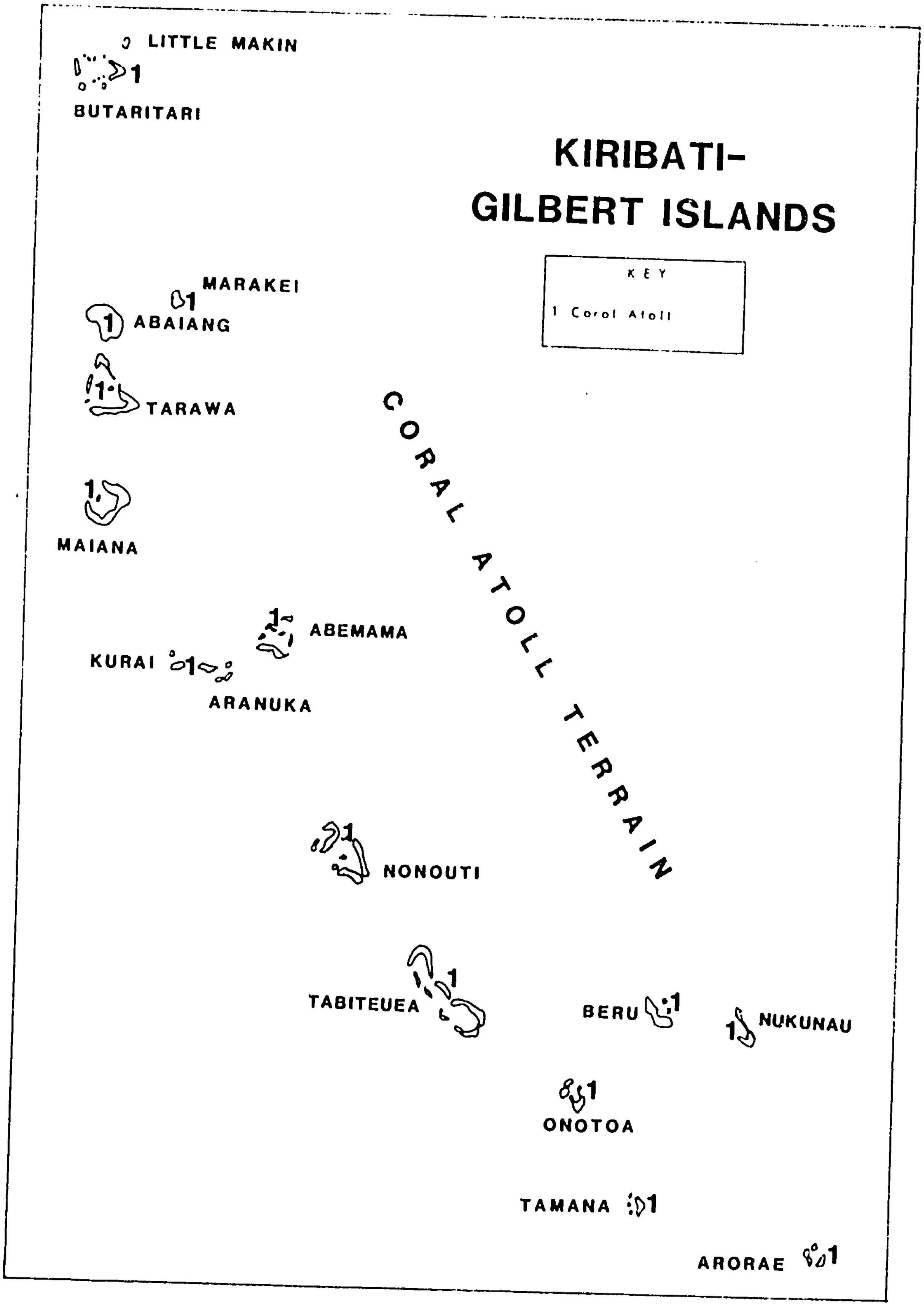


Figure 5.2 Composition map of Kiribati.

there is a small secondary rainfall peak occurring about June (Figure 5.3).

Unlike rainfall, temperature varies little throughout Kiribati. The average annual temperature is 28.3^{o}C with a variability of no more than one degree Celcius throughout the year (Table 2.2). Both the northeast and southeast trade winds blow seasonally.

Natural disasters in addition to drought include potential tsunamis, earthquakes and epidemics. (See Appendix B for episodic event data, 1951-82.)

C. Agriculture

There is very little agriculture in Kiribati due to the shallow sandy soil and variable rainfall. The only commercial crop grown is coconut and copra production has fluctuated greatly over the years. Food crops for local consumption include coconuts, bananas, taro (babai), cassava and breadfruit, harvested year-round and sweet potatoes, harvested April to August in the southern islands (Table 5.1).

D. Economy

The economy of Kiribati is very limited. Copra production accounts for 80 percent of all exports while handicrafts, fisheries and other small commodities make up the other 20 percent. The last phosphate mining operation closed in 1979 and there are no other proven mineral deposits. Trial timber plantings achieved little success.

There are some future prospects for the economy, however. In April, 1978 Kiribati declared a fishing and economic zone, giving them control of a 1,061,300 sq. km. sea area. Considerable hopes are placed on the development of marine resources, particularly in brine shrimp, pennaeid shrimp and fish around Tarawa. Tourism is also expected to increase with the newly-formed Kiribati Visitation Bureau. With expanding air and hotel accomodations, as well as war relic attractions, it is hoped that the tourism industry will play a significant role in the country's future.

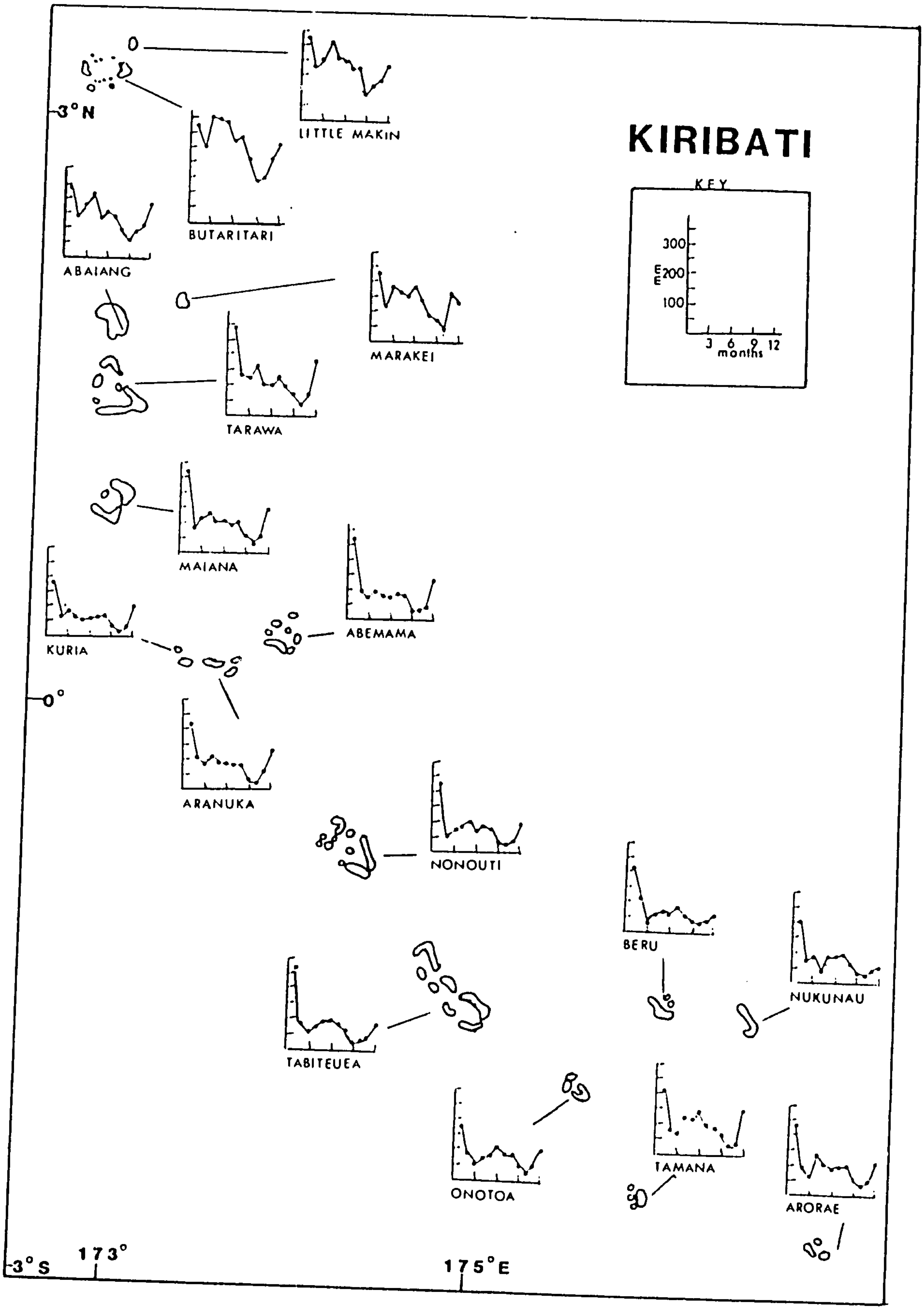


Figure 5.3 Mean monthly rainfall (mm) histograms for selected stations in Kiribati.

TABLE 5.1

ESTIMATED CROP CALENDAR FOR KIRIBATI (GILBERT ISLANDS)

///Planting, —Transplanting, 000 Harvesting

Crop	J	F	M	A	M	J	J	A	S	O	N	D
Northern Islands:												
Banana	000	000	000	000	000	000	000	000	000	000	000	000
Coconut	000	000	000	000	000	000	000	000	000	000	000	000
Taro (Babai)	000	000	000	000	000	000	000	000	000	000	000	000
Cassava	000	000	000	000	000	000	000	000	000	000	000	000
Breadfruit	000	000	000	000	000	000	000	000	000	000	000	000
Southern Islands:												
Taro	000	000	000	000	000	000	000	000	000	000	000	000
Sweet Potato	///	///		000	000	000	000	000				///

CHAPTER VI

FIJI ISLANDS

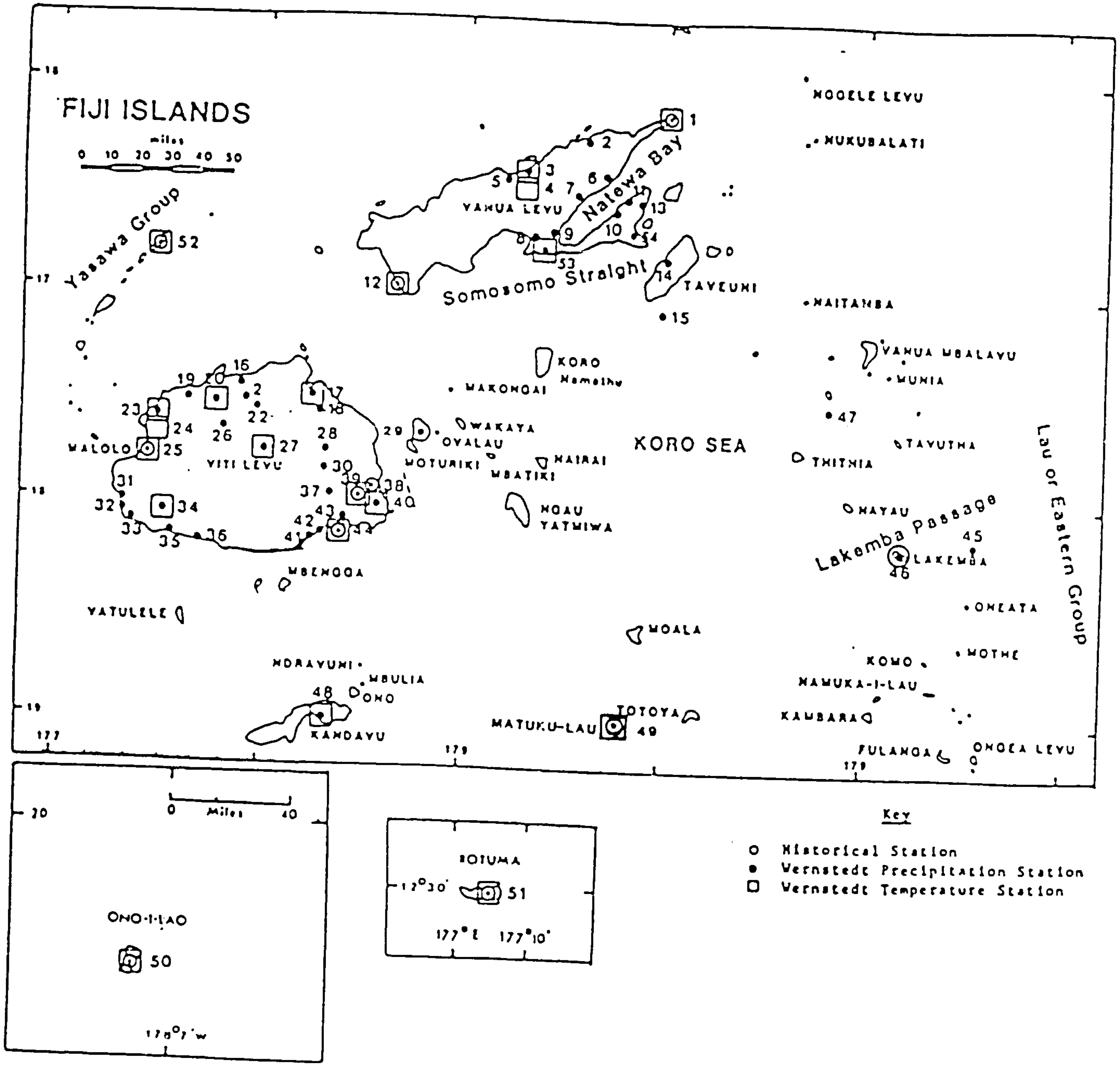
A. Physical Environment

The Fiji Islands consist of 361 islands covering 18,257 sq. km. The two islands of Viti Levu and Vanua Levu make up ninety percent of the total land area. Fiji is located in the northwestern part of the Pacific Ocean between 15°S and 22°S latitude and 177°W and 174°E longitude. Rotuma Island, located 4°NW of the main Fiji groups, is also considered part of the area (Figure 6.1). Current population in the Fiji Islands as of 1983 was 676,000 with an annual growth rate of 1.9 percent.

The north central part of Viti Levu consists of high mountainous terrain (Figure 6.2). The island of Vanua Levu is much less rugged. Taveuni has mountain ranges running in a southwest to northeast direction. These mountain ranges are situated at right angles to the prevailing wind direction.

Most of the larger islands are ancient volcanic peaks. Others are upthrust limestone pierced by volcanic cones or coral formations that cap islands remaining below the water surface (Figure 6.3). These island groups rise from two platforms in a submerged mountain chain. Viti Levu and Vanua Levu, the largest and most populous islands, and the smaller island groups of Yasawa and Lomaiviti rise from the broader western platform. The eastern platform forms the base of the Lau Island group made up of about 50 islands, mainly limestone, and a few atolls, some of which are volcanic in origin. The two platforms are separated by the Roro Sea with the ridge of the Mauku Passage joining them.

Tropical rain forest covered about fifty percent of the high islands on the windward side. Much, however, has been destroyed by slash-and-burn agricultural methods and has been replaced by secondary bamboo, reed, and scrub growth. The leeward sides give way to open areas called talasiga (sunburned land) that are



NO. STATION
1. Undu Point
2. Wainikoro
3. Labasa Mill
4. Lambasa Airport
5. Wailevu
6. Natova
7. Waiqele
8. Balaga
9. Valeci
10. Vunilangi
11. Mua
12. Nambouwalu
13. Vanaira
14. Waiyevo
15. Salialevu
16. Tavua
17. Penang Mill
18. Dobuilevu
19. Tagitagi
20. Rarawai Mill
21. Koronubu
22. Vatukoula
23. Lautoka Mill
24. Lautoka PO
25. Nadi
26. Veisaru
27. Nandarivatu
28. Nayavu
29. Levuka
30. Vunidawa
31. Lomawai
32. Tau
33. Navo
34. Nacoco..vu
35. Lavangga
36. Tamanua Reservoir
37. Wailoku
38. Nausori Airfield
39. Lauthala Bay
40. Nausori Mill
41. Naitonitoni
42. Nakukavesi
43. Suva, Tholo-I-
44. Suva
45. Lauthala Island
46. Lakemba
47. Mango Island
48 Vunisea
49. Matuku-Lau
50. Ono-I-Lau
51. Rotuma
52. Yasawa-I-Kara
53. Savusavu AP
54. Matei

Figure 6.1 Fiji Islands historical and normal stations.

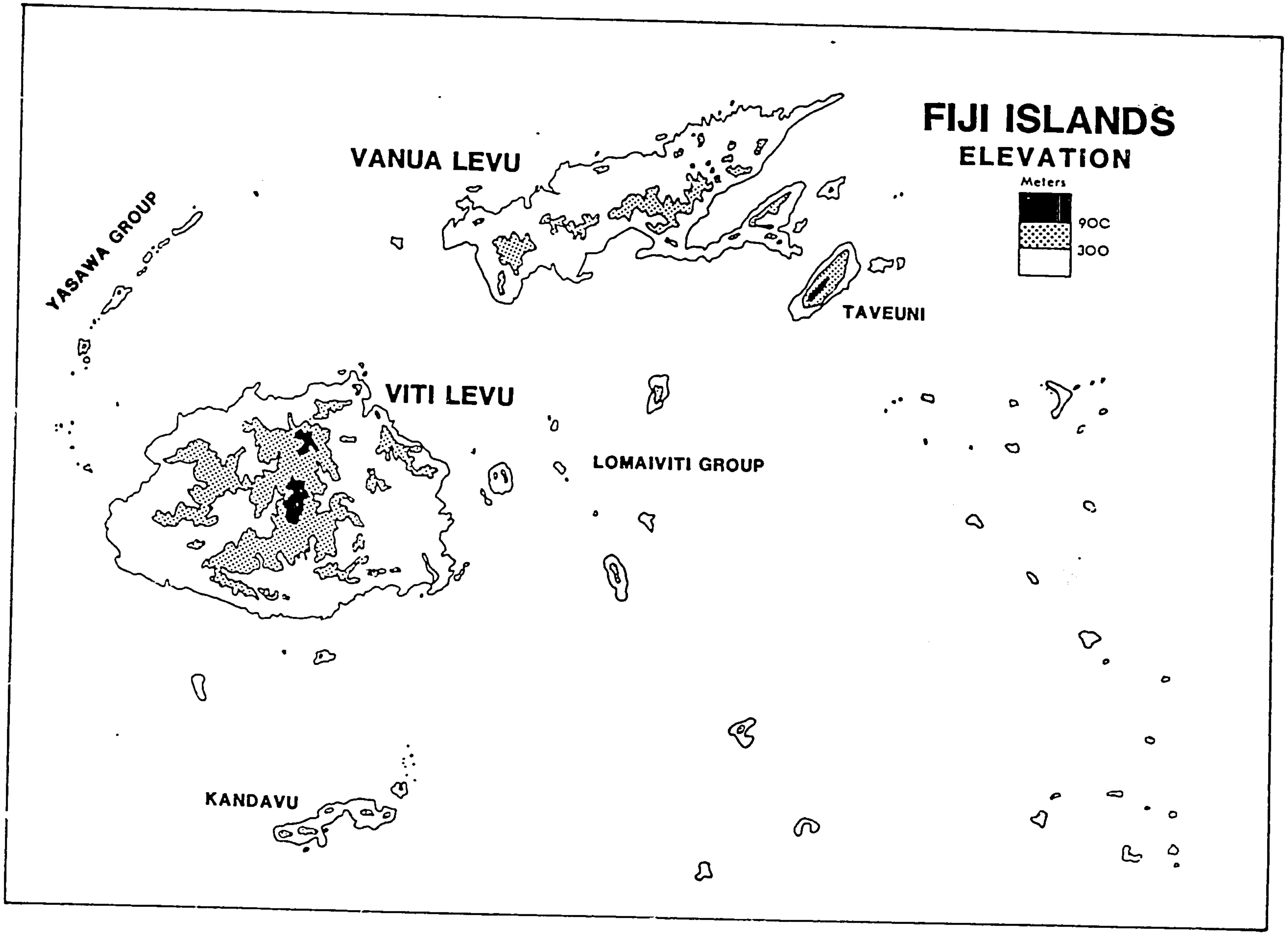


Figure 6.2 Elevation map of the Fiji Islands.

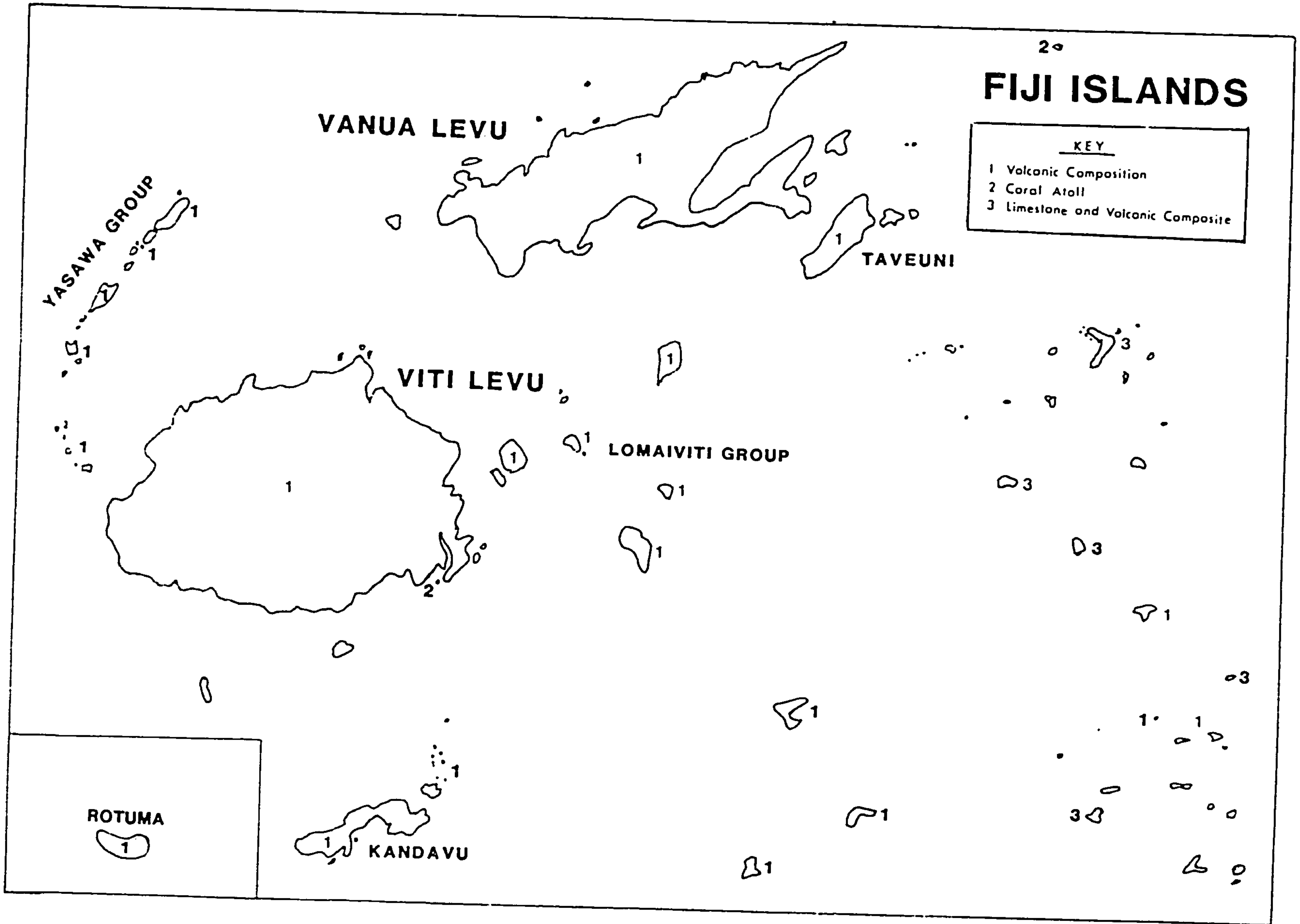


Figure 6.3 Composition map of the Fiji Islands.

dry and contain only sparse, low vegetation. The low islands are sparsely timbered with little spontaneous vegetation due to low amounts of precipitation and sandy soils.

B. Climate

Fiji has a tropical maritime climate with warm, humid southeast trade winds. The windward sides have relatively high average rainfalls of about 3,000-5,100 mm annually. The central mountains create a rain shadow on the northern and western sides lowering the precipitation average to just over 1,700 mm annually. The interior of the larger islands, with elevations over 1,500 m in places, often receive as much as 7,700 mm of annual precipitation while the low islands are often so dry that even drinking water is scarce. This problem is alleviated at times by severe cyclonic tropical storms.

February and March are usually the wettest months in both the dry and wet areas. The dry areas do have a clearly defined rainy season December through April. The driest months are in July and August with monthly rainfall ranging from 50 mm in the dry areas to 125 - 150 mm in the wet areas (Figure 6.4a and b).

The average annual temperature in Fiji is around 25°C with little seasonal variability. The lowest temperatures generally occur during July and range from 22°C-25°C while the highest temperatures generally occur during January and February and range from 26°C-28°C. The exceptions are Nandarivatu, located in central Viti Levu, with considerably lower temperatures ranging from 18.3°C-22.0°C and Rotuma Island which reaches a low of only 26.4°C (Table 2.2).

The temperature is modulated to some extent by continual breezes from the sea, particularly in the higher elevations. The southeast trade winds prevail during most of the year, but are replaced by the northwest monsoons in the hot, summer months. Humidity varies from 70-85 percent with an annual average of 77 percent (Table 2.3).

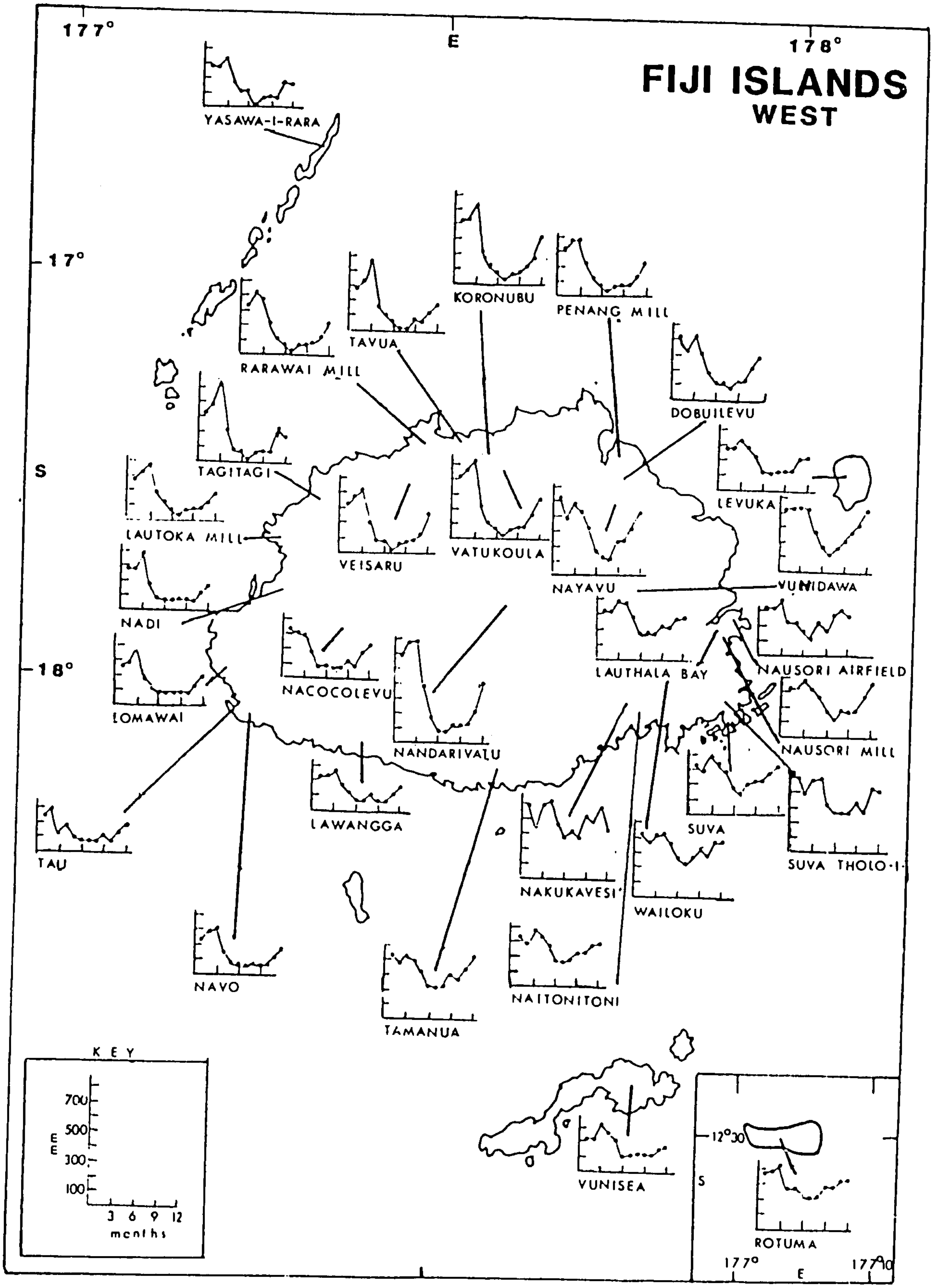


Figure 6.4a Mean monthly rainfall (mm) histograms for selected stations in West Fiji.

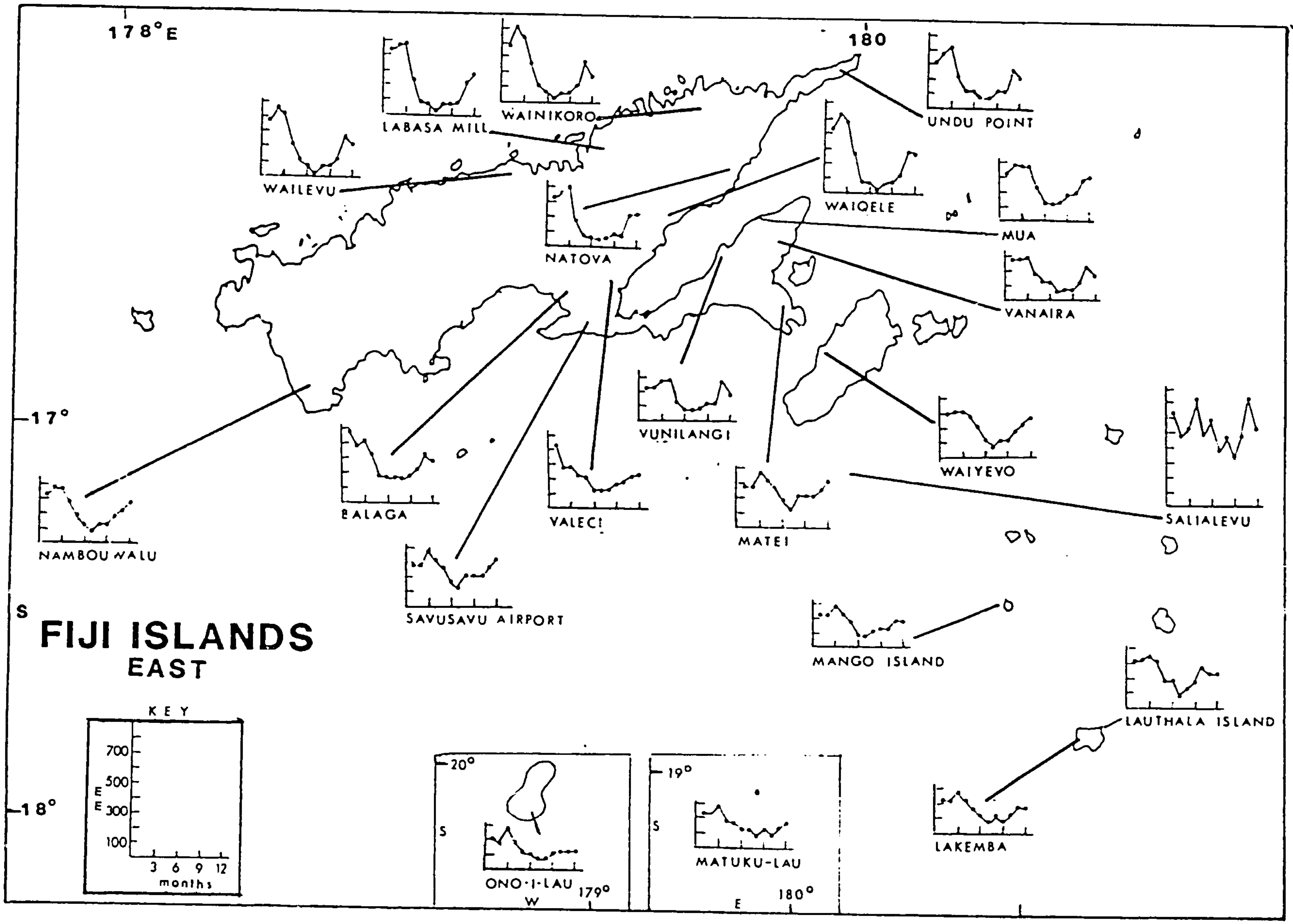


Figure 6.4b Mean monthly rainfall (mm) histograms for selected stations in East Fiji.

The Fiji Islands are exposed to several types of natural disasters including tropical cyclones, hurricanes (particularly from mid-November through April), earthquakes, tsunamis, drought, landslides and floods. Hurricanes and tropical cyclones are the most common, occurring an average of once or twice a year (Figure 2.3 and 2.4). (See Appendix B for episodic event data from 1951-82.)

C. Agriculture

Much of the population of the Fiji Islands is employed in agriculture. Both commercial crops for export and subsistence crops for local consumption are important to the Fijians. The land use pattern in Fiji is indicated in Figure 6.5. A comparison with Table 2.4 shows that only about 13 percent of the total land area is arable. Figure 6.6 shows the distribution of selected crops in Fiji.

Sugarcane is the most important of the commercial crops and accounts for more than 70 percent of all exports. It is grown and cut by small independent farmers and production is generally confined to the western and northern areas of Viti Levu and Vanua Levu. The crop calendar for sugarcane is closely tied to local climatic conditions. The harvest period can occur year-round but the planting season generally begins in September with harvest from May to November. About 70 percent of the planted area is harvested annually.

Coconut is the second most important cash crop although this is changing as the production of coconuts has declined steadily due to old trees, hurricane damage, drought and fluctuating prices. There has, however, been some recovery since the mid 1970's. Most of the coconut production is limited to plantations on Vanua Levu and outer islands such as Taveuni. Viti Levu grows no coconuts due to presence of the purple moth, a destructive pest peculiar to this island. Harvesting generally occurs year-round.

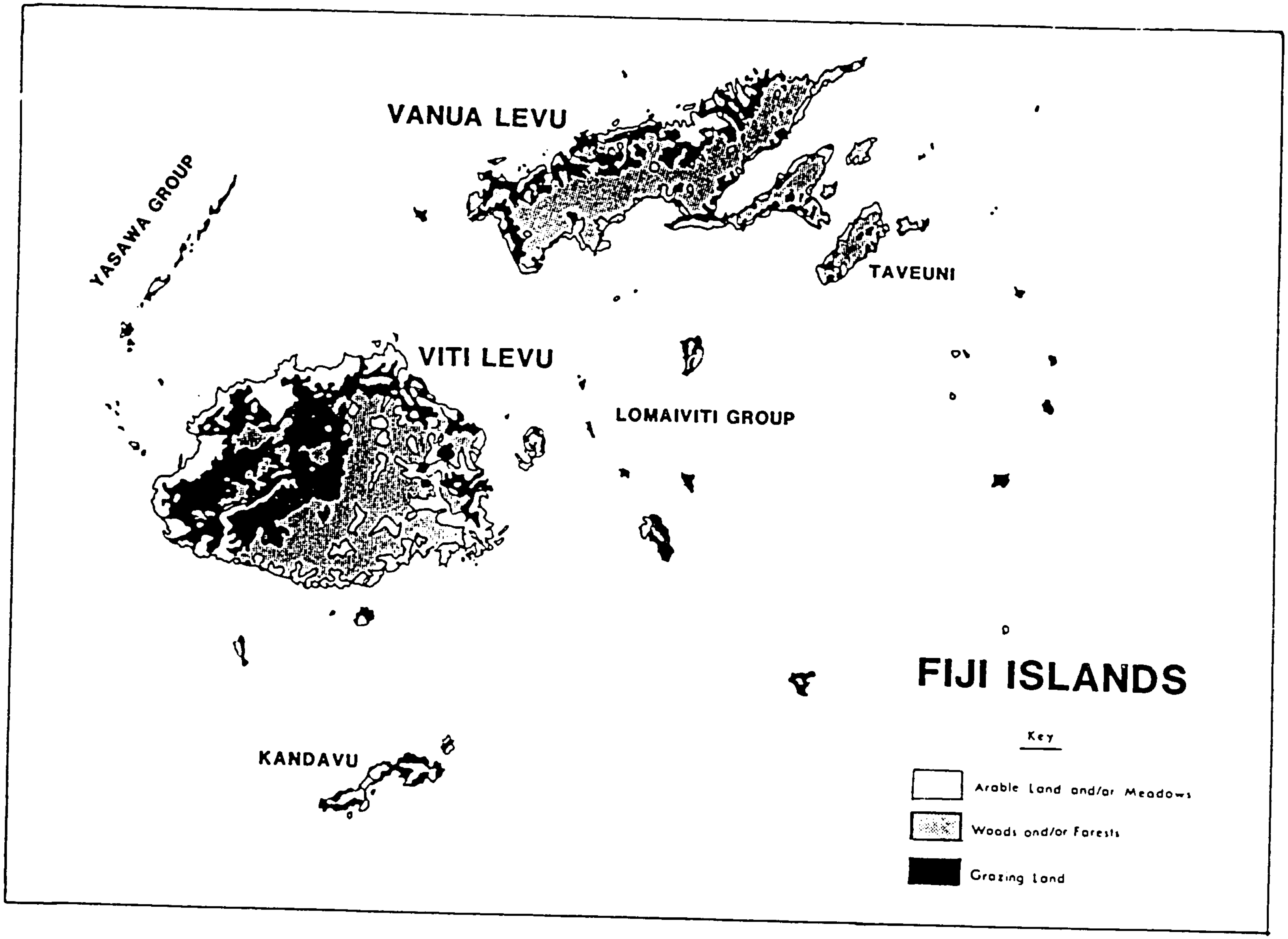


Figure 6.5 Land use in Fiji.

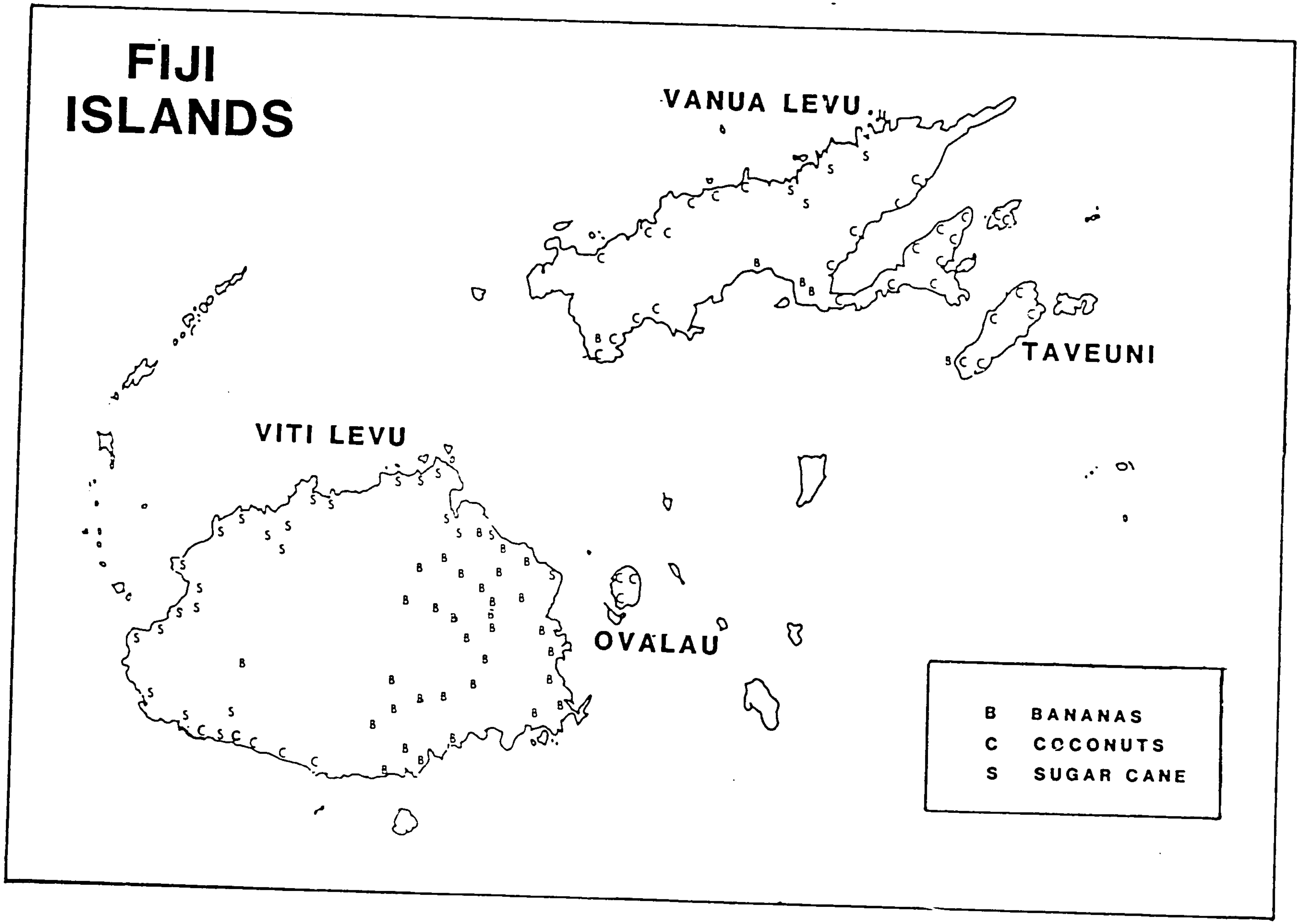


Figure 6.6 Distribution of selected crops in the Fiji Islands.

Bananas, the third most important cash crop, are produced along the tributaries of the Rewa River in southeastern Viti Levu. Bananas also face production problems due to disease, strong winds, and adverse market conditions. There is no specific calendar for this crop.

Other cash crops in Fiji include cacao, pineapples and passion fruit (processed for export), and yams, dalo, beans, and tomatoes which are sold in New Zealand.

Rice is the principal crop grown for local consumption in Fiji and is a staple food in the Fijian diet. The main production areas are in the Rewa Valley and the Navua district (both near Suva), the northwestern coast of Viti Levu and northern Vanua Levu. About 8,900 ha of double-cropped irrigated ricelands are planted annually with the main harvest period lasting from March to April and the secondary harvest from October and November. Although Fiji has yet to become self-sufficient in rice production, efforts are being made to increase yields to attain this goal.

Other crops grown for local consumption include corn, harvested April and May; millet and sorghum, harvested August and September; pigeon peas, harvested September and October; groundnuts, harvested June to September; and sweet potatoes, vegetables, taro and cassava, harvested year-round (Table 6.1).

D. Economy

The main components of the economy of Fiji are agriculture, tourism, timber, manufacturing and mining. Sugarcane is the mainstay of the economy, accounting for more than 70 percent of exports and providing 15 percent of the GDP.

Tourism is Fiji's second most important industry, although it is rapidly growing and may replace agriculture in the future. As of September, 1983, tourism accounted for 13 percent of the GDP.

TABLE 6.1

ESTIMATED CROP CALENDAR FOR FIJI ISLANDS

///Planting, ---Transplanting, 000 Harvesting

Crop	J	F	M	A	M	J	J	A	S	O	N	D
Banana	000	000	000	000	000	000	000	000	000	000	000	000
Coconut	000	000	000	000	000	000	000	000	000	000	000	000
Taro	000	000	000	000	000	000	000	000	000	000	000	000
Cassava	000	000	000	000	000	000	000	000	000	000	000	000
Corn	///			000	000							///
Millet					///	///		000	000			
Sorghum					///	///		000	000			
Sweet Potato	000	000	000	000	000	000	000	000	000	000	000	000
Pigeon Peas						///	///		000	000		
Groundnut			///	///	///		000	000	000			
Rice (main)	///-	---	000	000								///
Rice (second)					///	---				000	000	
Sugarcane					000	000	000	000	000	ØØØ	ØØØ	000

Timber is the principal natural resource of Fiji. The Caribbean Pine is a good source of potential income and could replace sugarcane as the leading export. Pine plantings have been widely expanded particularly in larger, dry, unused areas in the hill country of Viti Levu and Vanua Levu.

Manufacturing is expanding in Fiji particularly in new light industries. Three industrial subdivisions have been developed at Suva and industry is tending to move out in the direction of Nausori as land becomes scarce in the cities.

Fiji's mineral industry contributes only one percent of the GDP and large increases are not expected. Gold has been the principal mineral but high grade ores are being depleted. Low grade copper reserves have been found in Namosi but no immediate profit is anticipated.

In summary, Fiji's economic future will be shifting from agriculture, primarily sugarcane, to tourism and manufacturing. Timber and possibly the untapped copper reserves are also expected to boost the economy of Fiji.

CHAPTER VII

TONGA

A. Physical Environment

Tonga is an archipelago in the southern Pacific Ocean consisting of 150 islands, 45 of which are inhabited. They are located between 15°S and 23°30'S and 173°W and 177°W longitude. The islands are divided into three main groups, Vavua, Haapai and Tongatapu, and make an 800 km line running north and south (Figure 7.1). Total land area of the Tonga Islands is estimated at 747 km with a population of 97,400 as of 1980. The annual growth rate is 1.5 percent. Nearly two-thirds of the population live on the main island of Tongatapu.

The Tonga Islands fall into two fairly parallel chains; the eastern chain consists of low coral islands and the western chain consists of high volcanic islands (Figure 7.2). These summits of volcanic undersea mountains are of two types. Most have a limestone base formed from uplifted coral formations while others consist of a volcanic base overlayed with limestone (Figure 7.3).

The vegetation of Tonga is generally bushland or secondary forests, but some of the smaller islands such as Eua, Kao, Tufua, and Late are forested.

B. Climate

The climate of Tonga is subtropical with a southeastern trade wind most of the year. The climate changes from south to north with increasing rainfall from 1,600 mm to 2,400 mm. Tonga has a definite rainy season from December to April with the peak rainfall occurring in March. The dry season lasts from May to November (Figure 7.4).

The average annual temperature also increases south to north ranging from 23°C to 27°C. The hot season coincides with the rainy season from December to April. During May to November the temperatures are the lowest and are cooler than that of most tropical islands (Table 2.2). Relative humidity ranges from 70-80 percent with an annual average of 76 percent (Table 2.3).

Hurricanes are the most common type of disaster occurring every two to three years, particularly in the northern islands. Other natural disasters in Tonga are earthquakes, floods, tsunamis, volcanic eruptions and droughts. (See episodic event data listed for 1981-82 in Appendix B.)

C. Agriculture

Agriculture is extremely important to the Tongans with more than 90 percent of the population involved in farming. The land use map for Tonga is shown in Figure 7.5. A wide variety of crops are grown both for commercial and subsistence use. The crop calendar for Tonga is shown in Table 7.1.

Coconuts are the primary commercial crop and account for about 50 percent of the cultivatable land. They are grown year-round throughout the islands with the exception of the higher areas of Eua, Vavau, and the volcanic islands where they are not produced.

Coconut production has suffered throughout the years due to many destructive forces. The rhinoceros beetle has destroyed coconut trees for over 10 years, and while these pests have been cleared from Niuatoputapu, they still remain a problem in Haapai, Tongatapu and Vavau. Other factors such as old trees, hurricanes and market fluctuations have also hurt production.

Bananas, the second most important commercial crop, are harvest November to March. Production areas are scattered but can be found in the Late, Tofua, and Kao Islands. Unfortunately, banana production is also declining due to hurricane destruction, plant disease, and market problems. New Zealand, the biggest market for Tongan bananas, has begun using Ecuador as a major supplier.

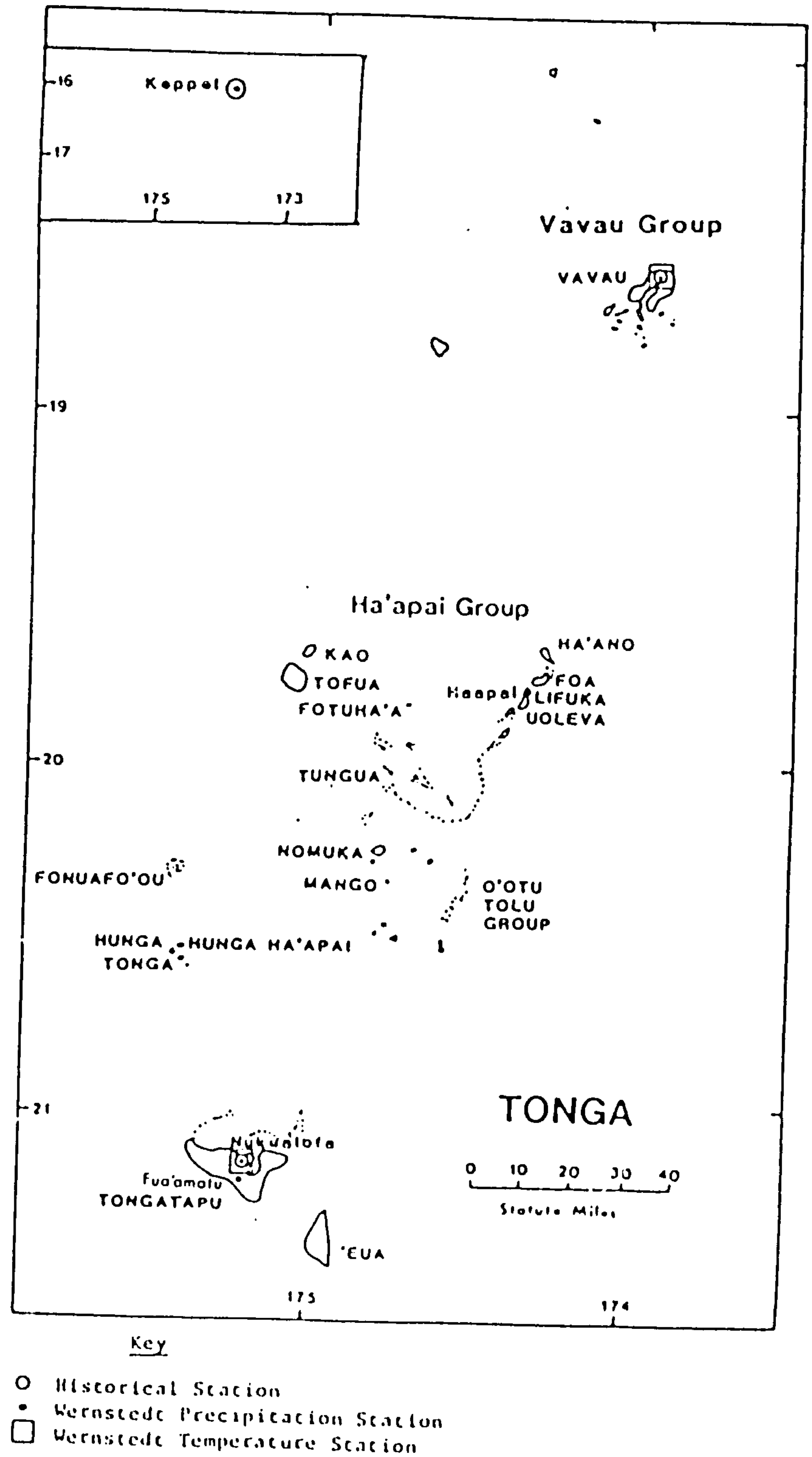


Figure 7.1 Tonga historical and normal stations.

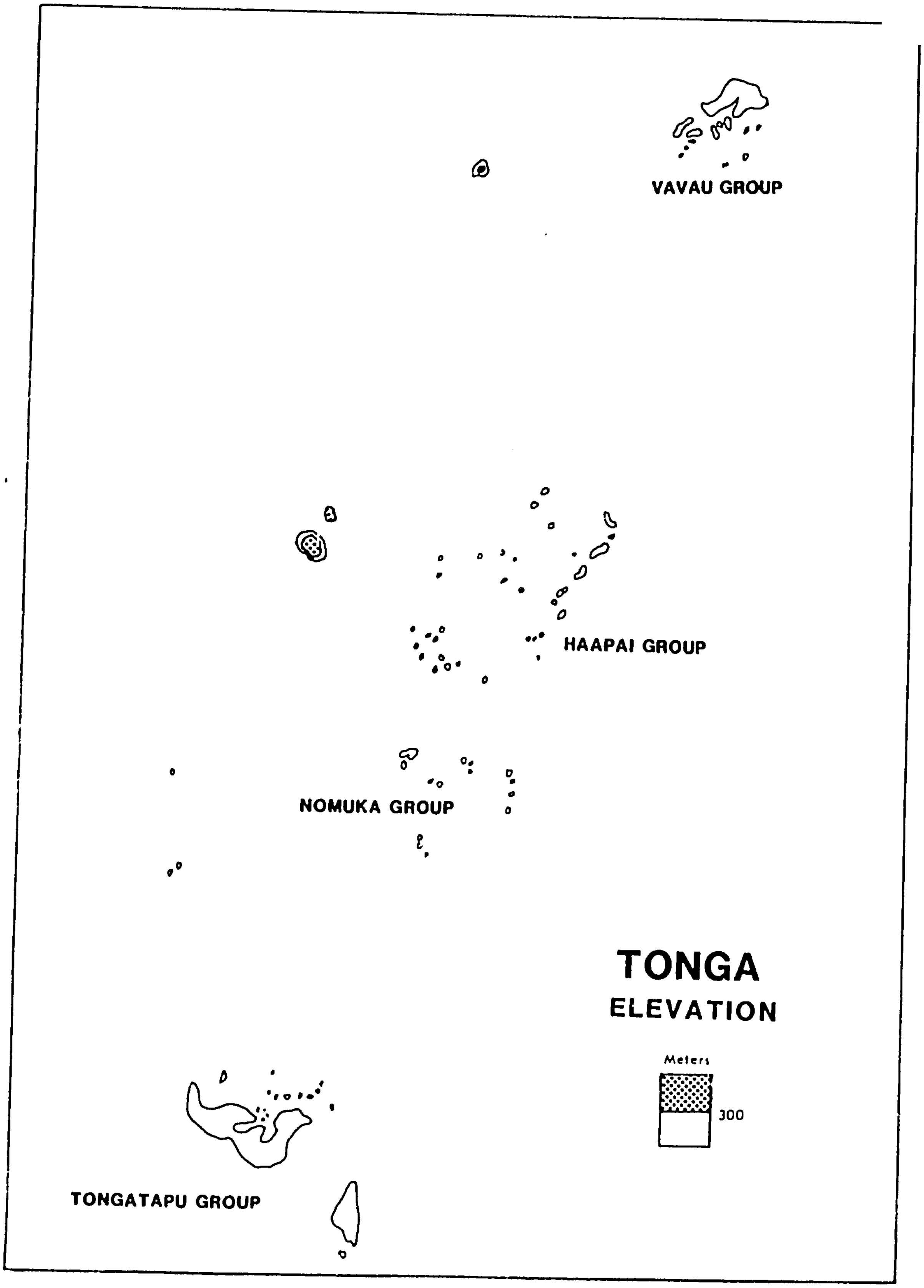


Figure 7.2 Elevation map of Tonga.

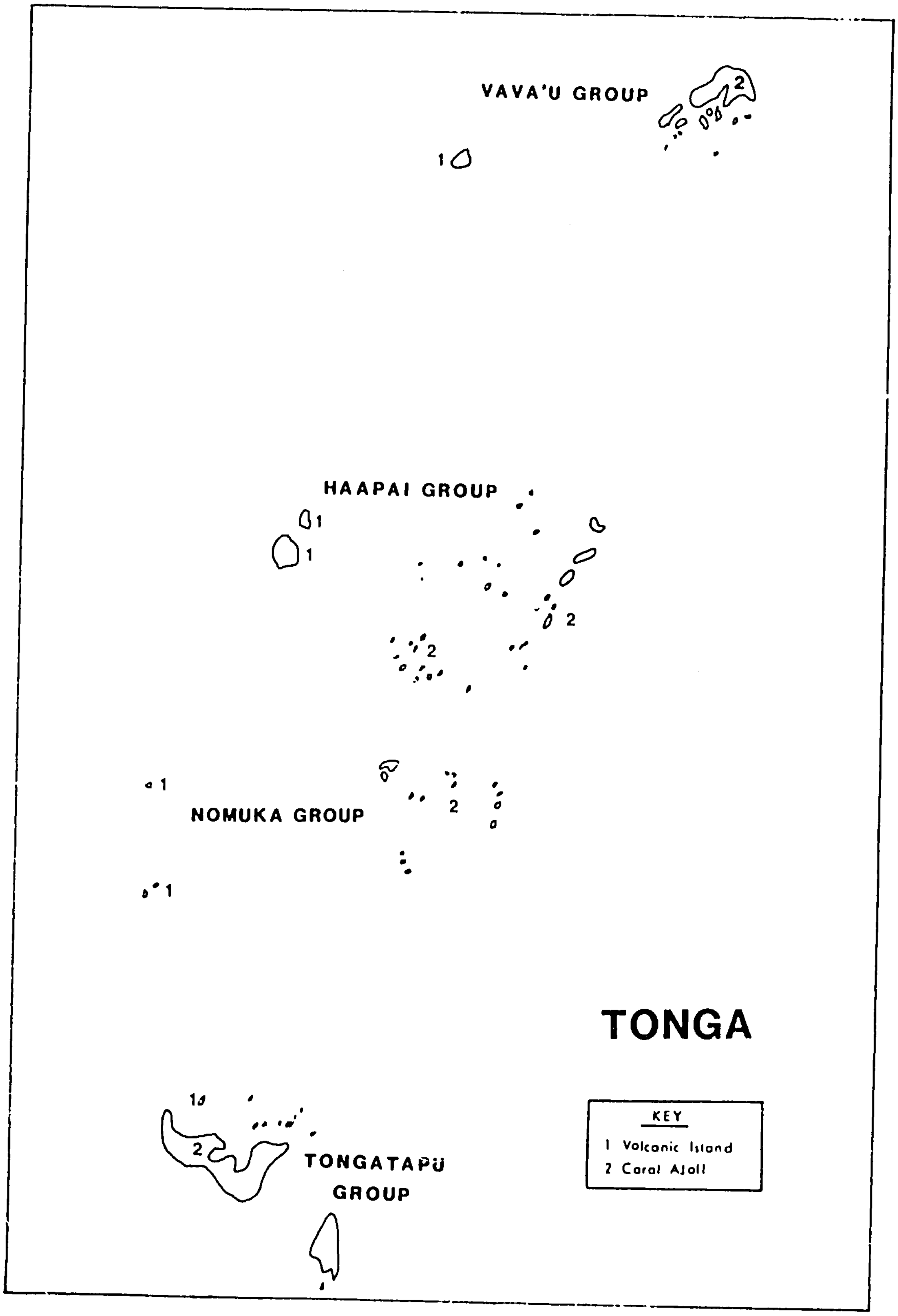


Figure 7.3 Composition map of Tonga.

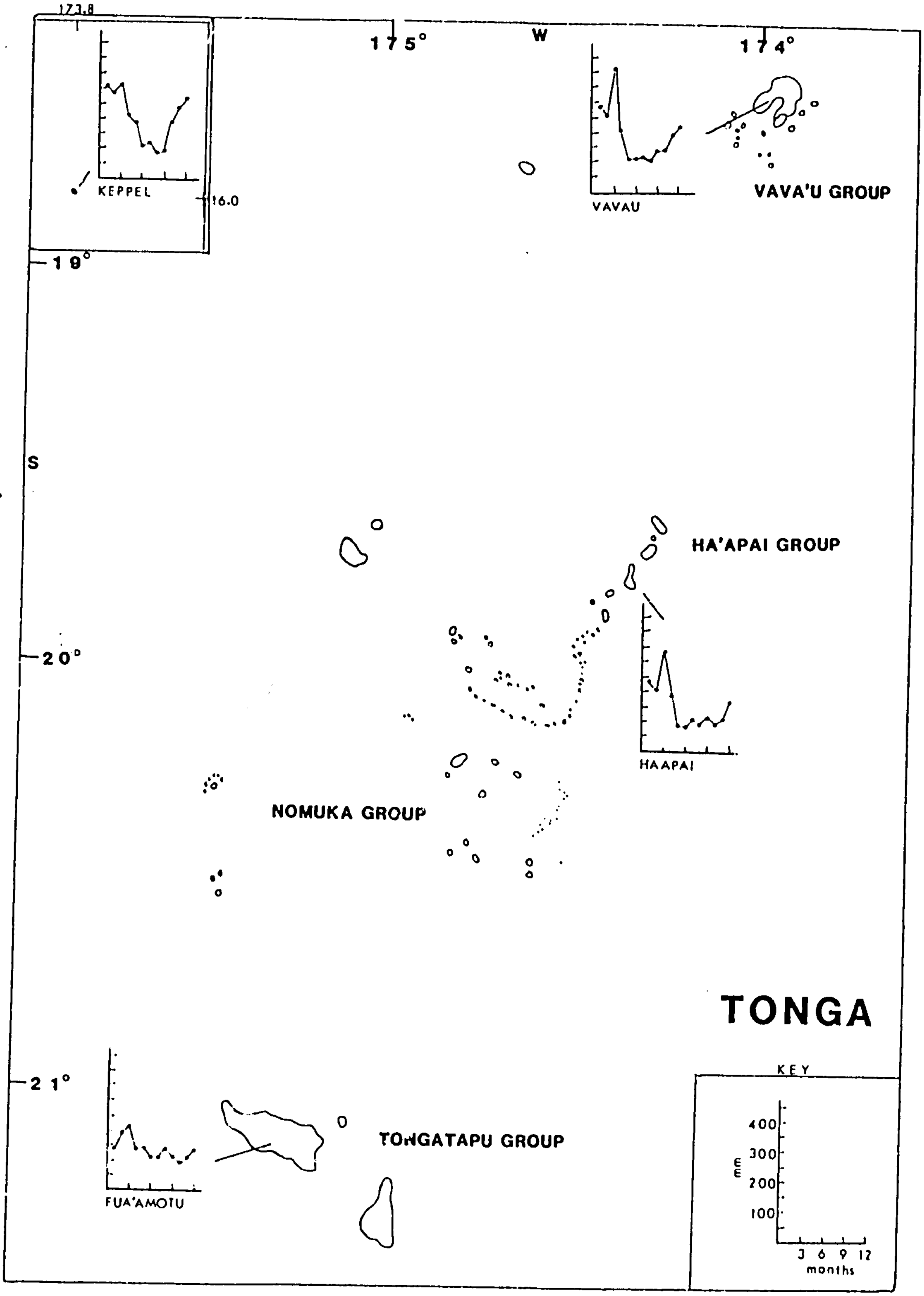


Figure 7.4 Mean monthly rainfall (mm) histograms for selected stations in Tonga.

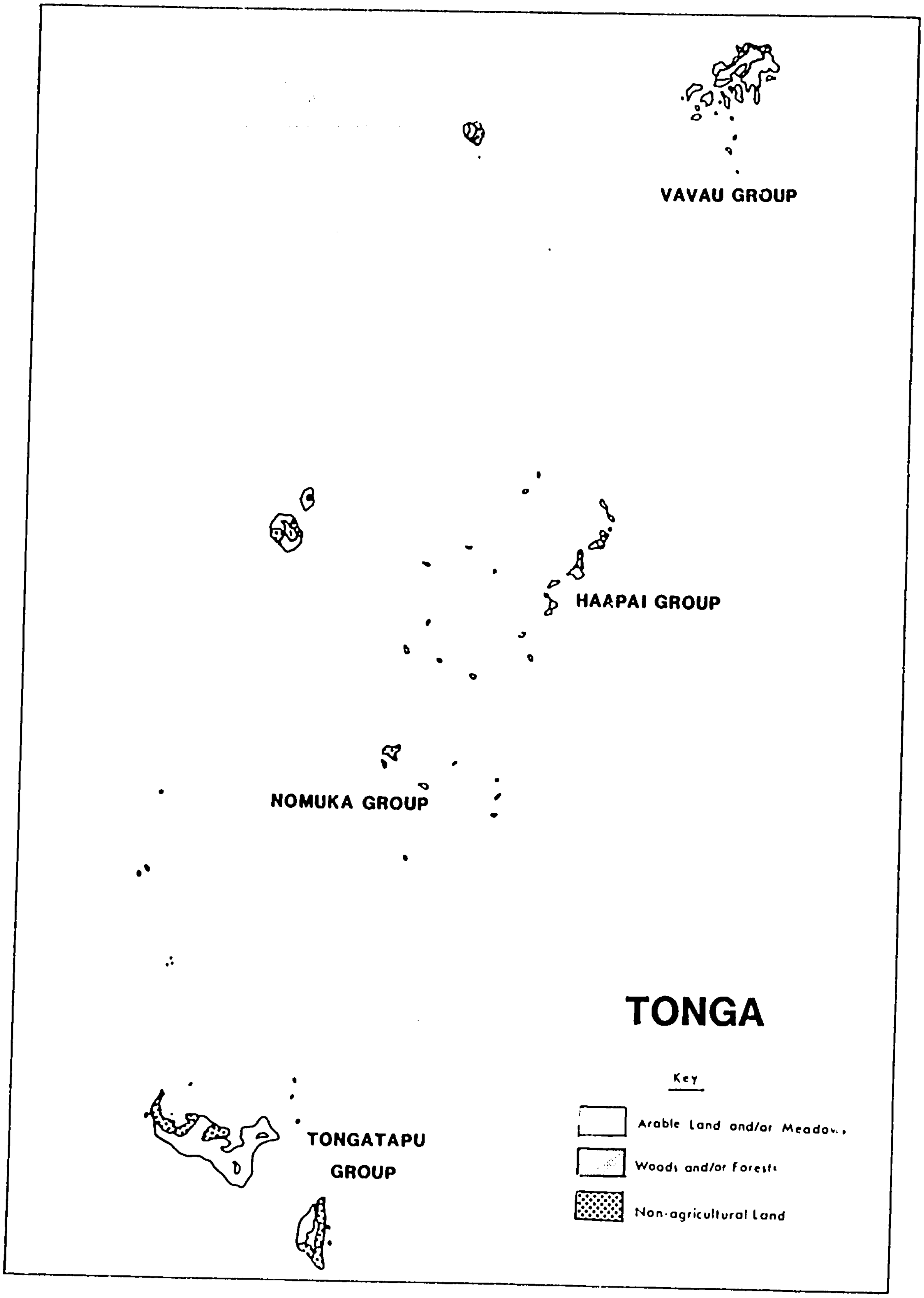


Figure 7.5 Land use in Tonga.

TABLE 7.1

ESTIMATED CROP CALENDAR FOR TONGA ISLANDS

///Planting, ---Transplanting, 000 Harvesting

Crop	J	F	M	A	M	J	J	A	S	O	N	D
Coconut	000	000	000	000	000	000	000	000	000	000	000	000
Groundnut	000	000	000	000	000	000	000	000	///	///	///	///
Rice				000	000					///	///	---
Yams	000	000	000	ØØØ	ØØØ	ØØØ	ØØØ					000
Cassava								000	000	000	ØØØ	ØØØ
Taro							000	000	000	000	ØØØ	ØØØ
Sweet Potato			000	000							///	///
Bananas	000	000	000								ØØØ	ØØØ

Although coconut and banana production has suffered, other cash crops have been improved. Vanilla bean production has increased recently to become the third most important commercial crop. The production of watermelon, vegetables and kawa have also been increased.

A wide range of subsistence crops are grown in Tonga. Taro is harvested July to December, cassava is harvested August to December, groundnuts are harvested January through August, rice is harvested April and May, sweet potatoes are harvested March and April and yams are harvested December through July. Fruits and vegetables are also grown.

Agricultural practices have remained unchanged over the years with the bush-fallow method being predominant. In the past land was left fallow for four to five years before it was recultivated. Today more intense cultivation methods are employed with the addition of fertilizers to maintain the soil.

D. Economy

Tonga's economy is based on agricultural production, with coconut and banana exports providing more than 50 percent of the GDP. Other characteristics of the economy are a large non-monetary sector and a heavy dependence on subsistence crops.

The major industry in Tonga is the processing of coconut to copra for export while manufacturing is primarily based on handicrafts. These areas contribute only three percent of the GDP.

Other small scale industries that feed the economy are tourism, fisheries and some timber.

Potential contributors to a more progressive Tonga are the further development of the tourism industry, new fishery projects and the diversification of manufacturing and mining industries. Exploration of oil has also begun and is providing a new facet to the economy's future.

CHAPTER VIII

THE ROLE OF SEA SURFACE TEMPERATURE ANOMALIES IN THE EQUATORIAL PACIFIC

Large scale sea surface temperature (SST) anomalies in the equatorial Pacific appear to have significant influence on the wintertime climatic anomalies in the extratropics. Some of the cause and effect relationships involved are presented in this Chapter. Further, the reliability of Multi-Channel Sea Surface Temperature (MCSST) measurements is increasing the use of SSTs as a potential prognostic tool in early warning assessment.

A. Southern Oscillation Index (SOI)

Sir Gilbert Walker, in the early 1920s, was the first to observe that the pressure patterns between the eastern and western tropical Pacific oceans are inversely related. High pressures in the eastern tropical Pacific are accompanied by low pressures in the western tropical Pacific and vice-versa. This phenomenon is known as the Southern Oscillation (Rasmusson and Hall, 1983).

Later, in 1932, Sir Gilbert Walker and his associate E.T. Bliss observed that high pressure in the Pacific Ocean is accompanied by low presure in the Indian Ocean extending from Africa to Australia. These conditions were associated with low temperatures in both areas, whereas rainfall was inversely related to pressure. They also observed that these conditions are related differently in summer and winter (Rasmusson and Carpenter, 1982).

According to Kidson (1975), the state of this oscillation is indicated by the Southern Oscillation Index (SOI) in which normalized departures of a number of heterogenous variables are arbitrarily weighted. Positive index values are associated with above normal pressures and vice-versa.

Quinn (1977) applied a triple 6-month running mean filter while computing the Southern Oscillation Index. Pressure differences between sites representing the South Pacific subtropical high and the Indonesian equatorial low were used in studying the 1976 El Nino event.

Rasmusson and Hall (1983) used the sea-level pressure difference anomaly between Tahiti (Society Islands) and Darwin (Australia) as a Southern Oscillation Index (Figure 8.1).

B. Sea Surface Temperature Anomalies in the Equatorial Pacific

The southern coasts of Ecuador and Peru are influenced by a weak warm ocean current during December. The natives termed it El Nino meaning "The Child". In some years, such as in 1972, 1976 and 1982, the current is a few degrees warmer and deeper than usual. Such a situation prevents the upwelling of nutrient laden water from the lower layers and drastically reduces the anchovy catch in these waters.

Recent studies (Quinn, 1977; Chen, 1983; Donguy and Dessier, 1983; Rasmusson and Carpenter, 1982; Rasmusson and Hall, 1983; Yi Hong Pan and Oort, 1983) have shown the El Nino phenomenon to be part of a meso-scale phenomenon involving the Southern Oscillation.

Quinn (1977) used sea surface temperature trends to predict the El Nino. He found the three-month running mean plots of the SOI (using pressure differences between Easter Island and Darwin) and the SST anomalies to be useful in predicting the El Nino 3 to 18 months prior to its onset.

Rasmusson and Carpenter (1982) examined the large scale ocean atmosphere interactions involved in the El Nino warmings. Some of their conclusions are discussed briefly:

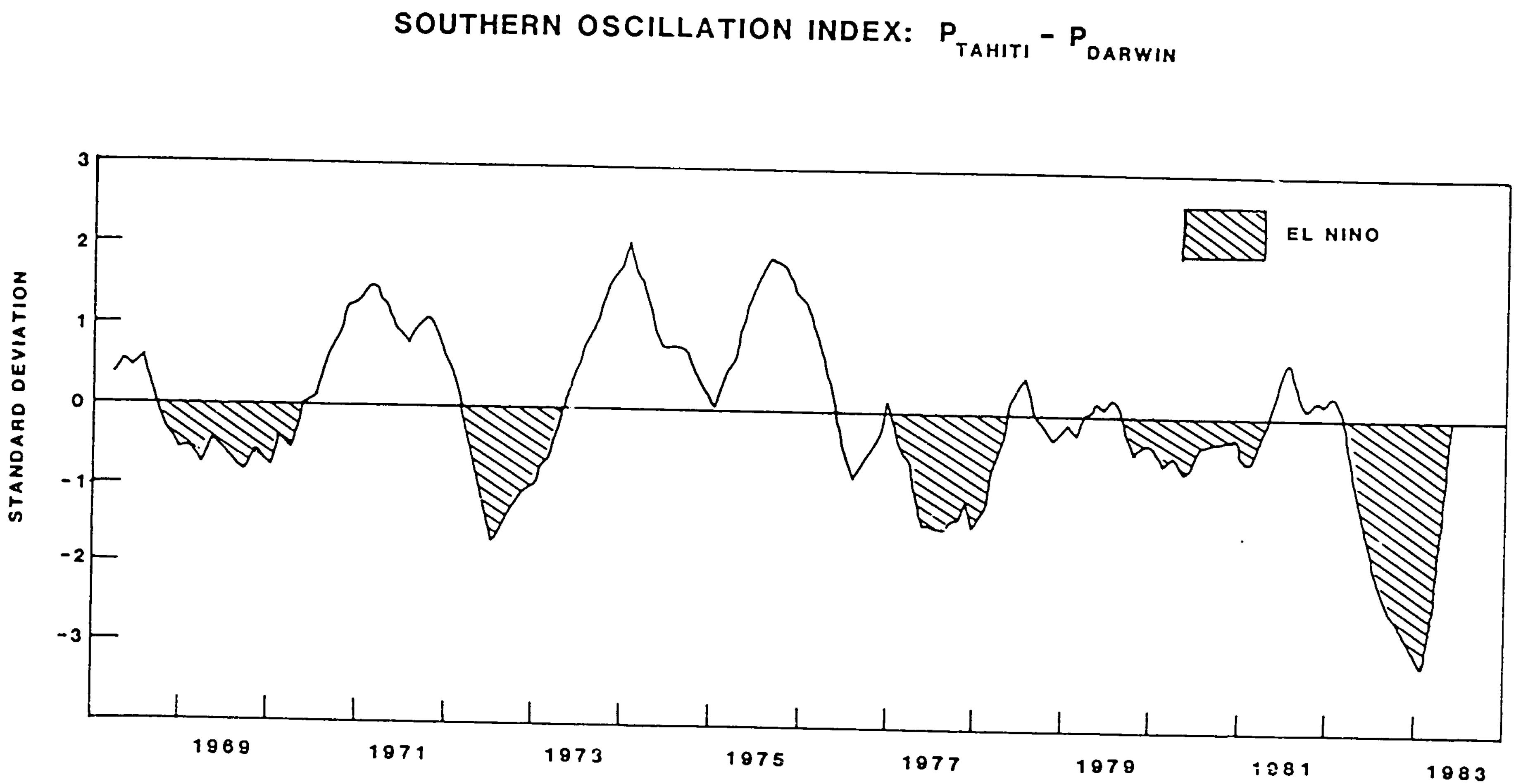


Figure 8.1 The Southern Oscillation Index (Pressure difference between Tahiti and Darwin) for the equatorial Pacific. The shaded areas indicate El Nino years (Adapted from Rasmusson and Hall, 1983).

1. Antecedent conditions (September of year prior to El Nino year).
   - o Initially the SST's along the Ecuador-Peru coast are below normal.
   - o The equatorial easterlies are stronger than normal west of the dateline.
   - o The South Pacific Convergence Zone (SPCZ) is displaced southwest of its normal position.
   - o The SST anomalies are found to be positive to the west and southwest of the normal position of the SPCZ (NSPCZ) but negative to its northeast.
   - o There is anomalous convergence to the southwest and divergence to the northeast of NSPCZ. Consequently, precipitation amounts are enhanced to the southwest (Indonesia, Eastern Australia, Vanuatu and Fiji Islands) of the NSPCZ but are below normal to its northeast (Line Island and Nauru-Banaba/Ocean Islands).
2. Conditions during the onset phase (December prior to El Nino year).
   - o The SST's along the Ecuador-Peru coast are near normal but rising rapidly. Significant positive SST anomalies appear west of Chile.
   - o The SPCZ has by now returned to its near normal position.
   - o The wind flow is generally westerly to northwesterly across most of the South Pacific.
   - o The positive SST anomalies to the southwest of the SPCZ observed earlier disappear and another positive SST anomaly appears near the dateline.
   - o There is enhanced precipitation along the equator west of the dateline. However, there is no positive precipitation anomaly to its east.

3. Conditions during the peak phase (April).

   - o Large scale SST anomalies appear across the equator from South America to about 160°E. The maximum SST anomalies along the South American coast occur around April-June.
   - o The positive SST anomaly observed earlier near the dateline has extended both eastward and westward (Figure 8.2)
   - o Positive precipitation anomalies are observed over the central and eastern equatorial Pacific (Galapagos, Line, Nauru and Banaba/Ocean Island). Negative precipitation anomalies appear southwest of the NSPCZ.

4. Conditions during the transition phase (September).

   - o Large scale SST anomalies still dominate vast areas of the eastern and central Pacific. But the SST anomaly near the South American coast has diminished by now.
   - o The associated wind flow is typically westerly, east of 160°E.
   - o The precipitation anomalies are at their peak across Nauru-Banaba/Ocean Island and are increasing over the Line Islands. The large positive precipitation anomalies over the Galapagos have now decreased.
   - o The SPCZ is now displaced n. .heast. Negative SST anomalies appear to the southwest of the NSPCZ while positive anomalies appear to its north-east.

5. Conditions during the mature phase (January following El Nino year).

   - o Positive SST anomalies continue to cover large areas of the central and eastern equatorial Pacific. These anomalies attain a maximum in December at about 170°W. The SST's along the Ecuador-Peru coast have now returned to normal (Figure 8.3).

SOUTH PACIFIC

SEA SURFACE TEMPERATURE ANOMALIES

MARCH-APRIL

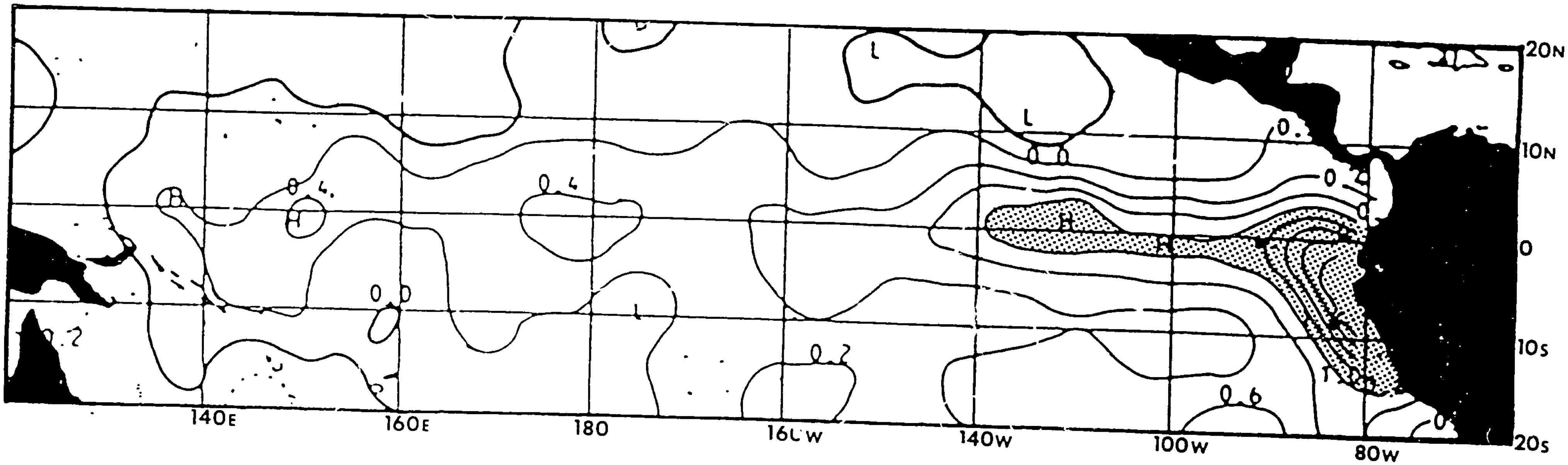


Figure 8.2 Sea Surface Temperature Anomalies in the South Pacific During the Peak Phase. (Adapted from Rasmussen and Carpenter, 1982)

SOUTH PACIFIC

SEA SURFACE TEMPERATURE ANOMALIES

DECEMBER-FEBRUARY

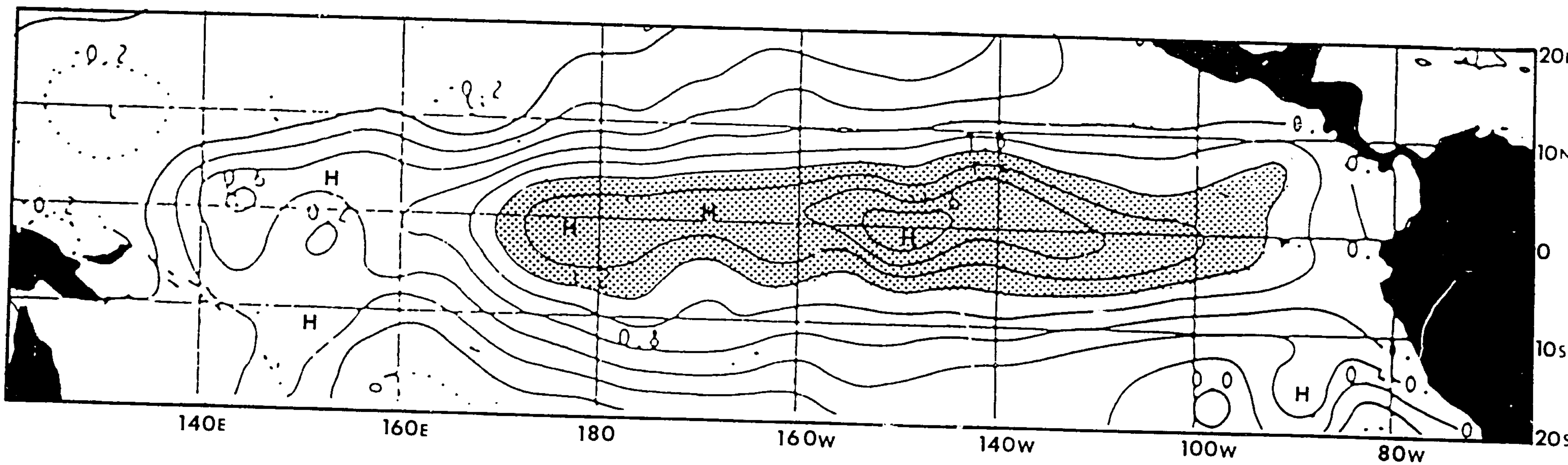


Figure 8.3 Sea Surface Temperature Anomalies in the South Pacific During the Mature Phase. (Adapted from Rasmussen and Carpenter, 1982)

- The precipitation enhancement over the Line Islands is at its peak. Normal January precipitation for stations near the dateline is usually zero except in an El Nino year.
- The precipitation anomaly pattern over the western Pacific, Indonesia and northern Australia is diminished due to increased divergence in the area.

Rasmusson and Carpenter (1982) have shown that the northern hemisphere winter following a typical El Nino year is characterized by positive SST and precipitation anomalies concentrated along the central equatorial Pacific.

Shukla and Wallace (1983) cite several studies which indicate that under certain conditions tropical SST anomalies are capable of producing climate anomalies in the extratropics. Apparently perturbations in the mean distribution of precipitation in the tropics influence the extratropical circulation through the action of quasi-stationary, two dimensional Rossby waves. In low latitudes, the perturbations in divergence in the lower and upper troposphere are opposite in polarity. At higher latitudes, the circulation changes assume an equivalent barotropic vertical structure.

Chen (1983) studied the global climate of spring 1983 following the 1982 El Nino event. The United States experienced its second coldest spring over the past 53 years. However, precipitation amounts were well above normal over most of the country. Eastern Canada experienced above normal temperatures and heavy precipitation. Below normal temperatures and heavy precipitation occurred over extreme western Europe. Western Eurasia was generally milder than normal while eastern Eurasia was cooler than normal.

C. Multi-Channel Sea Surface Temperature Measurements

The Global Operational Sea Surface Temperature Computation (GOSSTCOMP) procedure was started by the National Environmental Satellite Service (NESS) to provide global SST maps (Strong and McClain, 1984). A vertical temperature profiling radiometer (VTPR) was used to account for cloud and moisture corrections. The SST's were estimated by combining these measurements with single-channel infrared readings from a scanning radiometer (SR) (Legeckis et al, 1983). The temperature estimates provided by GOSSTCOMP had a bias of 1-4°C. Apparently, this bias was reduced after introducing the Advanced Very High Resolution Radiometer (AVHRR) on board the NOAA polar orbiting satellites.

The Multi Channel Sea Surface Temperature (MCSST) techniques utilize the AVHRR. The AVHRR has sensors in the following four channels: 0.55-0.68, 0.725-1.10, 3.55-3.93 and 10.5-11.5 micron meters. An additional fifth channel, 11.5-12.5 micron meters, is available only on board the NOAA-7 satellite. The spatial resolution of the AVHRRs are 1.1 km and 4 km (Strong and McClain, 1984; Van Dyk et al, 1984).

Strong and McClain (1984) developed algorithms to correct the MCSST brightness temperatures from any given channel for atmospheric attenuation. A linear relationship between satellite derived and drifting buoy SST values was observed. The root mean square (r.m.s.) error between the AVHRR and drifting buoy measurements was only 0.8°C. This is a definite improvement over the GOSSTCOMP estimates.

The National Environmental Satellite, Data and Information Service (NESDIS) of the National Oceanic and Atmospheric Administration (NOAA) uses the differences in energy emitted from the sea surface at 3.7, 11 and 12 micron meters to correct for atmospheric attenuation. Objective analysis techniques are applied to provide a daily global SST analysis map with a spatial resolution of 100 km. The equatorial Pacific and the coastal U.S. maps (50 km resolution) are analyzed on a weekly basis (Legeckis et al, 1983).

Real-time SST analyses of the South Pacific can provide assessors with a new prognostic tool. Observing SST anomalies can provide useful information on large-scale rainfall anomalies in the South Pacific region. For this reason the potential role of SST analyses in the early warning assessments should be further explored.

CHAPTER IX

EARLY WARNING ASSESSMENTS FOR THE SOUTH PACIFIC

The Early Warning Assessment Program for the South Pacific island groups developed jointly by NOAA/NESDIS/AISC and the Atmospheric Science Department of the University of Missouri-Columbia (UMC) is outlined in Figure 9.1. The program is based on a combination of 1) bi-weekly weather assessments provided by the Climate Assessment Branch (CAB) of AISC and 2) monthly crop condition assessments issued by the Models Branch (MB) of AISC. The purpose of these assessments is to provide the USAID/OFDA with timely and reliable information on current crop conditions and the potential for any climate related food shortages. Such assessments can assist the OFDA in making policy and decisions regarding disaster relief and food security in the South Pacific. Assessment verification is achieved primarily by user feedback from USAID missions in the region.

A. Assessment Format

The general format for issuing the AISC early warning assessments is as follows: 1) Impact, 2) Perspective, 3) Model Results, 4) Weather Analysis and 5) Support Information. Only information relevant to the Impact are included in statements 2 through 5.

Impact

This statement directly communicates the information needed to the decison maker. The assessor states the potential problem (drought, floods, etc.) and identifies the impacted crops and regions. Any preliminary estimates of production losses can be extremely useful. The impact of typhoons and tropical storms are also discussed as appropriate. On the other hand, if crop conditions during

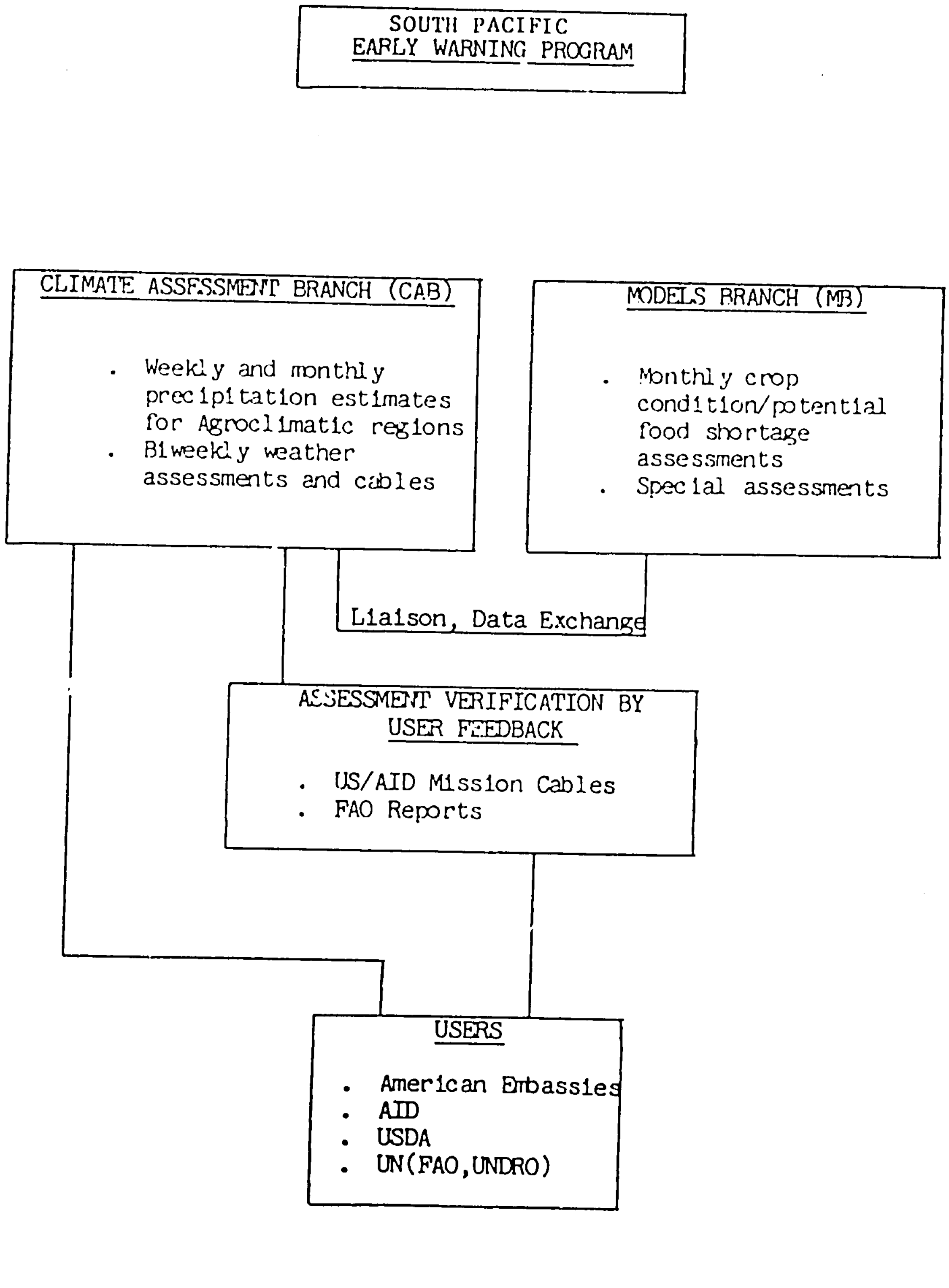


Figure 9.1 Flow Chart for the AISC Early Warning Program.

the assessment period are very favorable then it is also mentioned. Obviously the need for food aid is reduced, or even unnecessary, if crop conditions within a country are forecasted to be above normal.

Perspective

The perspective statement qualifies the impact statement by describing the expected scope and magnitude of the potential problem. For example "Country X is in the grip of the worst drought in 30 years" or "The typhoon damage to crops and livestock is comparable to that during typhoon X in 1979." The object is to provide the decision maker with information on the magnitude of the problem.

Model Results

Results from the assessment models (agroclimatic/crop condition indices, crop yield models, etc.) are presented after the perspective statement. For example, statements such as "Agroclimatic/Crop condition indices in 1984 for country X are in the lower 10th percentile range indicating possible crop failure" or "The 1984 paddy crop in country X is forecasted to be well below the 1983 paddy crop" help decision makers to plan disaster relief and food aid.

Weather Analysis

The weather analysis section describes the weather and climatic conditions associated with the impact. Information on the duration of drought, seasonal rainfall amounts, recent typhoons or tropical storms, etc., are also included in this section.

Support Information

This section of the assessment includes any reliable information from secondary sources. Field reports are generally reliable but news media reports should be considered with some caution, particularly while assessing crop losses.

B. Bi-Weekly Weather Assessments

Bi-weekly weather assessments are based on station level precipitation data and reports of anomalous weather events. Information sources include surface weather observations, climatological normals, historical data (Appendix C shows the historical station data directory), surface and upper air analyses and satellite imagery. Real-time meteorological data are obtained by NOAA through the World Meteorological Organization/Global Telecommunications System (WMO/GTS). Locations of these operational stations are shown in Appendix D.

The availability of real-time monthly precipitation data for several stations in the South Pacific is quite limited due to missing daily reports. A major task involved is the quality control and estimation of precipitation data. Satellite imagery from various NOAA operational satellites is used to estimate precipitation.

Anomalous weather events such as high winds, typhoons, flooding, etc., are analyzed on a daily basis to provide a real-time episodic event data base for use in assessments.

C. Monthly Crop Condition Assessments

The monthly crop condition assessments are based on cumulative rainfall analysis at the station level. The crop calendar information is used to identify the crops to be assessed and also to determine the stage of the crop. Subsistence level agriculture in the South Pacific is generally rainfed and so cumulative rainfall analysis can be used to monitor overall crop conditions. Drought resistant crops such as taro and cassava are planted and harvested throughout the year and are difficult to assess.

The assessment months for the cumulaive rainfall analysis at selected stations in the Solomon, Vanuatu, Kiribati, Fiji and Tonga island groups are shown in Figures 9.2 a-e. The assessment periods for the other island groups

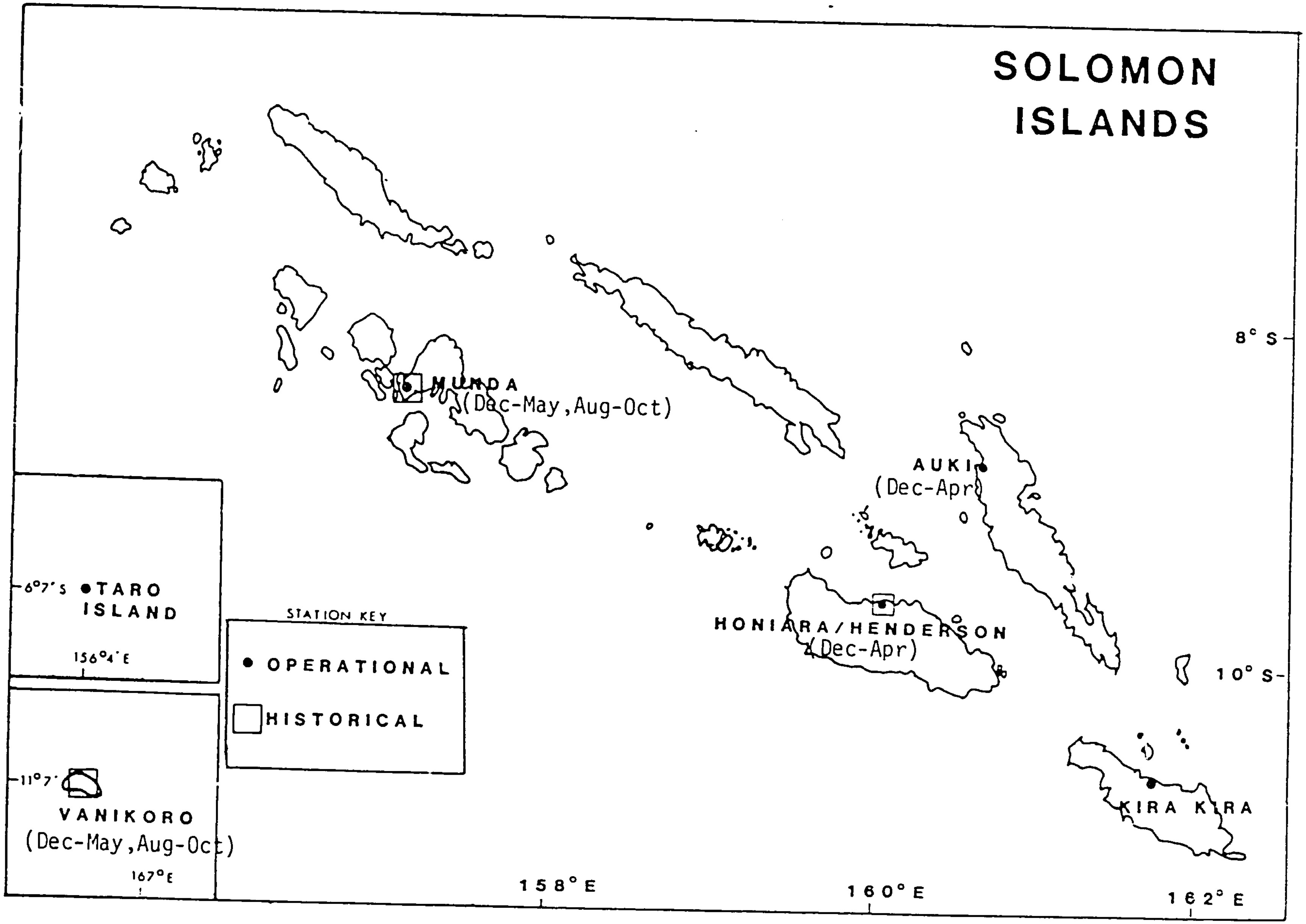


Figure 9.2(a) Assessment Months at Selected Stations in the Solomon Islands.

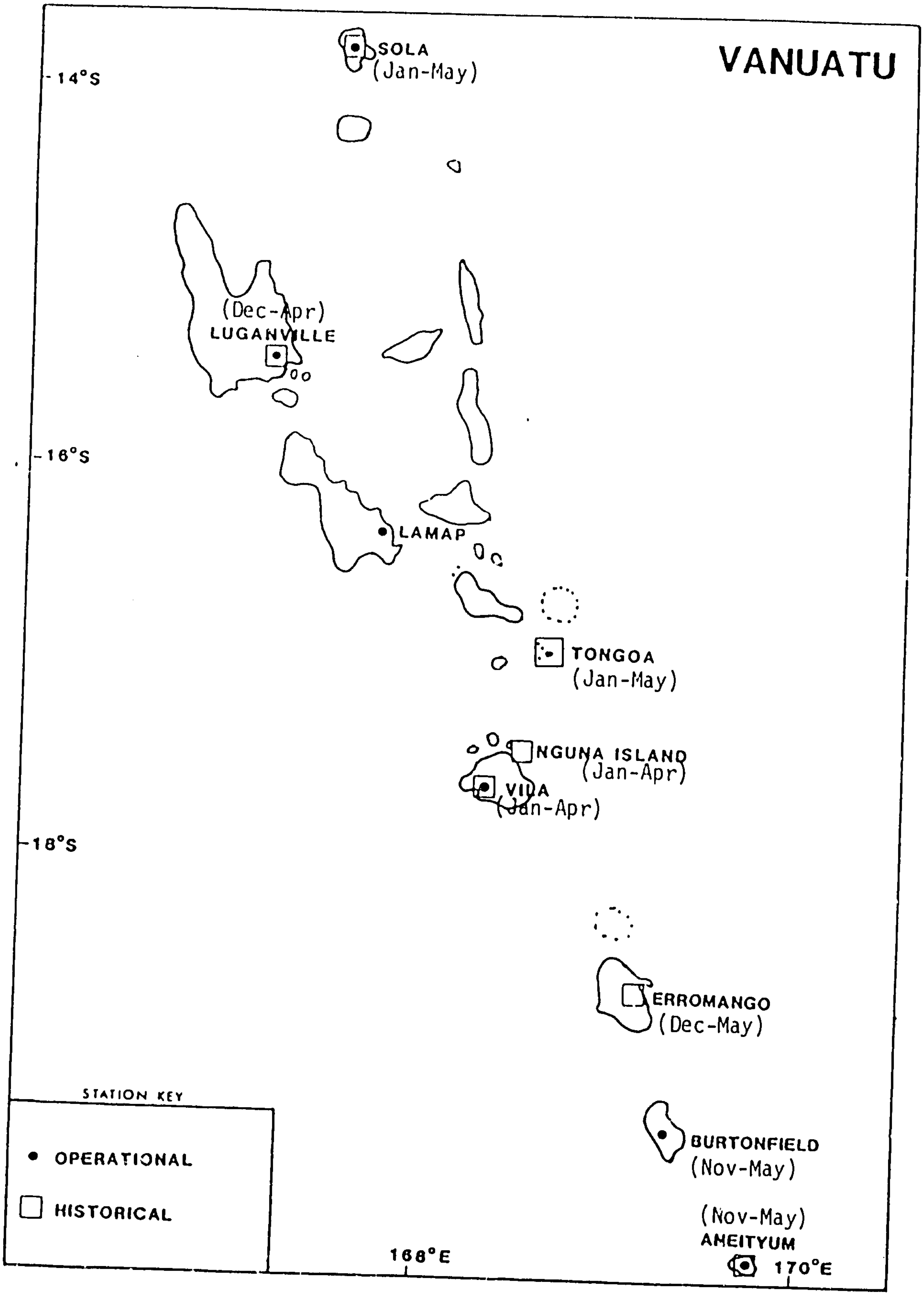


Figure 9.2 (b) Assessment Months at Selected Stations in Vanuatu.

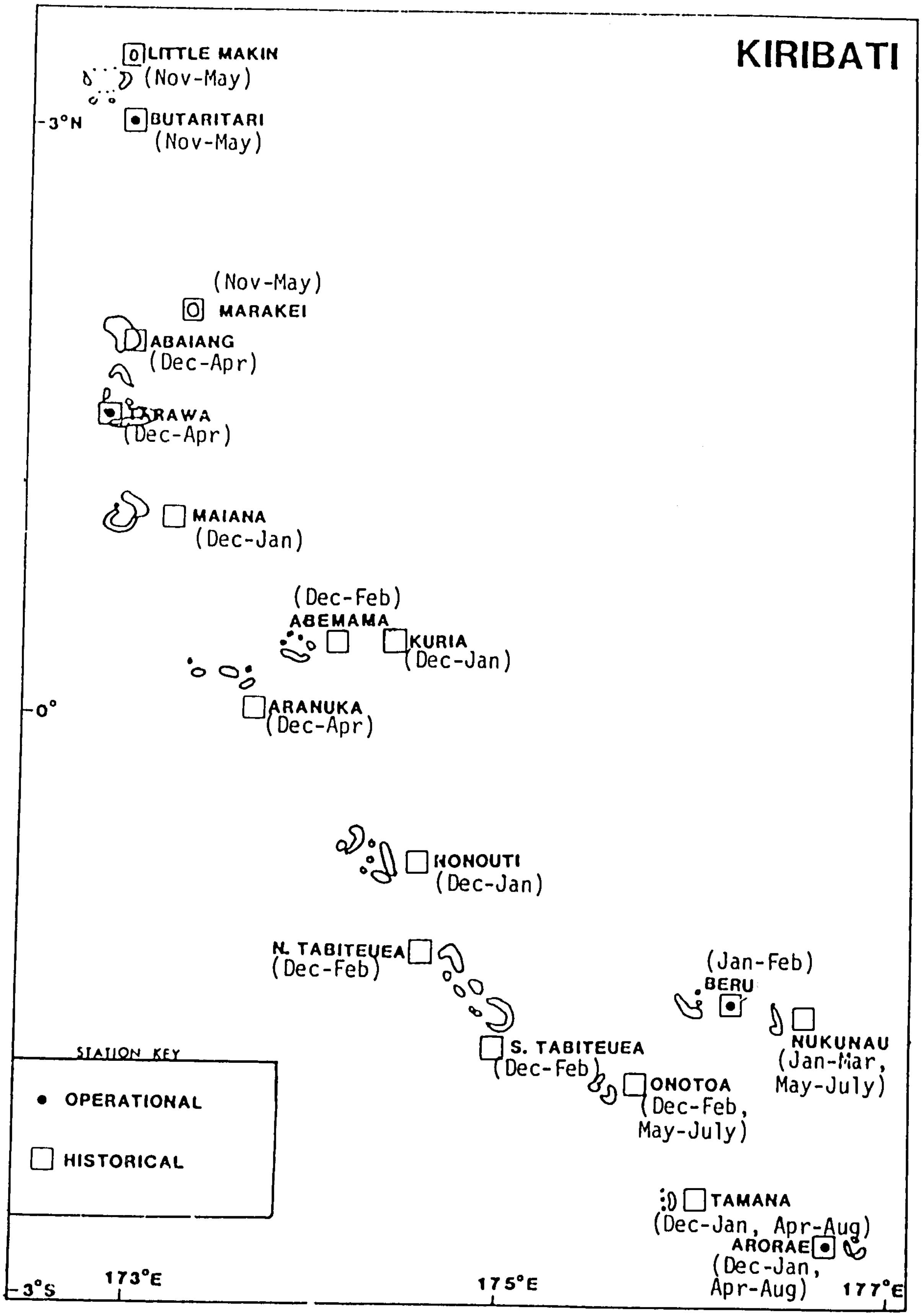


Figure 9.2(c) Assessment Months at Selected Stations in Kiribati.

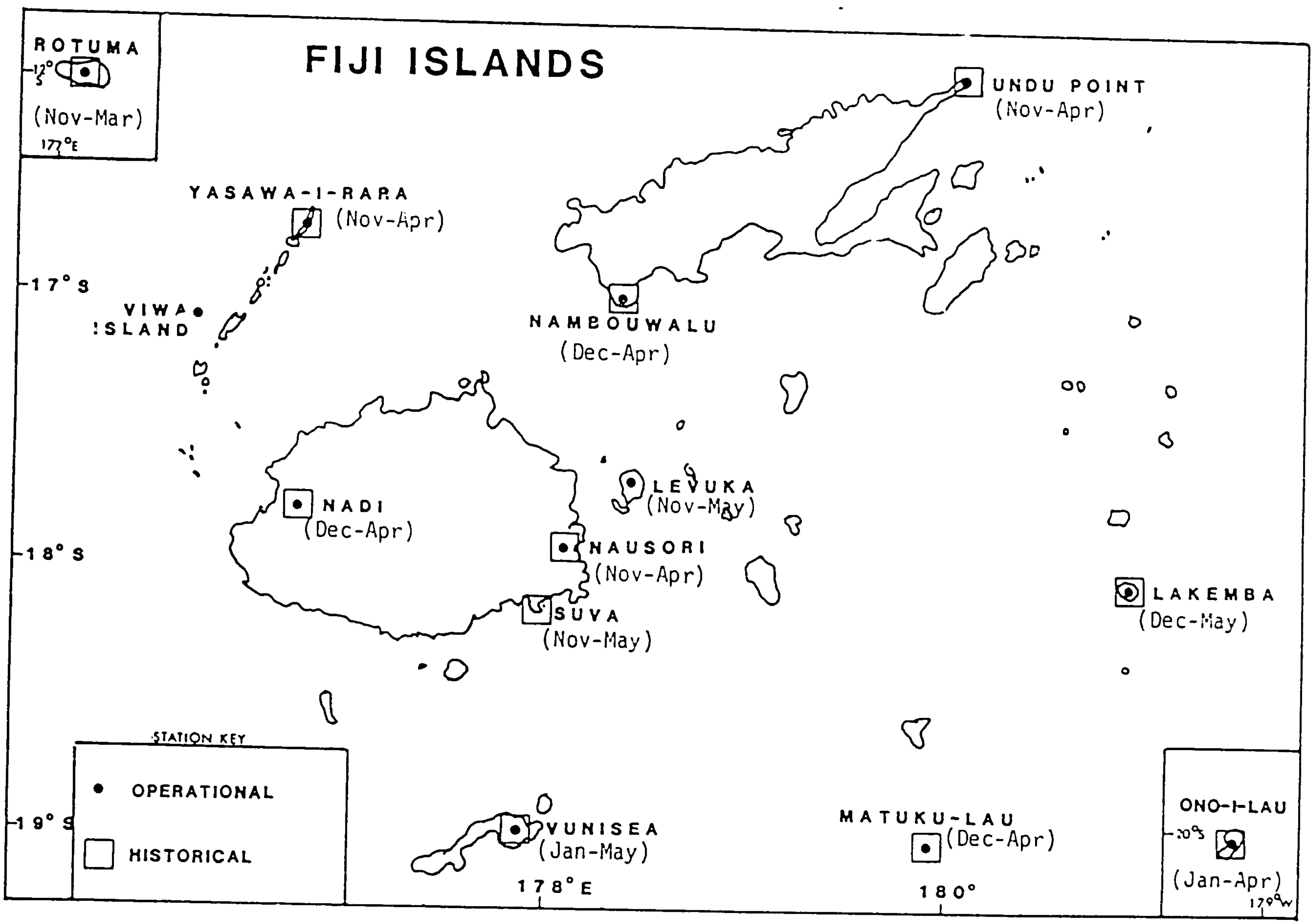


Figure 9.2(d) Assessment Months at Selected Stations in the Fiji Islands.

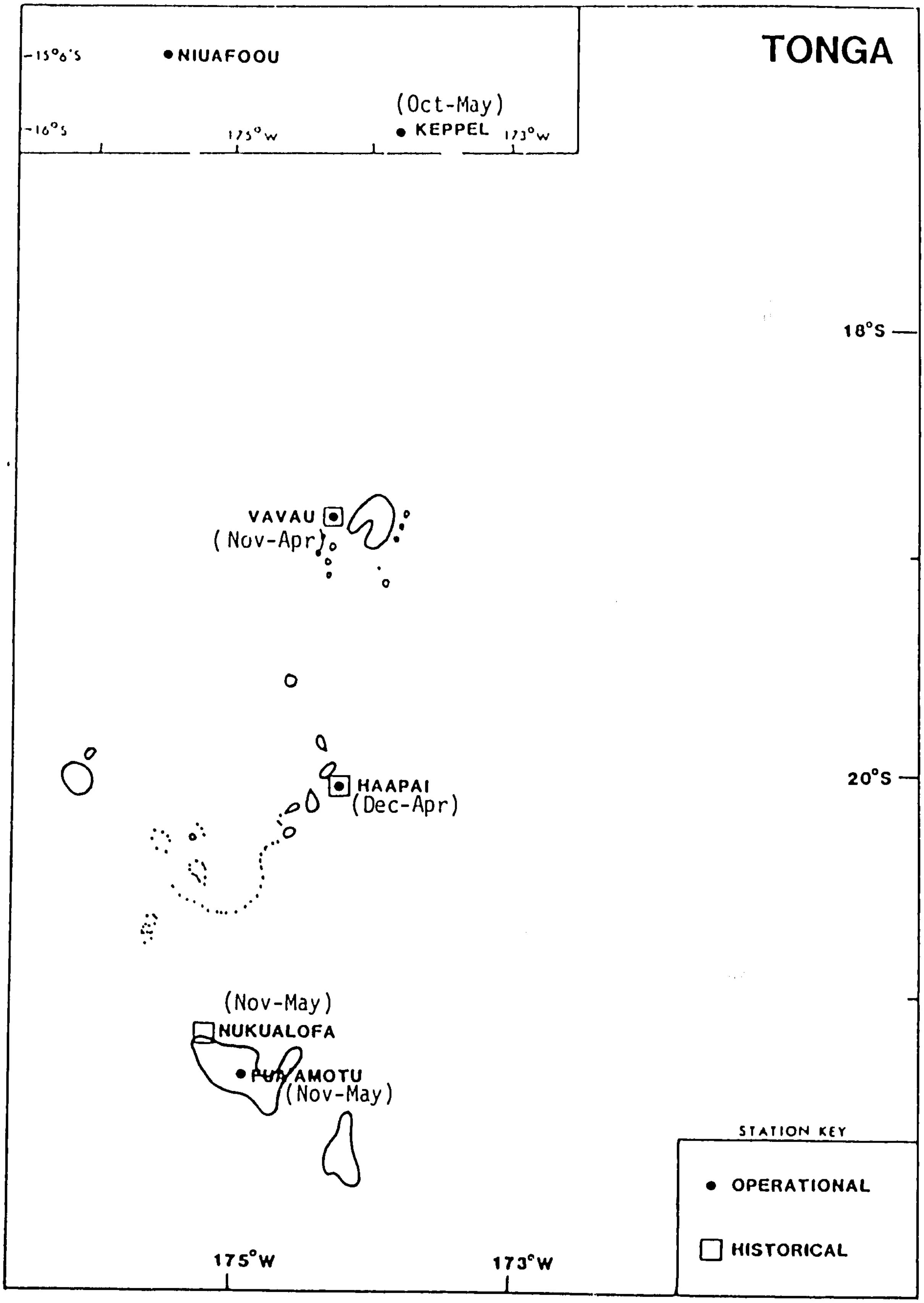


Figure 9.2(e) Assessment Months at Selected Stations in Tonga.

are included in Appendix E. These assessment periods are based on the normal rainfall pattern for each station.

The cumulative rainfall values for each station in all the island groups are expressed as 1) observed, 2) percent of normal and 3) percentile ranks. Percentile rankings are not computed for stations with a short period of record. A sample of cumulative rainfall analysis, for the station Suva in Fiji, is shown in Table 9.1.

Examples of the AISC South Pacific Early Warning Assessments provided during 1983 are shown in Appendices F.1 and F.2, respectively.

D. Special Assessments

Special assessments summarizing the impact of, for example, drought during the assessment year in any given island group may be requested by users such as the USAID missions. The format for special assessments is designed to provide decision and policy makers with key information on the severity of the current situation and the potential for any food shortages. The special assessment issued by AISC on the 1983 drought situation in Fiji is shown in Appendix F.3.

Agencies and organizations involved in providing disaster relief need early warning on the magnitude and extent of drought impact. Timeliness in providing this information to these agencies is of utmost importance when providing such assessments.

STATISTICS FOR SELECTED STATIONS IN SOUTH PACIFIC
STATISTICS FOR DEFINED ASSESSMENT PERIODS
CUM--> CUMULATIVE RAINFALL. PCTN--> PERCENT OF NORMAL CUMULATIVE RAINFALL
PCTR--> PERCENTILE RANKING OF CUMULATIVE RAINFALL

ISGN=FIJI   STA=SUVA   ID=200   ASSMTHOS=NOV-MAY

YR	CUM1	CUM2	CUM3	CUM4	CUM5	CUM6	CUM7	PCTN1	PCTN2	PCTN3	PCTN4	PCTN5	PCTN6	PCTN7	PCTR1	PCTR2	PCTR3	PCTR4	PCTR5	PCTR6	PCTR7
1945	356	752	1118	1527	2077	2156	2313	134	134	124	132	136	115	109	74	77	83	86	88	77	68
1946	220	387	685	1058	1591	1877	2205	83	64	79	91	104	100	104	48	29	35	43	57	52	59
1947	124	273	455	1285	1656	2122	2325	47	49	52	111	108	114	109	19	12	8	68	62	76	70
1948	140	540	1083	1267	1810	2447	3362	53	96	125	109	119	131	158	26	51	76	66	76	91	96
1949	234	615	1193	1404	1807	2102	2333	88	109	135	121	118	112	110	57	68	85	75	75	74	73
1950	369	581	845	1177	1467	1636	1772	134	103	98	101	98	88	83	71	65	55	54	51	31	25
1951	24	437	815	1214	1504	1654	1830	9	74	94	105	94	88	86	1	35	52	59	52	33	30
1952	245	352	1051	1435	1712	1887	2071	92	58	121	124	112	101	97	54	54	70	81	67	54	45
1953	55	267	643	957	1240	1553	1631	21	48	74	83	81	83	77	4	10	27	32	28	23	20
1954	753	1005	1355	1589	2121	2381	2811	283	179	156	137	139	127	132	98	93	89	88	90	84	89
1955	163	532	1067	1404	2123	2441	2617	61	95	123	121	139	131	123	34	49	72	75	91	89	82
1956	246	559	925	1068	1338	1808	1974	92	99	107	92	88	97	93	56	57	63	46	39	47	39
1957	195	332	437	776	1088	2045	2142	73	59	50	67	71	110	103	40	19	6	13	17	69	54
1958	509	785	1108	1389	1843	2231	2416	191	140	125	120	121	119	113	88	81	81	73	81	79	75
1959	210	344	681	992	1415	1736	1647	79	61	79	86	92	93	84	46	22	33	35	42	39	35
1960	456	693	945	1177	1287	1637	1773	171	123	104	101	84	87	83	83	73	67	54	33	30	26
1961	652	1101	1501	2092	2474	2787	2972	245	196	185	180	162	149	140	94	95	96	97	97	97	92
1962	202	453	849	1012	1311	1993	2243	76	81	98	87	86	107	105	42	39	57	38	34	65	62
1963	204	705	913	1423	1860	2117	2327	77	125	105	123	122	113	109	43	74	62	80	82	75	71
1964	194	423	633	1132	1589	1800	2254	73	75	73	98	104	96	106	39	32	25	51	56	46	64
1965	99	151	445	545	822	1247	1446	37	27	52	47	54	67	68	13	0	7	3	2	6	6
1966	143	335	565	815	899	1341	1541	54	60	65	70	59	72	72	27	21	17	18	4	13	11
1967	45	253	381	620	928	1045	1305	17	45	44	53	61	56	61	3	9	4	5	5	1	2
1968	131	316	470	830	1421	1671	1744	49	56	54	72	93	89	82	22	17	10	21	44	35	23
1969	248	555	735	963	1196	1604	1807	93	99	85	83	78	86	85	59	55	39	31	23	28	27
1970	806	993	1530	1920	2110	2470	2768	303	177	176	166	139	132	131	99	92	94	95	89	93	88
1971	238	738	1113	1481	1881	2425	2648	89	131	128	128	123	130	124	52	75	82	83	84	86	90
1972	265	531	696	1030	1725	2433	2644	100	94	80	89	113	130	124	64	48	36	40	69	87	83
1973	223	382	534	656	1129	1514	2100	84	68	62	57	74	81	101	49	27	15	6	18	20	52
1974	260	754	1375	1583	1953	2204	2670	98	134	159	136	129	118	125	61	78	91	87	86	78	85
1975	559	1179	1627	1984	2252	2459	3029	210	210	188	171	148	132	142	92	96	97	96	95	92	94
1976	417	574	782	1145	1612	1864	1954	157	102	90	99	106	101	92	81	64	46	53	59	53	37
1977	57	194	.	.	.	.	.	21	35	.	.	.	.	.	5	2	.	.	.	.	.
1978		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1979	201	222	499	687	993	1694	1745	76	40	58	59	65	91	82	41	5	12	8	7	38	24
1980	471	595	888	1250	1395	1671	1970	177	106	102	108	91	89	92	86	66	61	65	40	35	38
1981	681	822	1363	1589	1963	2314	2504	256	146	157	137	129	124	120	96	83	90	88	86	83	78
1982	188	251	493	925	1153	1255	1341	71	45	57	78	76	67	65	38	8	11	27	22	5	3
1983	171	517	667	922	1277	1670	.	64	92	77	79	84	89	.	36	46	32	28	32	34	.
1984	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

N=102

Table 9.1 Cumulative Rainfall Analysis for Suva in the Fiji Islands.

CHAPTER X

SUMMARY AND RECOMMENDATIONS

An Early Warning Assessment Program for the South Pacific island groups has been developed with a view to providing reliable and timely information on the potential for weather related food shortages. The program is based on a combination of bi-weekly weather assessments and monthly crop condition assessments. Special summary assessments are provided whenever the situation demands.

The assessments provided during 1983 were subsequently verified by in-country observers. The special assessment during the 1983 drought in Fiji demonstrated our capability to respond quickly to specific user requests.

The required background information, preparation of data bases, procedures and the software needed have been developed by AISC during the course of this project. Efforts are continuing to expand and improve the meteorological and agronomic data bases for use in other indices and techniques. For example, the role of sea surface temperature (SST) anomalies in augmenting the early warning assessments should be further explored. Crop condition assessments using the AVHRR data (Channels 1 and 2) on-board the NOAA satellites may not be applicable to the South Pacific island groups due to the small area of these islands.

The island groups in the South Pacific depend largely on cash crops such as coconuts, bananas, sugarcane and cacao for export earnings. In turn, they import most of their processed foods, rice, flour, etc. Any weather related production losses can rapidly lower purchasing power due to reduced foreign exchange earnings. Subsistence agriculture in the South Pacific is largely rainfed due to poor irrigation facilities; weather is therefore a primary factor in food security.

The Early Warning Program developed by AISC for the South Pacific is very cost-effective, timely and reliable. The typical lead-time provided by these assessments is between 30-60 days prior to harvest. Bi-weekly weather assessments and monthly crop condition assessments are currently being provided by AISC on an operational basis. It is hoped that this program will help the USAID/Office of Foreign Disaster Assistance in increasing the food security of the South Pacific.

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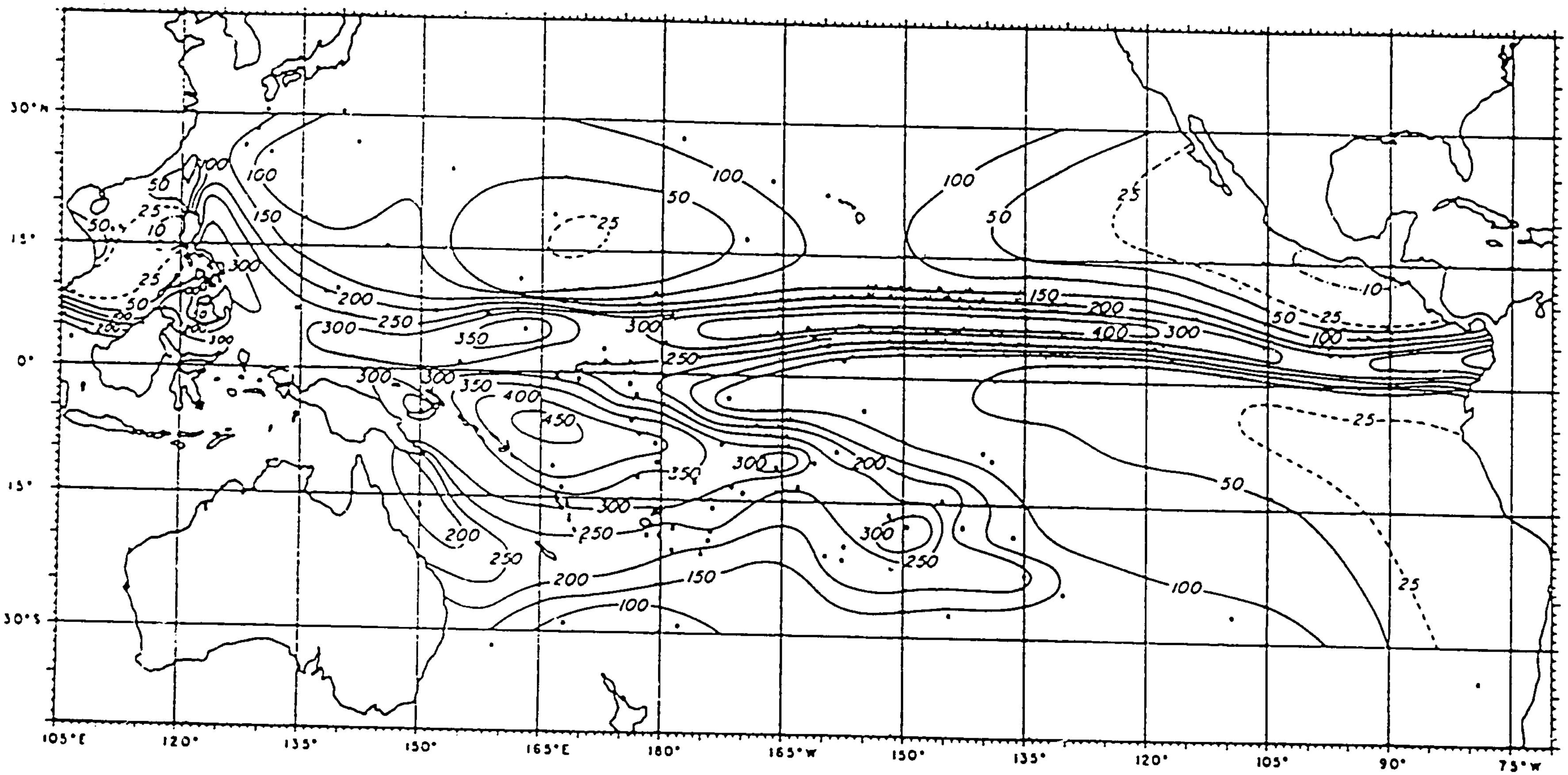
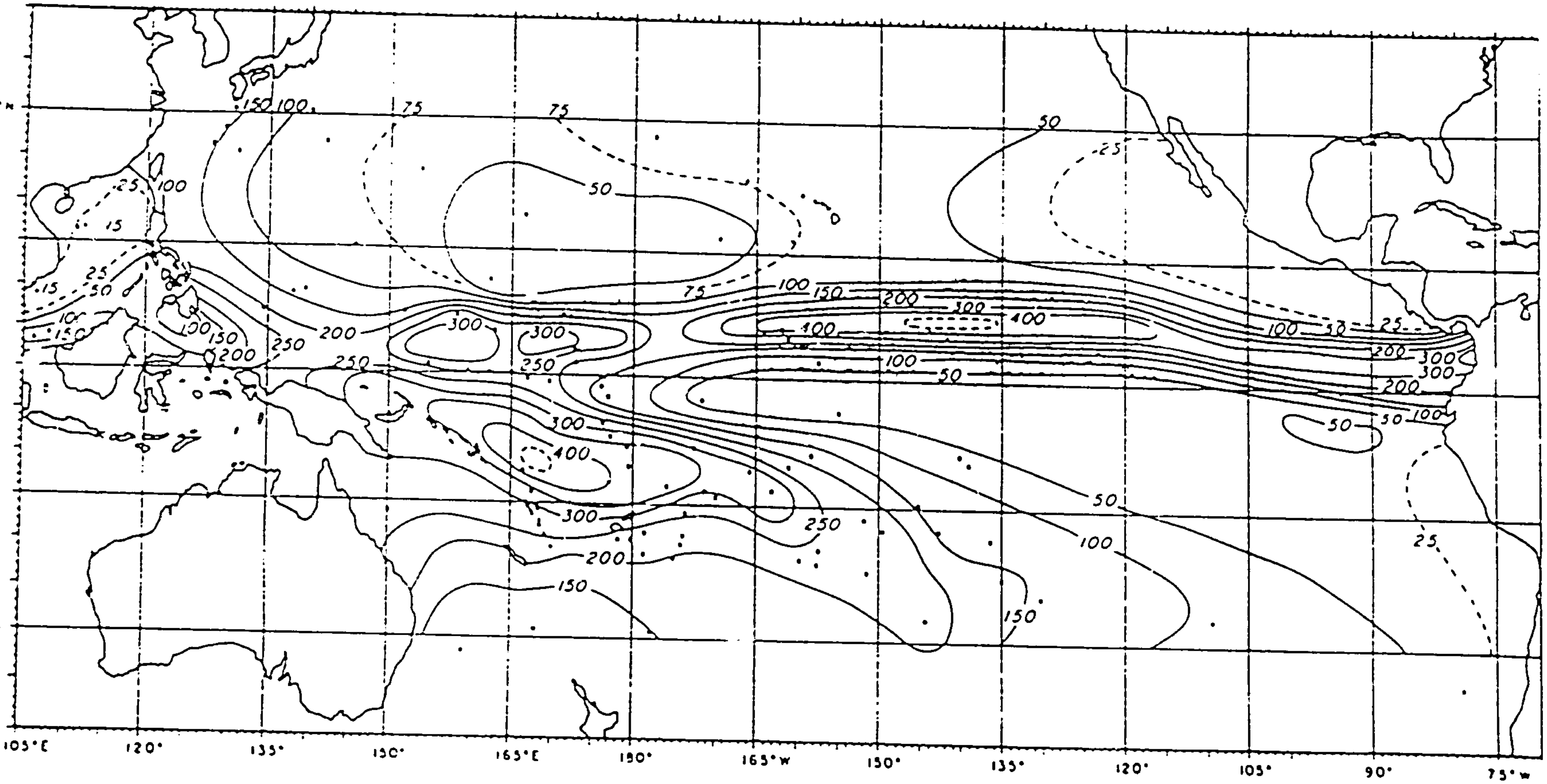
APPENDIX A

DISTRIBUTION OF MONTHLY RAINFALL

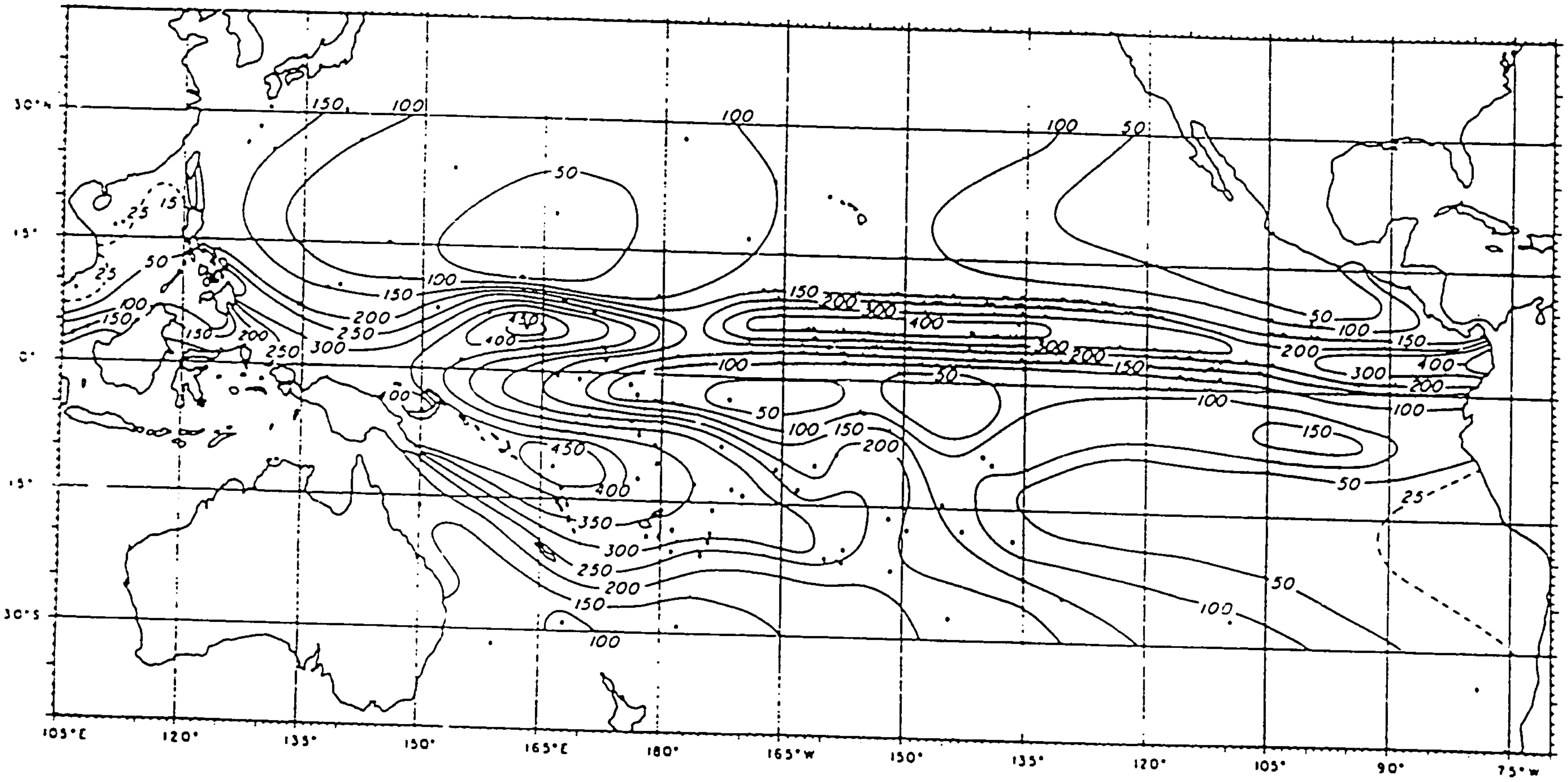
(ADAPTED FROM TAYLOR, 1973)



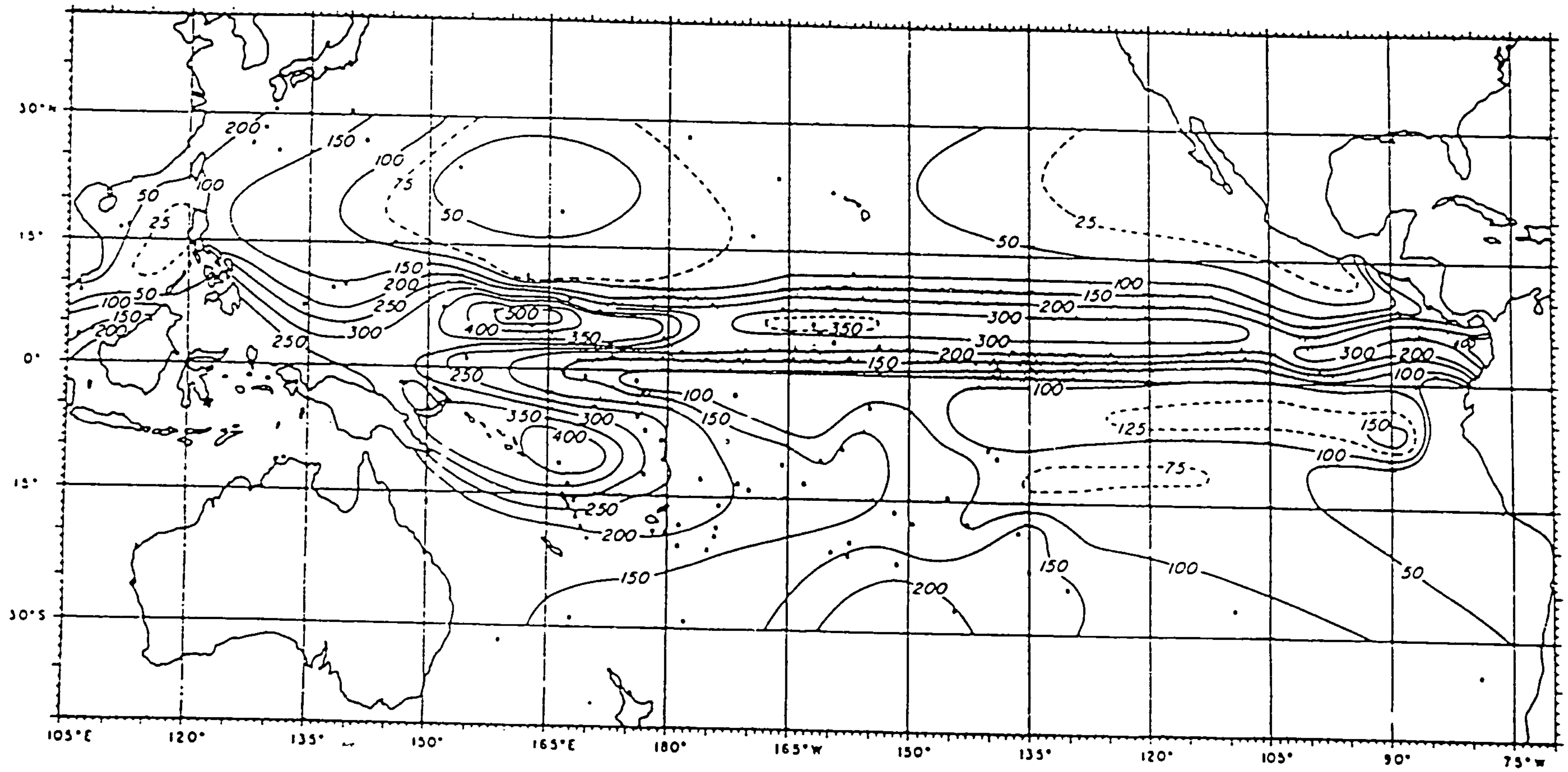
Distribution of Mean Monthly Rainfall (mm), January.



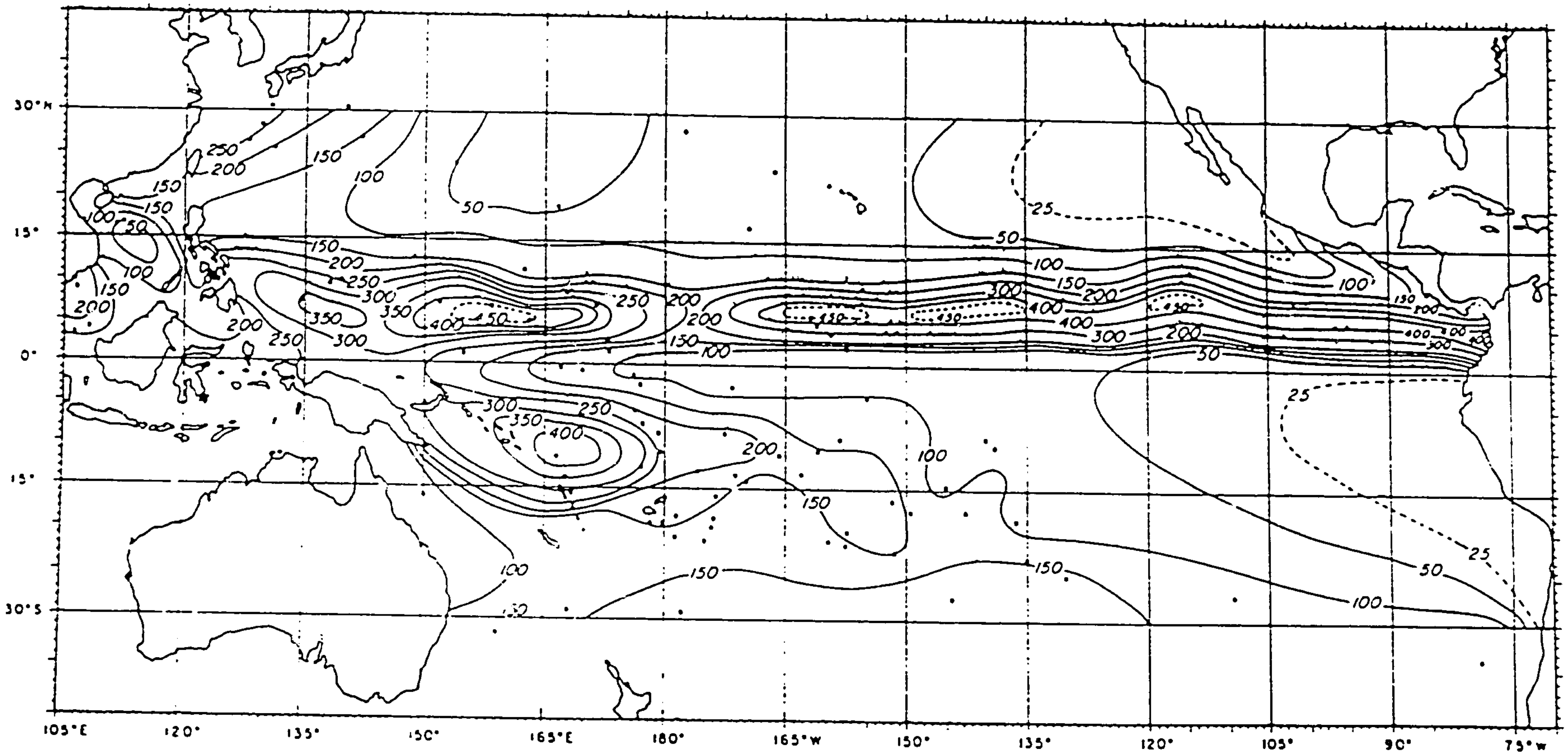
Distribution of Mean Monthly Rainfall (mm), February.



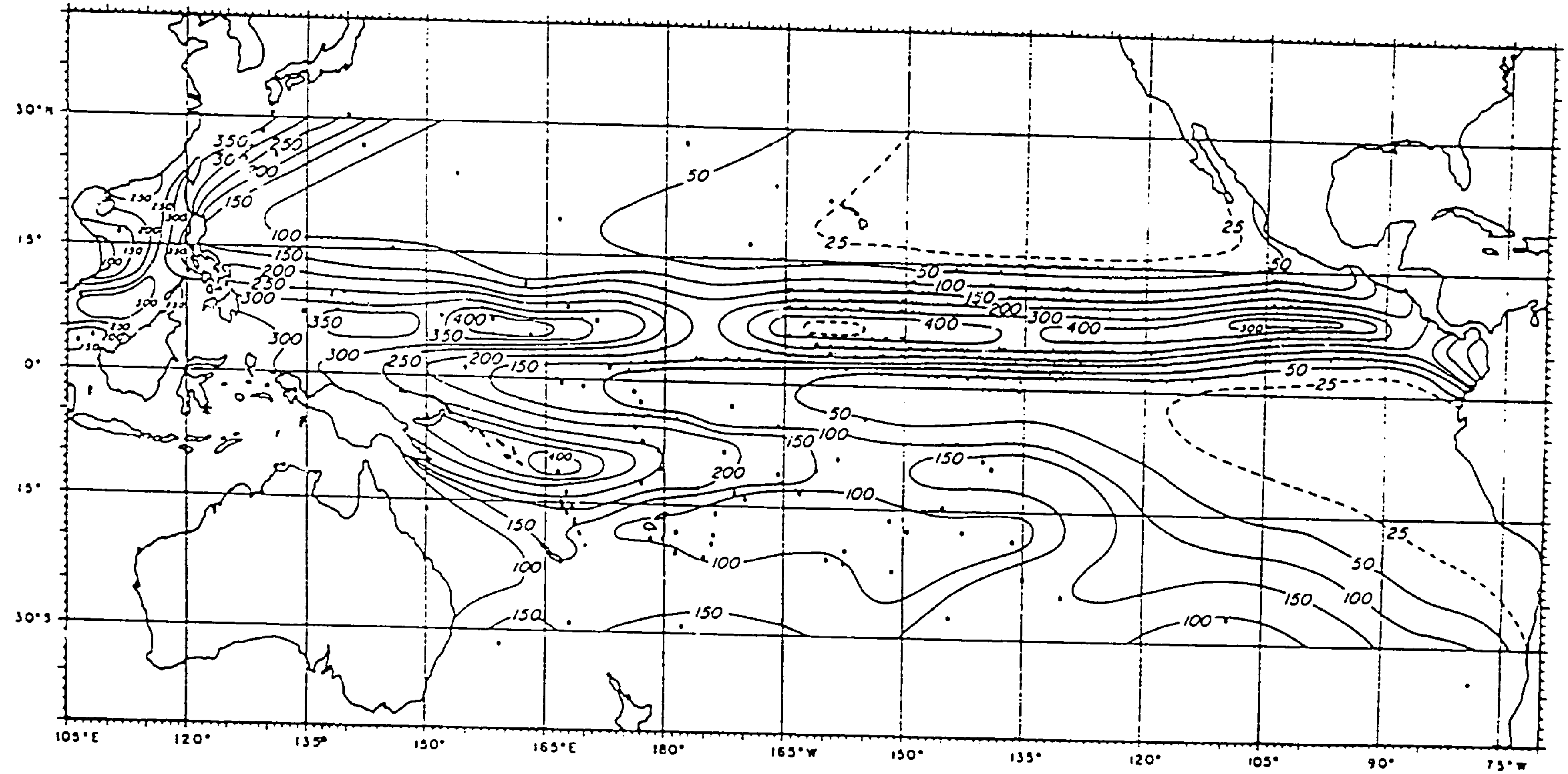
Distribution of Mean Monthly Rainfall (mm), March.



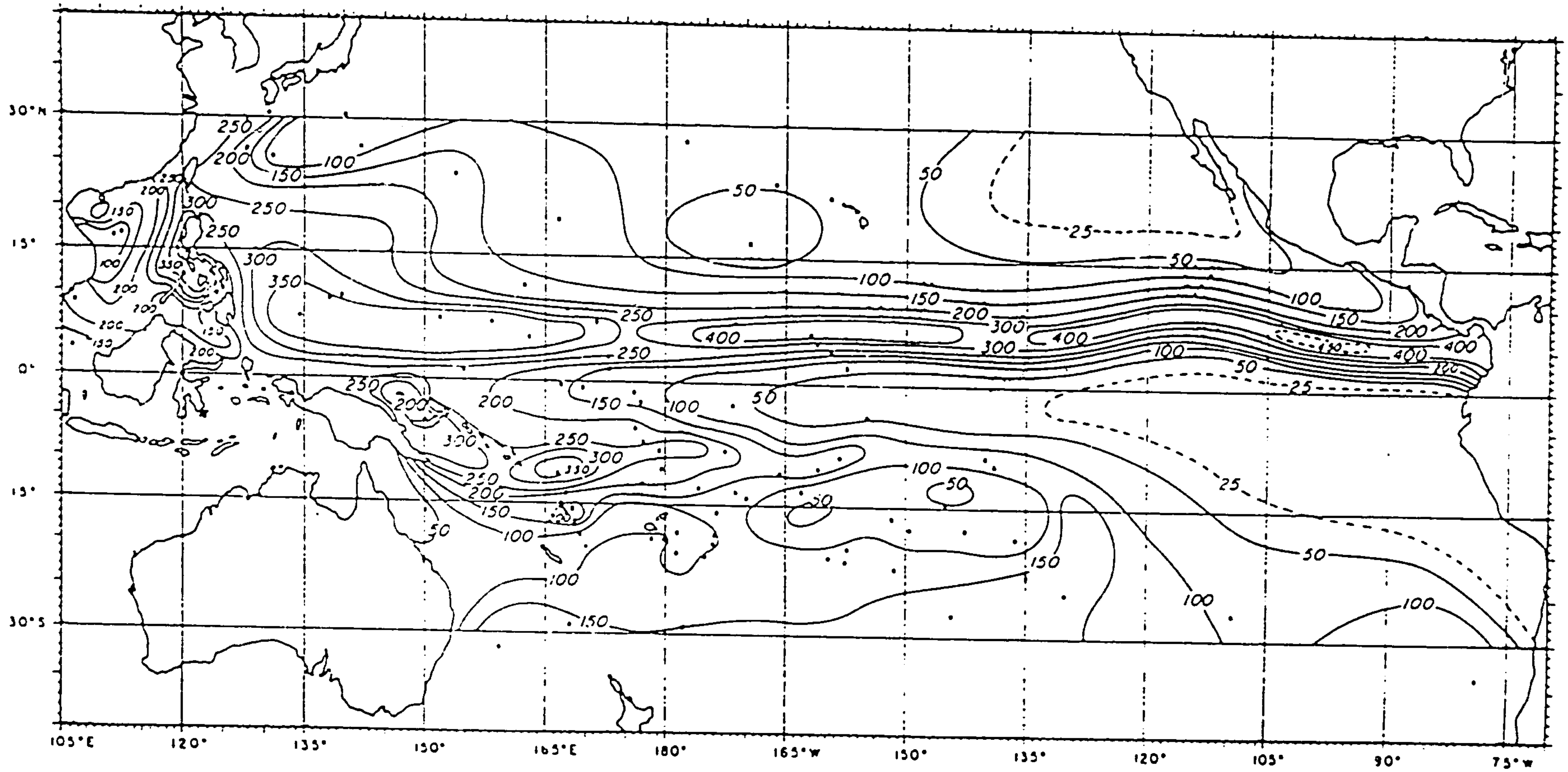
Distribution of Mean Monthly Rainfall (mm), April.



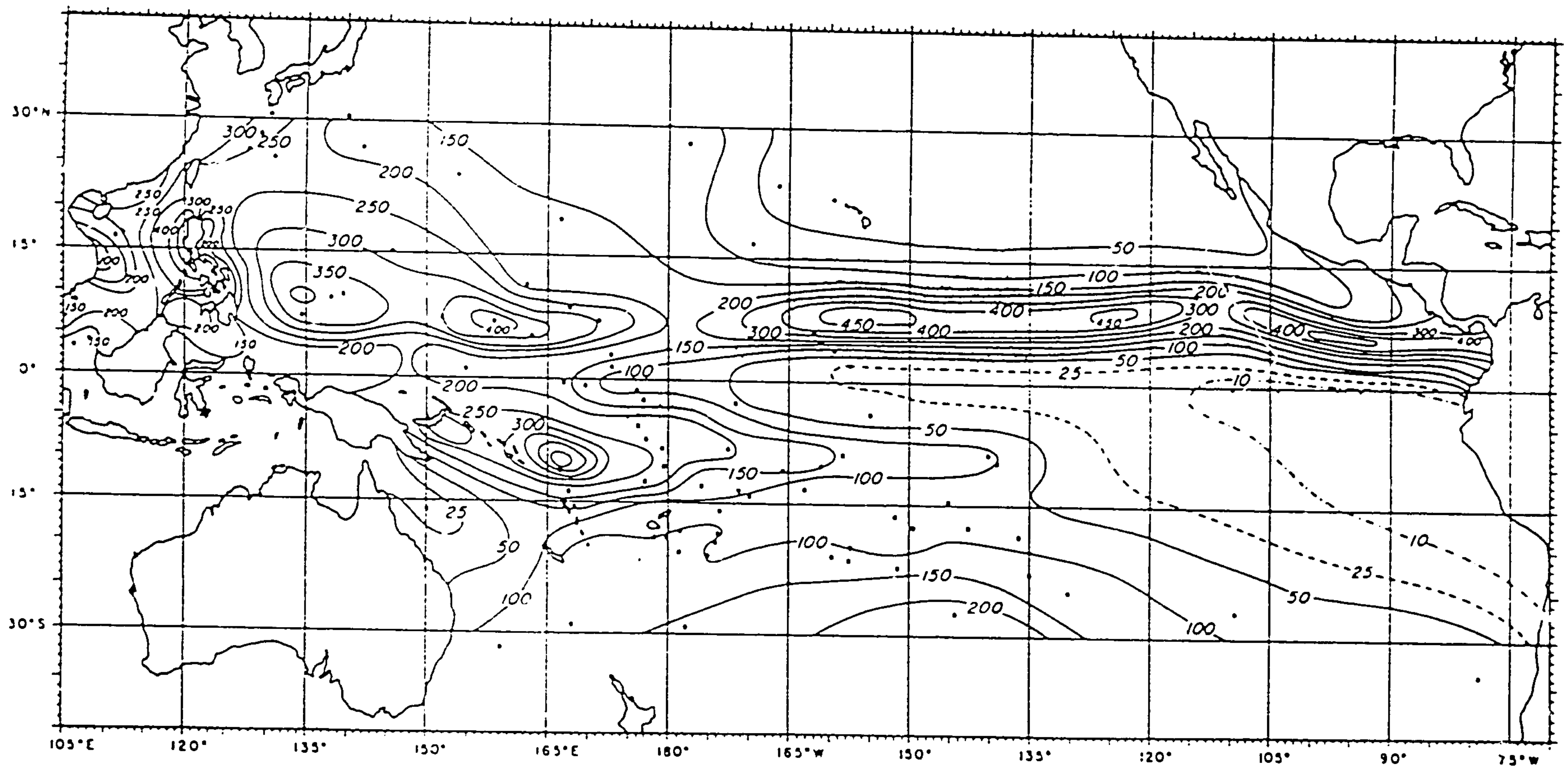
Distribution of Mean Monthly Rainfall (mm), May.



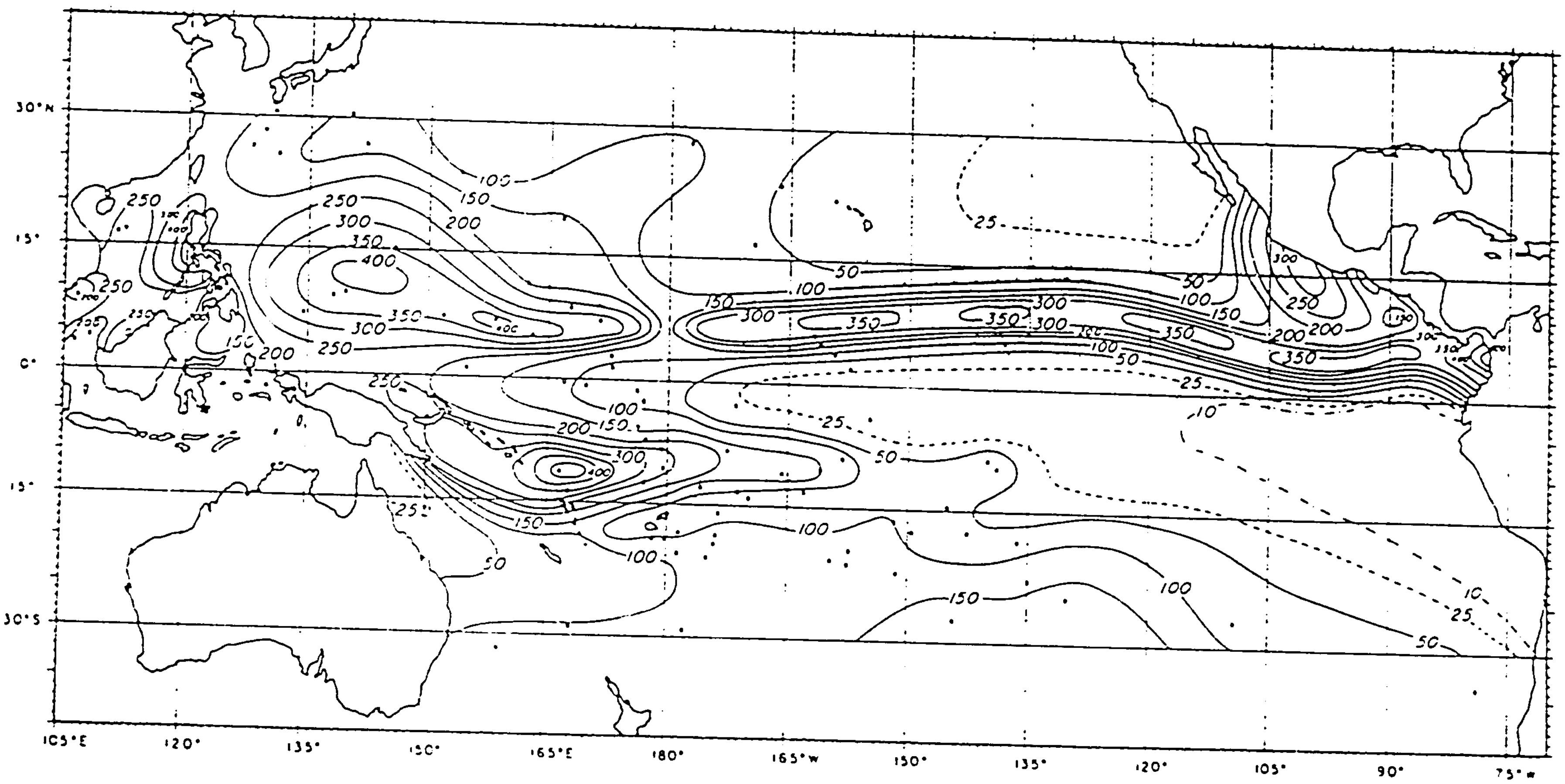
Distribution of Mean Monthly Rainfall (mm), June.



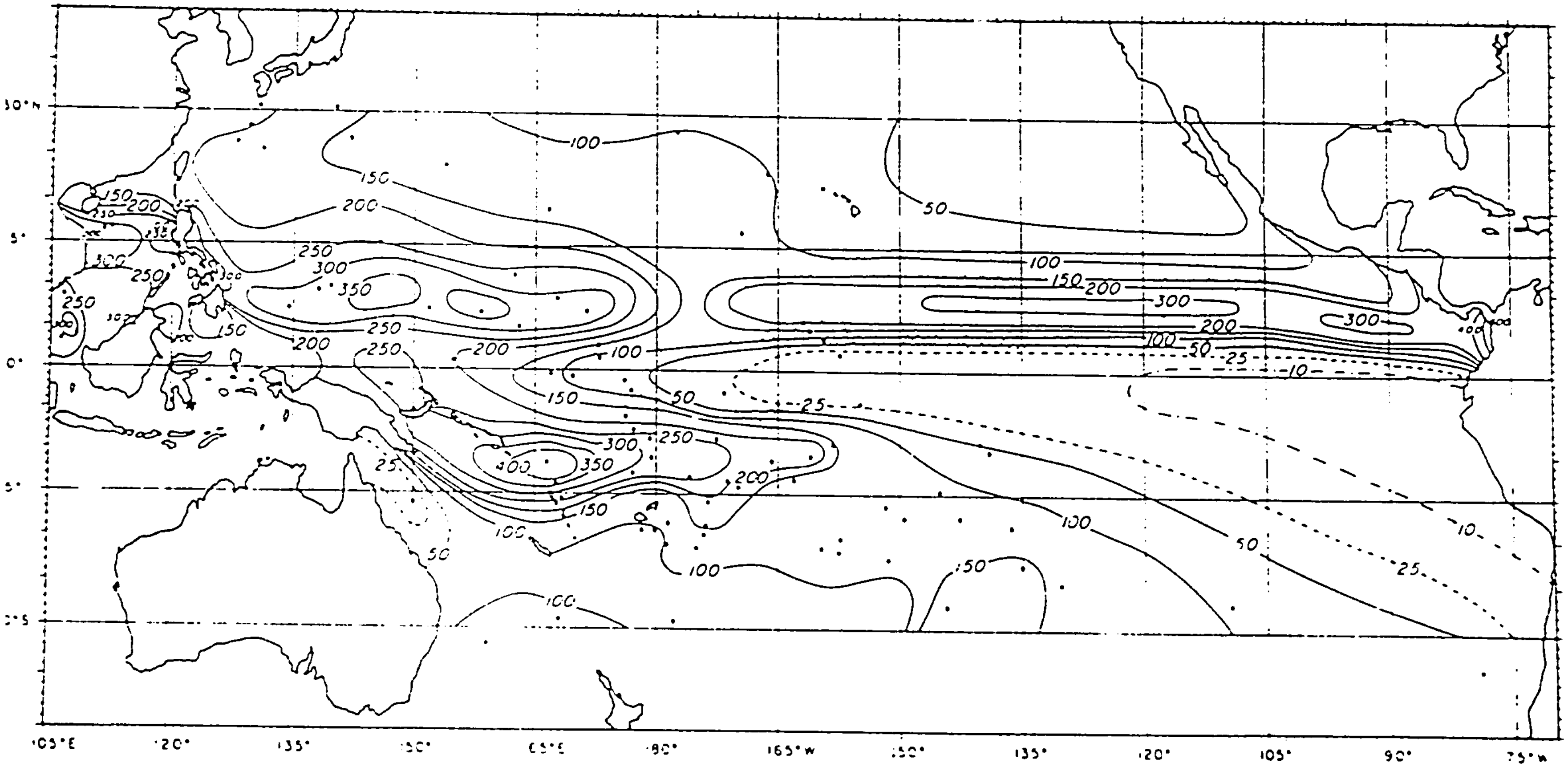
Distribution of Mean Monthly Rainfall (mm), July.



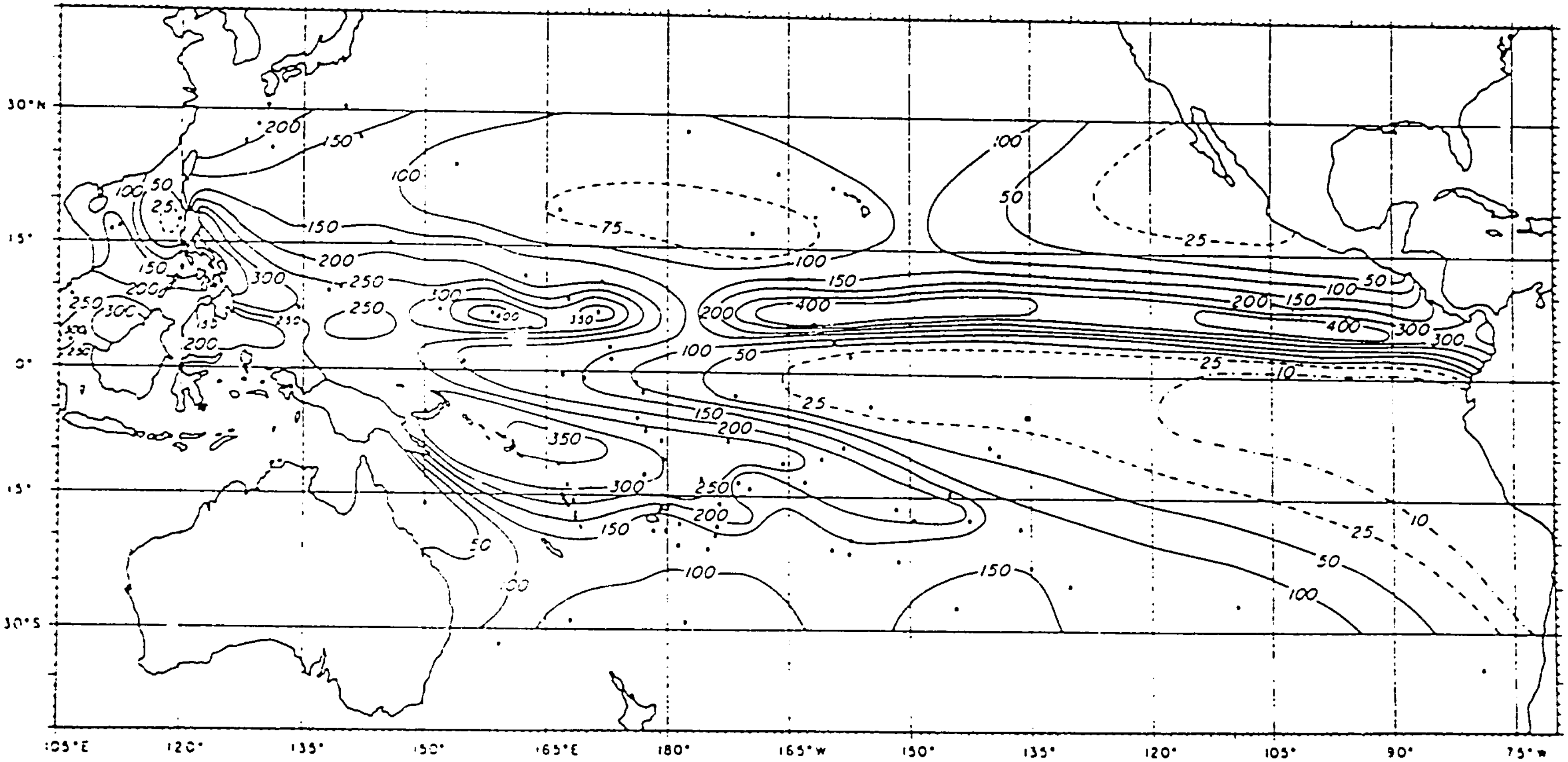
Distribution of Mean Monthly Rainfall (mm), August.



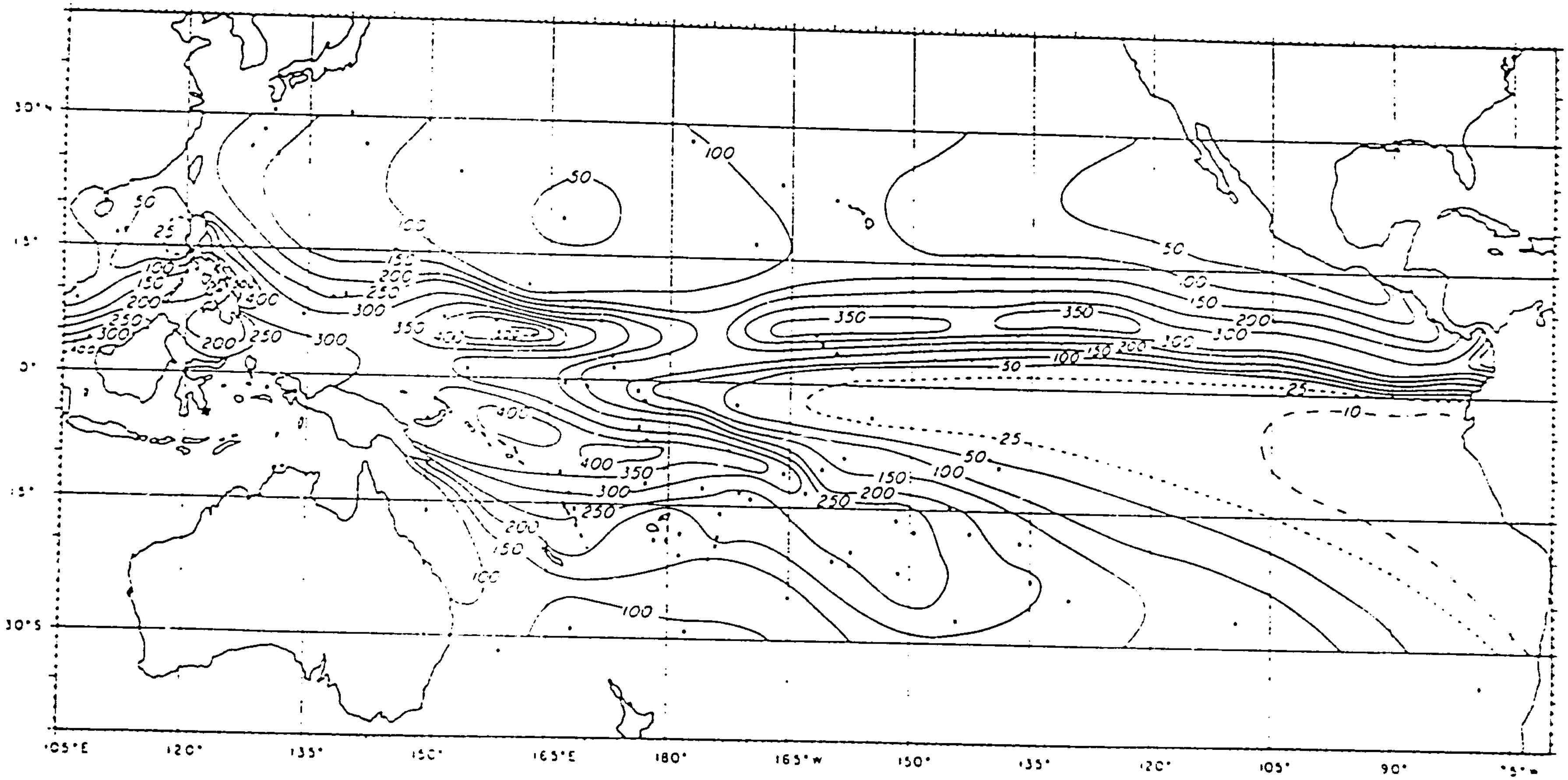
Distribution of Mean Monthly Rainfall (mm), September.



Distribution of Mean Monthly Rainfall (mm), October.



Distribution of Mean Monthly Rainfall (mm), November.



Distribution of Mean Monthly Rainfall (mm), December.

APPENDIX B

EPISODIC EVENT DATA

APPENDIX A.1
SOLOMON EPISODIC EVENT DATA 1951-1982

1951, Storm: March 24-25.

1952, January 23-24 cyclone: developed south of the Solomon Islands but caused much damage from high seas.

1955, March 23 storm.

1959, March 7-8 storm south of main islands.

1959, December 20-22 severe storm at Choiseul Bay.

1959, Serious earthquake producing landslides, flooding and tidal waves in the south Guadalcanal area.

1960, An earthquake in Chile caused a tsunami in the Solomons.

1966, March 28 cyclone "Glenda": widespread damage in Guadalcanal and San Cristobal, mostly from high seas.

1966, November 14 cyclone "Angela": small, violent cyclone over Malaita and Guadalcanal; caused extensive damage.

1967, November 11-12 storm "Annie": caused widespread and heavy damage especially in the more western islands; winds of 100 mph.

1968, December 11-12 cyclone "Becky": widespread damage in central islands, especially Malaita and San Cristobal.

1971, Tinakula in Santa Cruz erupted pouring lava for two months. It caused extensive damage and left 6,000 homeless.

1971, "Ursula": violent storm over Santa Anna, 1 dead, 2,500 homeless.

1972, "Carlotta": loss of lives, serious damage to buildings and agricultural areas.

1972, Hurricane "Ida": destroyed valuable timber.

1977, July 7 earthquake (7.3R)

1978, November 4 earthquake (7.5R)

1979, February 20 "Kerry": affected eastern Solomon Islands; 6,000 homeless, 2 dead, and several seriously injured.

1980, July 8 earthquake (7.3R)

1980, July 9 earthquake (6.8R)

1982, April 2-4 cyclone "Bernie": winds of 35-40 knots and gusts of 70-75 knots; heavy surf and falling trees caused much damage.

Adapted from Disaster Preparedness and Disaster Experience in the South Pacific, Franco, A.B., Hamnett, M.P., and Makasiale, J., East-West Center Honolulu, Hawaii. Sponsored by AID.

APPENDIX A.2

VANUATU EPISODIC EVENT DATA 1951-1982

1951, December 24-25 - Severe hurricane: northern Vanuatu, Epi, Ambrym, Malekoula; almost all villages and plantations destroyed in Epi and Ambrym; 100 dead, 9 small ships sunk.

1952, November 30 - Storm and hurricane affected Efate and southern islands.

1954, February 15 - Storm caused some damage from Banks to Malekoula.

1955, March - Tropical cyclone; considerable damage to coconut trees and some rainwater damage.

1956, March 2 - Storm and hurricane affected Efate and southern island; damage to plantations.

1957, March 29 - Storm: Aneityum.

1959, March - Storm and hurricane: Tanna and Aneityum.

1959, December 28-29 - Hurricane "Amanda": from Epi to Aneityum; severe damage in Vila and southern Efate: winds of 75-85 knots with gusts up to 100 knots.

1960, January 1 - Storm and hurricane from Malekoula to Efate, where damage caused by "Amanda" was aggravated.

1963, November 18 - storm and hurricane from Pentecost to Tanna: one village destroyed on Tongoa, Furari mining installations damaged in Efate.

1963, November 18-19 - Moderate storm.

1964, February 21 - Cyclonic storm with gales and torrential rain.

1964, March 31 - Storm "Henrietta": Banks and Santo.

1965, August - The volcano Suretemataim on Vanua Lava erupted.

1968, March 4 - "Florence": affected southern islands.

1968, December 14 - Storm "Becky" affected area from Santo to Efate; severe damage on Malekoula and Shepherd Islands.

1971, December 9 - Storm "Ursula": affected central islands; floods on Efate.

1972, January 18 - "Carlotta": Santo to Aneityum; severe damage on Efate and Aneityum.

1972, February 2 - "Wendy": Banks to Malakula; severe damage on Banks and Santo, 4 dead.

1972, March 20 - Storm "Yolanda": Aneityum.

1972, April 17 - "Gail": Efate, Shepherd; severe damage on Tongoa, Emae, Mataso, Makura, and North Efate.

1974, February 3 - "Pam": central and southern Vanuatu; heavy rains, damage on Efate and Tanna.

1975, March 5 - Storm "Alison": from Malekoula to Efate; severe damage on Tongoa and Emae.

1976, January 14 - Storm "David": from Banks to Efate; heavy rains, some damage by wind on Malekoula.

1977, January 15 - "Marion": southern islands; subsistence crops destroyed.

1977, Janury 20 - "June": Efate, severe damage to housing and agriculture on Mataso, estimated winds of 80 knots in east Efate.

1977, March 16 - Storm "Norman": southern islands, winds of 45 knots, damage to subsistence agriculture on Aneityum, Futuna, Aniwa; landslides on Tanna and Futuna.

1978, January 5 - Storm "Bob": southern islands; tidal storm wave caused damage from Emae to Tanna; winds at Aneityum of 60 knots.

1979, January 6 - "Gordon": Torres, Banks, Santo, Malekoula; most of the houses destroyed in Loh (Torres); gardens destroyed on Banks Island; tidal wave on north Santo where sea reached 200 m. inland, severe damage to plantations and to 8 villages on the west coast; 65 houses destroyed in Malekoula and wharf destroyed in Norsup.

1979, May 1 - Earthquake (6.7 R)

1979, July 17 - Earthquake (8.0 R)

1981, February 11 - Cyclone "Cliff": extensive damage: houses destroyed on Pentecost, Malekoula, Ambrym, Epi, Efate and other islands; trees blown down in the capital and Vila blacked out for several hours; half of Air Club hangar's roof blown off and sheets of corrugated iron flung onto fence 50 m. away.

1981, July 15 - Major earthquake (7.0R)

1981, December 12 - "Gyan": northern groups and west Santo; heavy rains, floods on north Malekoula; major housing damage.

Adapted from Disaster Preparedness and Disaster Experience in the South Pacific, Franco, A.B., Hamnett, M.P., and Makasiale, J., East-West Center, Honolulu, Hawaii. Sponsored by AID

APPENDIX A.3

KIRIBATI (GILBERT ISLANDS) EPISODIC EVENT DATA 1951-1982

1963, Drought affected copra production.

1972, October 21 "Babe" severe hurricane: Funafuti devastated by winds of 180 mph, with 95% of the houses destroyed, 5 killed, 700 homeless; Fiji and Tonga also affected.

1973-74, Copra exports were seriously affected.

Adapted from Disaster Preparedness and Disaster Experience in the South Pacific, Franco, A.B., Hamnett, M.P., and Makasiale, J., East-West Center, Honolulu, Hawaii. Sponsored by AID.

APPENDIX A.4

FIJI EPISODIC EVENT DATA 1951-1982

1952, January 24 minor cyclone: southeastward over Vanua Levu and Lau Group.

1952, January 28 severe hurricane near Suva: 23 lives lost, new banana plantations wiped out, drop in production.

1953, Earthquake (6.75R) and tsunami struck in Suva-Mbengga zone.

1954, January 15 hurricane, flooding in Viti Levu.

1954, April 22-25 storm: moved southeast over Vanua Levu, Lakemba, and Tonga, causing strong winds in Lau.

1955, January 5-6 moderate storm: Yasawas.

1955, January 27-28 minor storm: eastward south of Viti Levu.

1956, January 29-February 2 storm: developed west of Rotuma, moved towards Fiji, then turned west of Yasawa; heavy rains and floods.

1957, Drought

1957, February 26 minor storm: southwestward through Koro Sea.

1958, January 7 moderate to severe cyclone: southward through Lau Group.

1958, April 9 minor storm: moved southeast over Yasawas.

1958, December 2-3 severe storm: southeastward over central Viti Levu; center passed over Ono-I-Lau.

1959, December 30 moderate cyclone: south of Fiji; coastal villages destroyed by flooding.

1961, Earthquake in Suva-Mbengga zone.

1964, November 22-23 minor cyclone: moved southeastward east of Vanua Levu and through northern Lau.

1964, December 6-7 minor storm: east of Vanua Levu and through northern Lau; trees uprooted at Katafaga Island.

1964, December 21 moderate to severe storm.

1965, February hurricane: wind damage not severe, widespread floods.

1966, December 4-5 minor storm: southeastward over Viti Levu and Southern Lau.

1967, April 9-10 severe cyclone: southward over Vanua Levu and just east of Viti Levu, passing near Ono-I-Lau; considerable damage to houses and food crops.

1968, Drought.

1970, Earthquake in Suva-Mbengga zone.

1970, January 11 minor cyclone: gale force winds in Kia, Vanua Levu, and Taveuni.

1970, October 29-30 cyclone "Nora": gale force winds in Yasawa and Mamanutha Groups, Viti Levu, Lomaiviti Group, Moala, and Toyota.

1970, December 17-18 cyclone "Priscilla": gale force winds in Yasawa and Mamanutha Groups, extreme southwestern section of Viti Levu, Vatulele, and Kadavu.

1972, October 23-29 hurricane "Bebe": severe hurricane affected much of the country; 18 dead, 120,000 homeless, 6,500 houses destroyed.

1973, February 2 "Henrietta": moderate storm in extreme eastern tip of Vanua Levu (Undu Point), Thikombia Island, and Nggele Levu.

1973, April 3-4 cyclone "Juliette": affected Savusavu and Bua; 160,000 homeless; later passed over Ha'apai, Tonga.

1973, December 18 cyclone "Lottie": affected Kadavu and Lau Group; 74 deaths, 1373 houses destroyed, 15,000 people rationed.

1974, April 26 "Tina": minor gale force winds in extreme eastern tip of Vanua Levu, Taveuni, Thikombia Island, Naitaumba (Northern Lau).

1975, January 30-February 2 cyclone "Val": affected the Lau Group; 75% of the houses destroyed, 23,000 mass fed for 6 months.

1975, April 5-6 "Betty": moderate hurricane in western Kadavu, Ono Island, Vatulele, and Ono-I-Lau; extensive damage in some Kadavu areas.

1975, Earthquake in Suva-Mbengga zone.

1976, Earthquake in Suva-Mbengga zone.

1977, December 25-26 "Anne": moderate hurricane affecting Naitaumba, Vanua Mbalavu, Munia Katafanga, and Thikombia-i-Lau.

1978, January 4-5 "Bob": moderate hurricane in strip of Viti Levu west of line from about Tavua to Lomeiwai, Yasawa, and Mamanutha Groups; one death in Sambeto, near Nadi, where several houses were demolished.

1978, February 4 storm: several islands affected.

1978, February 18-19 minor cyclone "Ernie": storm force winds in Thikombia Island, northeastern tip of Vanua Levu (Undu Point).

1978, December 29-30 moderate cyclone "Fay": storm force winds in Kia, Thikombia, eastern Vanua Levu, Taveuni; coastal damage from combined storm surge and heavy surf to some islands in Lau Group.

1979, March 26-28 severe hurricane "Meli": running in a straight line from the Eastern through parts of the Central and Western Divisions, traversing parts of the Lau, Kadavu, Rewa, and Nadroga provinces; heavy storm surge on March 27, reaching between 2-3 m. on the island of Nayau with wave wash reaching 6 m. in places; severe devastation, 53 persons dead, 300 injured, 15,000 homeless; at least 11 vessels lost, damaged, sunk, or a ground; 1,324 families left homeless and 263 school units destroyed.

1979, November, two earthquakes, 6.9R and 6.3R, respectively.

1980, January 2-5 minor hurricane "Peni": gale force winds in Mamanutha Group, extreme western strip of Viti Levu west of line from about Sigtoka to Nadi.

1980, March 24 moderate storm Tia: moderate storm, western Vanua Levu, southern Koro, Yathata, Thithia, Thuvutha, southern half of Vanua Mbalavu, and Nggamea; moderate flooding in Vanua Levu and Taveuni, storm surge in Savusavu area, landslides in Koro and Nggamea; 4 deaths, extensive damage to dwellings in Nggamea and Vanua Mbalavu, 504 homes and 31 school units destroyed.

1980, April 3-5 cyclone Wally: affected Vanua Levu and Viti Levu; severe gale, coastal and inland area between Korolevu and Navua, Vatulele, Kadavu, Mbegga; severe flooding in Navua, Rewa, and other coastal rivers of Viti Levu from Korolevu eastwards; 18 deaths, 10,000 homeless, 269 homes and 31 school units destroyed; heavy damage from flooding and landslides, extensive damage to Queen's Road between Korovisilou and Suva; severe loss of livestock, pasture, and crops especially in Navua.

1981, January cyclone "Arthur": severe damage to sugarcane industry; 952 homes and all schools in the Yasawa/Mamanuca Group, Lautoka, Nadi, and Nadroga areas destroyed.

1982, January "Hettie" caused three deaths.

Adapted from Disaster Preparedness and Disaster Experience in the South Pacific, Franco, A.B., Hamnett, M.P., and Makasiale, J., East West Center, Honolulu, Hawaii. Sponsored by AID.

APPENDIX A.5

TONGA EPISODIC EVENT DATA 1951-1982

1951, Drought adversely affected crop production.

1952, Drought adversely affected crop production.

1953, Drought adversely affected crop production.

1957, December 7-8 - Moderate cyclone: southeastward to south of Vava'u.

1960, January 17-18 - Storm: eastward north of Niaufoou on night of January 17 and near Keppel Island next morning.

1960, March 19-20 - Moderate storm: southwestward to north of Vava'u.

1961, March 16-17 - Severe cyclone: southward close to Vava'u and Ha'apai Groups and to east of Tongatapu; 2 dead and 50% of housing destroyed, leaving 8,000 homeless; banana crop wiped out; coconuts stripped and uprooted, setting back the copra industry two and a half years.

1963, March 11 - Moderate hurricane: WSW about 100 km. southeast of Keppel Island.

1964, November 19-24 - Cyclonic storm; minor damage to coconut trees and houses. Strongest winds reported at Nukualofa at force 10.

1972, October - Storm "Bebe".

1973, April 12 - Hurricane "Juliette": Ha'apai Group; severe damage to crops, housing, water tanks, schools, churches on 7 islands and in 17 villages. Three deaths, 700 affected, 33% of copra lost.

1974, Storm on Niuafo'ou.

1974, Volcanic eruption on Fonua Lei

1977, June 23 - Earthquake at Tongatapu and Eva, 7.2-7.4R.

1977, October - minor earth tremor at Tonga-Kermadeo.

1977, September 1978, January - Drought adversely affected crop production.

1977, December 27 - Storm "Anne": damaged crops and structures in Ha'apai.

1978, February 21 - Storm "Ernie": substantial damage in Ha'apai. Five injured, 10,000 affected, and damage estimated at US$1.1m (OFDA).

1979, Storm on Niautoputapu.

1980, June - Earth tremor (6.3R)

1981, September 1 - Earthquake (7.5R)

1982, March 3 - Cyclone "Isaac": severe tropical cyclcne; violent winds, heavy rain, and sea surge devastated Tonga leaving thousands homeless and 6 dead.

1982, June - Cyclone: Tongatapu, severe damage to more than 30 houses, crops almost destroyed, especially bananas in the eastern division.

1982, June 2 - Earthquake (6.5R)

Adapted from Disaster Preparedness and Disaster Experience in the South Pacific, Franco, A.B., Hamnett, M.P., and Makasiale, J., East-West Center, Honolulu, Hawaii. Sponsored by AID.

APPENDIX C

HISTORICAL DATA DIRECTORY

SOUTH PACIFIC ISLAND GROUPS: HISTORICAL STATIONS

Island Group	Station	WMO ID
Banaba	Banaba	915330
Caroline	Anguar	1
	Falalop	912030
	Kapingamarangi	914340
	Koror	914080
	Kosrae(Lele)	913560
	Lukunor	913390
	Mokil Atoll	155
	Ngasang	3
	Nukuoro	914250
	Pingelap	913530
	Ponape	913480
	Puluwat	913240
	Roi-Namur	913640
	Satawan Atoll	913380
	Tobi Island	914100
	Truk	913340
	Woleai	913170
	Yap	914130
Cook	Aitutaki	918300
	Hanan Ap, Niue	918230
	Mangaia I.	145
	Manihiki	918080
	Mauke	918400
	Palmerston	918260
	Penrhyn	918000
	Penrhyn	918010
	Pukapuka	918110
	Rakahanga	918040
	Rarotonga	918430
Fiji	Lakemba	916910
	Lambasa Airport	916570
	Levuka	916780
	Matei	916650
	Matuku-Lau	916970
	Nambouwalu	916590
	Nadi	916800
	Nausori	916830
	Ono-I-Lau	916990
	Rotuma	916500
	Savusavu Airport	916630
	Suva	200
	Suva/Lauthala Bay	916900

Island Group	Station	WMO ID
Fiji (cont.)	Undu Point	916520
	Viwa Island	916700
	Vunisea	916930
	Yasawa-I-Rara	916600
Futuna	Maopoopo	917540
Gambier	Muroroa	919520
	Totegegie/Rikitea	919480
Kiribati	Abaiang	100
	Abemama	105
	Aranuka	110
	Arorae	916290
	Beru	916230
	Butaritari	916010
	Kuria	130
	Little Makin	135
	Maiana	140
	Marakei	150
	Nonouti	175
	Nukunau	190
	Onotoa	195
	Tabiteuea (North)	210
	Tabiteuea (South)	215
	Tamana	220
	Tarawa	916100
Line	Christmas Island	914900
	Christmas Island	914910
	Fanning Island	914860
	Fanning Island	914870
	Malden	919020
	Malden (U. of Hawaii)	919030
	Palmyra	913850
	Washington Island	914840
Marquesas	Atuona	919250
	Taiohae	919200
Marshall	Ailinglapalap	913670
	Eniwetok	912500
	Jaluit	913690
	Kwajalein/Bucholz	913660
	Majuro	913760
	Mili	913780
	Wotje	913710

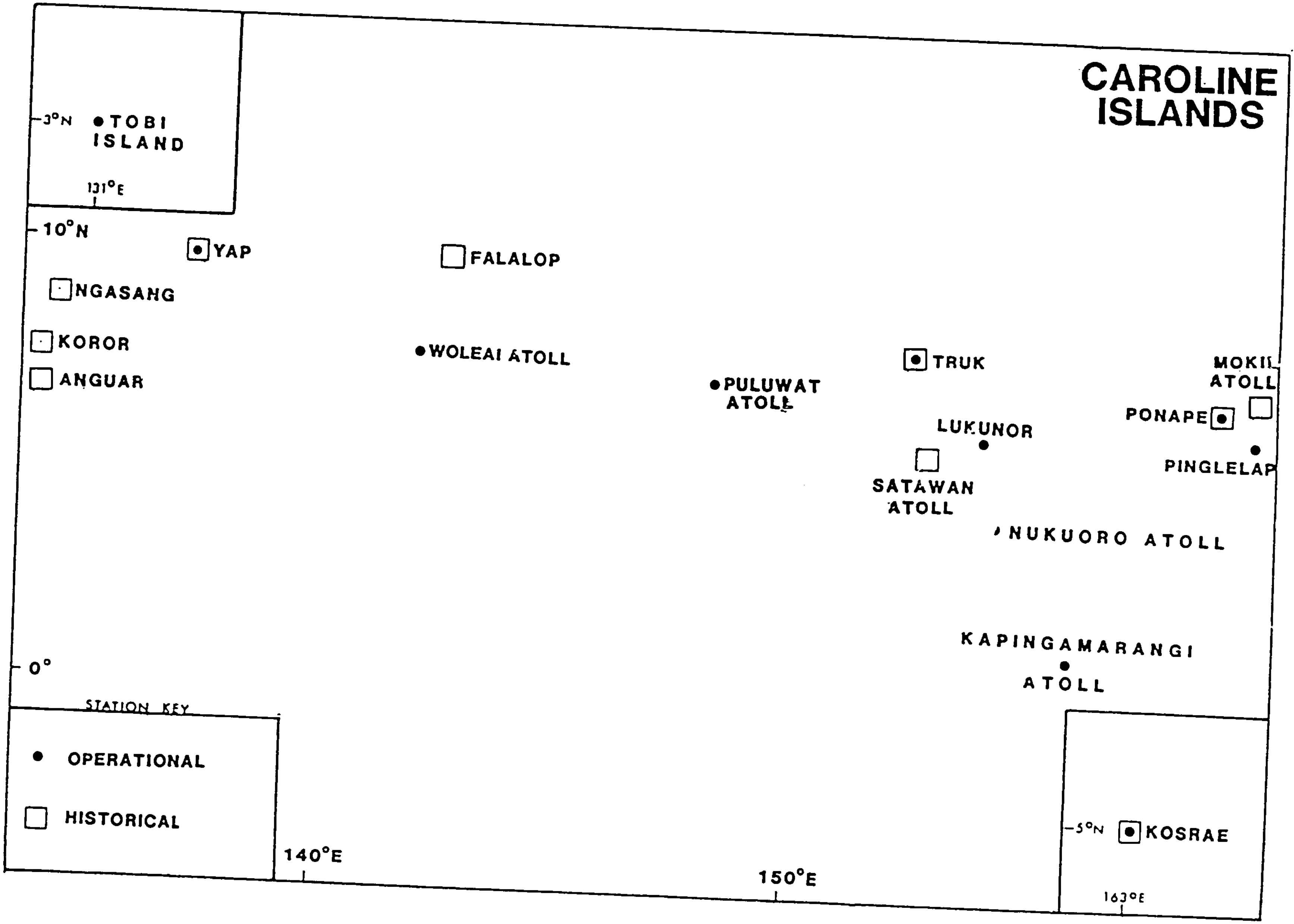
Island Group	Station	WMO ID
Nauru	Nauru	915300
New Caledonia	Ile Loop,Chesterfield	915740
	Ile Surprise	915700
	Koumac	915770
	La Rouche	915870
	La Tontouta	915900
	Matthew	915980
	Moue	915960
	Noumea	915920
	Ouanaham	915820
	Ouloup	915790
	Poindimie	915830
Niue	Alofi	918220
Papua New Guinea	Alotau	940770
	Amazon Bay	940590
	Daru	940030
	Dogura	940670
	Erave	940510
	Garaina	940340
	Gizarum, Umboi	940500
	Hoskins	940720
	Jinjo	940900
	Kainantu	940160
	Kalamadu	940860
	Kavieng	940760
	Kerema	940120
	Kieta	940970
	Kikori	940060
	Kiunga	940010
	Kundiawa	940110
	Kupiano	940660
	Lae	940270
	Lake Kutubu	940310
	Lihir	940880
	Losuia	940790
	Madang	940140
	Malala	940250
	Malekolon Plantation	940840
	Mendi	940210
	Menyamya	940200
	Misima	940870
	Momote	940440
	Morehead	940080

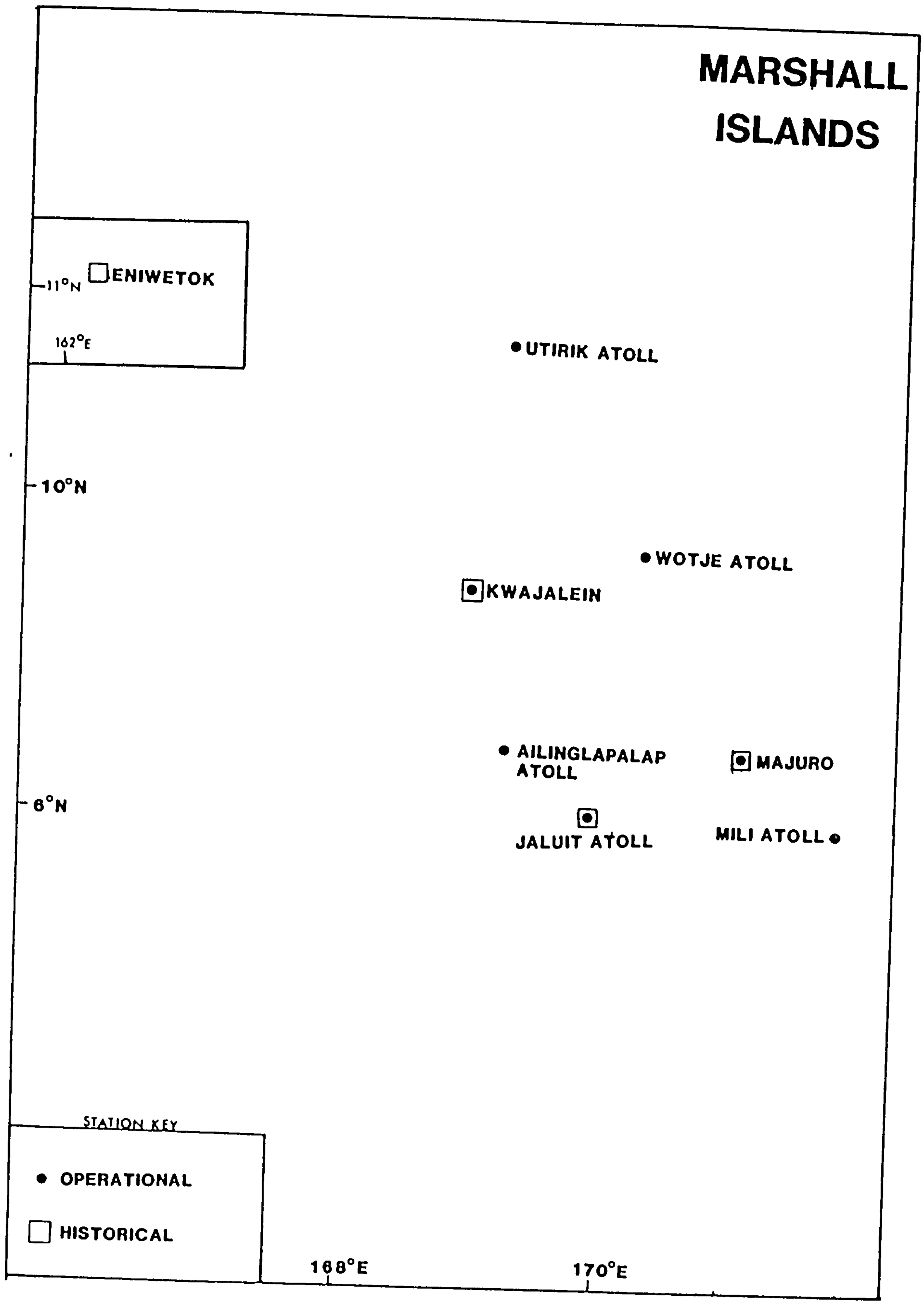
Island Group	Station	WMO ID
Papua New Guinea (cont.)	Mt Hagen	940050
	Nuguria	940820
	Popondetta	940560
	Port Moresby	940350
	Rabaul	940850
	Salamo	940800
	Tari	940300
	Tufi	940580
	Vanimo	940220
	Wau	940240
	Wewak	940040
Phoenix	Canton Island	917000
	Gardner Island	2
	Hull	125
	Sydney	205
Samoa	Apia	917620
	Asau	917600
	Faleolo	917590
	Pago Pago	917650
	Swain's Island	917350
	Tafuna AP	4
	Taputimu	917667
Society	Bora-Bora	919300
	Mopelia	919310
	Tahiti-Faaa	919380
	Uturoa	919340
Solomon	Auki	915070
	Honiara/Henderson	915200
	Kira Kira	915270
	Munda	915030
	Santa Cruz	915410
	Taro Island	915020
	Vanikoro	235
Tokelau	Atafu	917200
	Fakaofo	917270
	Nukunono	917240
Tonga	Fua'amotu	917920
	Haapai	917840
	Keppel	917760
	Niuafoou	917720

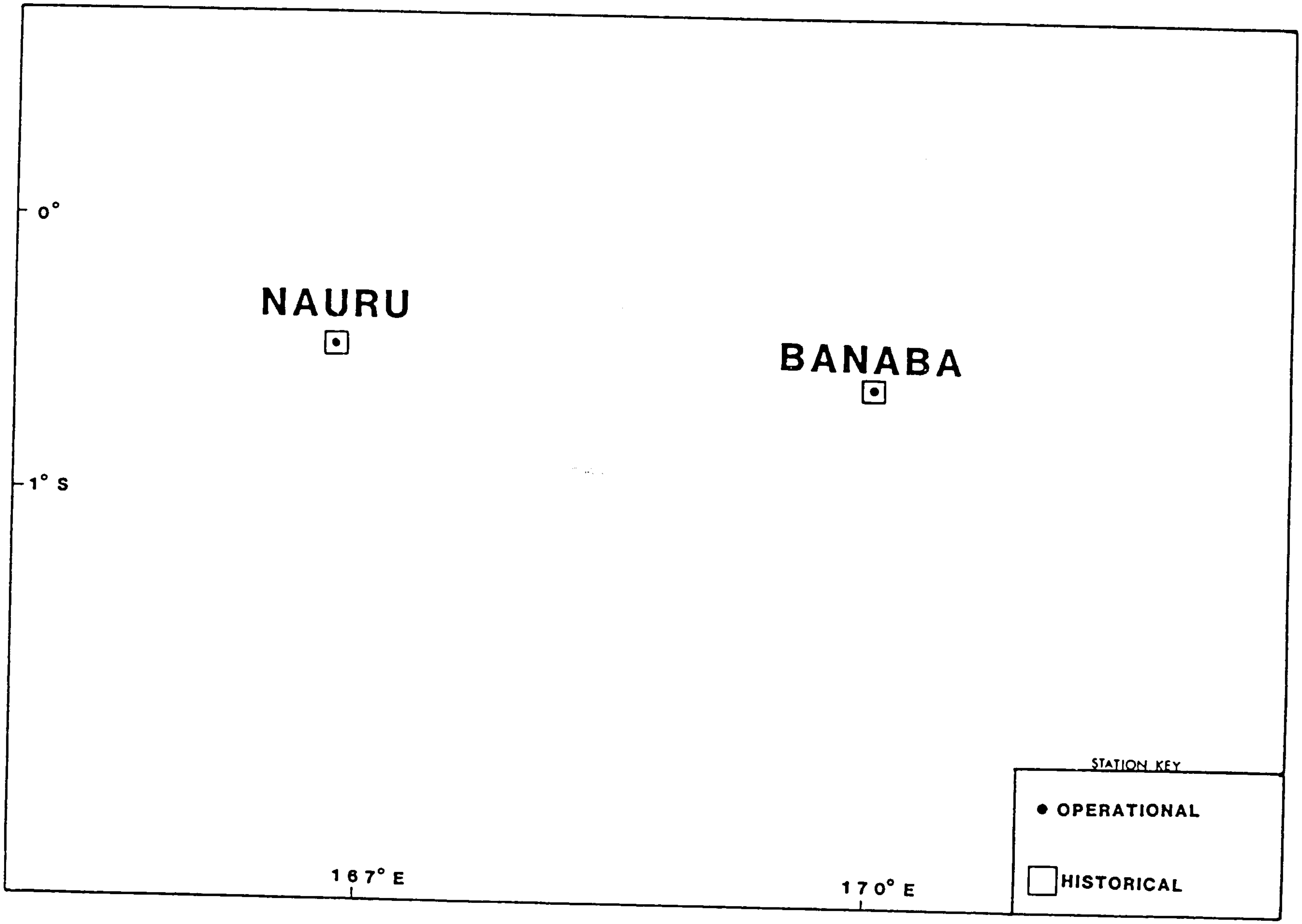
Island Group	Station	WMO ID
Tonga (cont.)	Nukualofa	917880
	Vavau	917800
Tuamotu	Hao	919440
	Hereheretue	919450
	Hikueru	120
	Napuka	919270
	Puka-Puka	919280
	Rangiroa	919410
	Takaroa	919430
Tubuai	Rapa	919580
	Rurutu	919500
	Tubuai	919540
Tuvalu	Funafuti	916430
	Nanumanga	160
	Nanumea	916310
	Niulakita	916480
	Niutao	170
	Nui	916360
	Nukufetau	180
	Nukulaelae	185
	Vaitupu	230
Vanuatu	Aneityum	915680
	Burtonfield	915650
	Erromango	115
	Lamap	915550
	Luganville	915540
	Nguna I	165
	Sola	915510
	Tongoa	225
	Vila	915580
Wallis	Wallis/Hihifo	917530

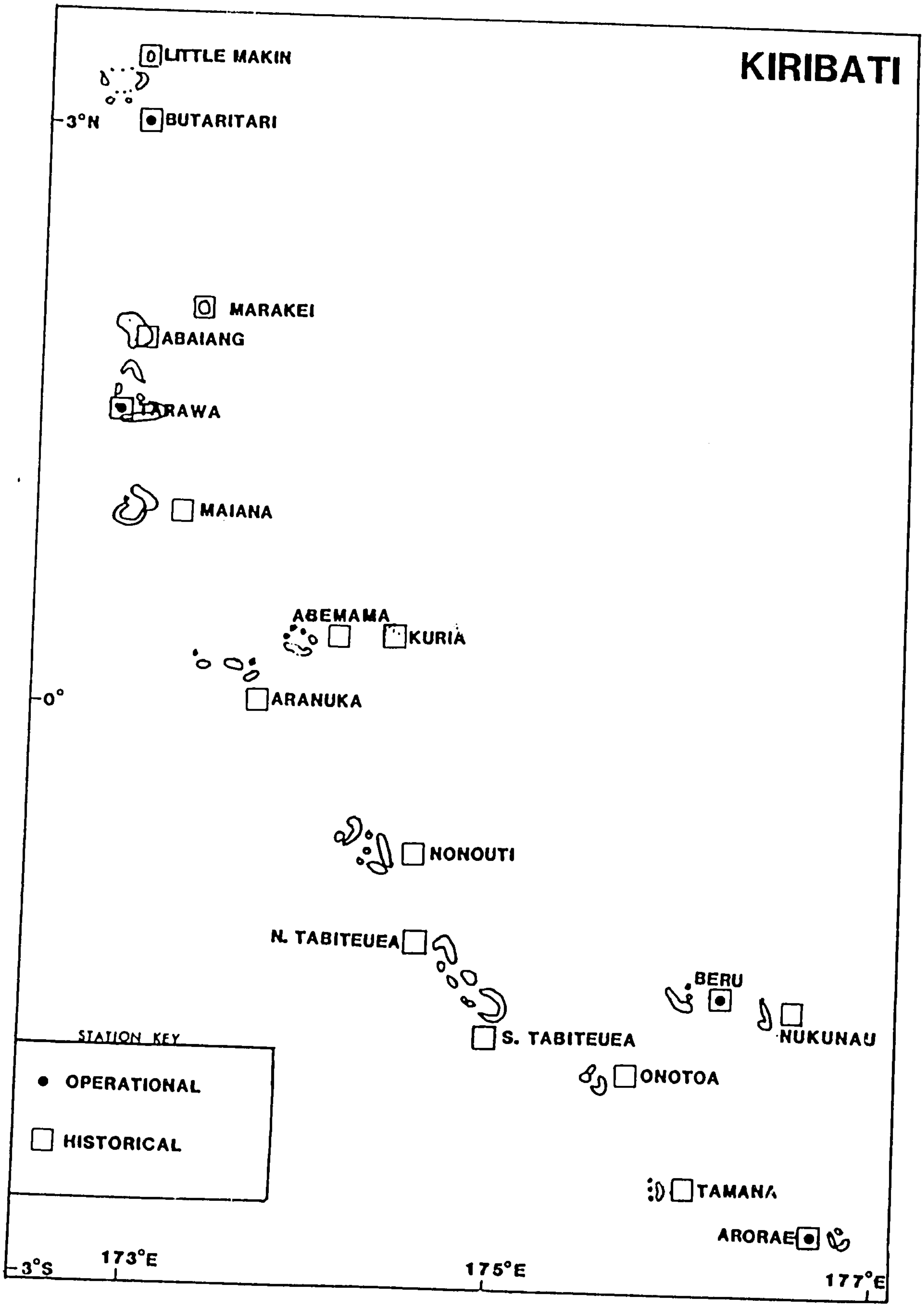
APPENDIX D

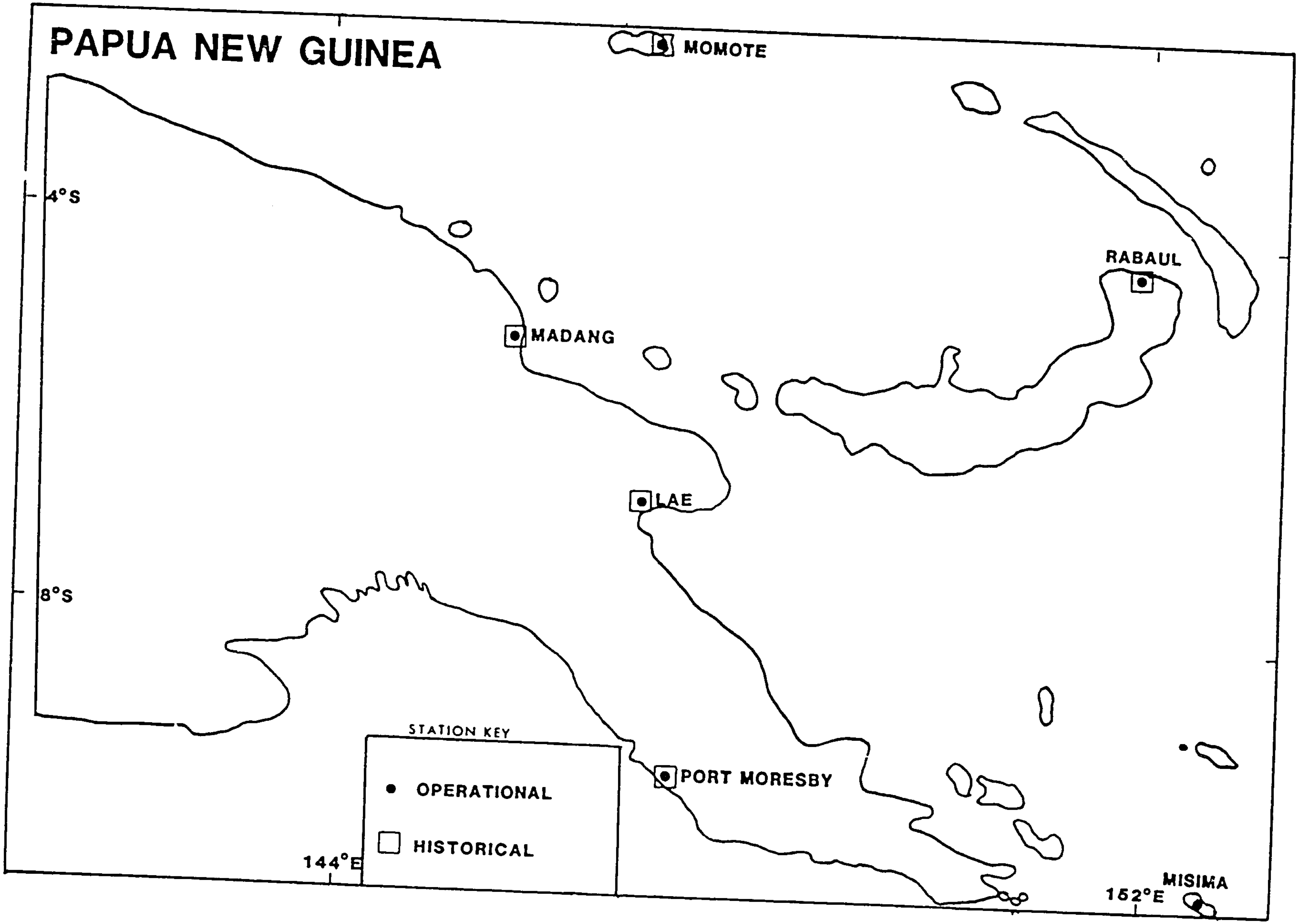
OPERATIONAL (REAL-TIME) AND HISTORICAL STATIONS

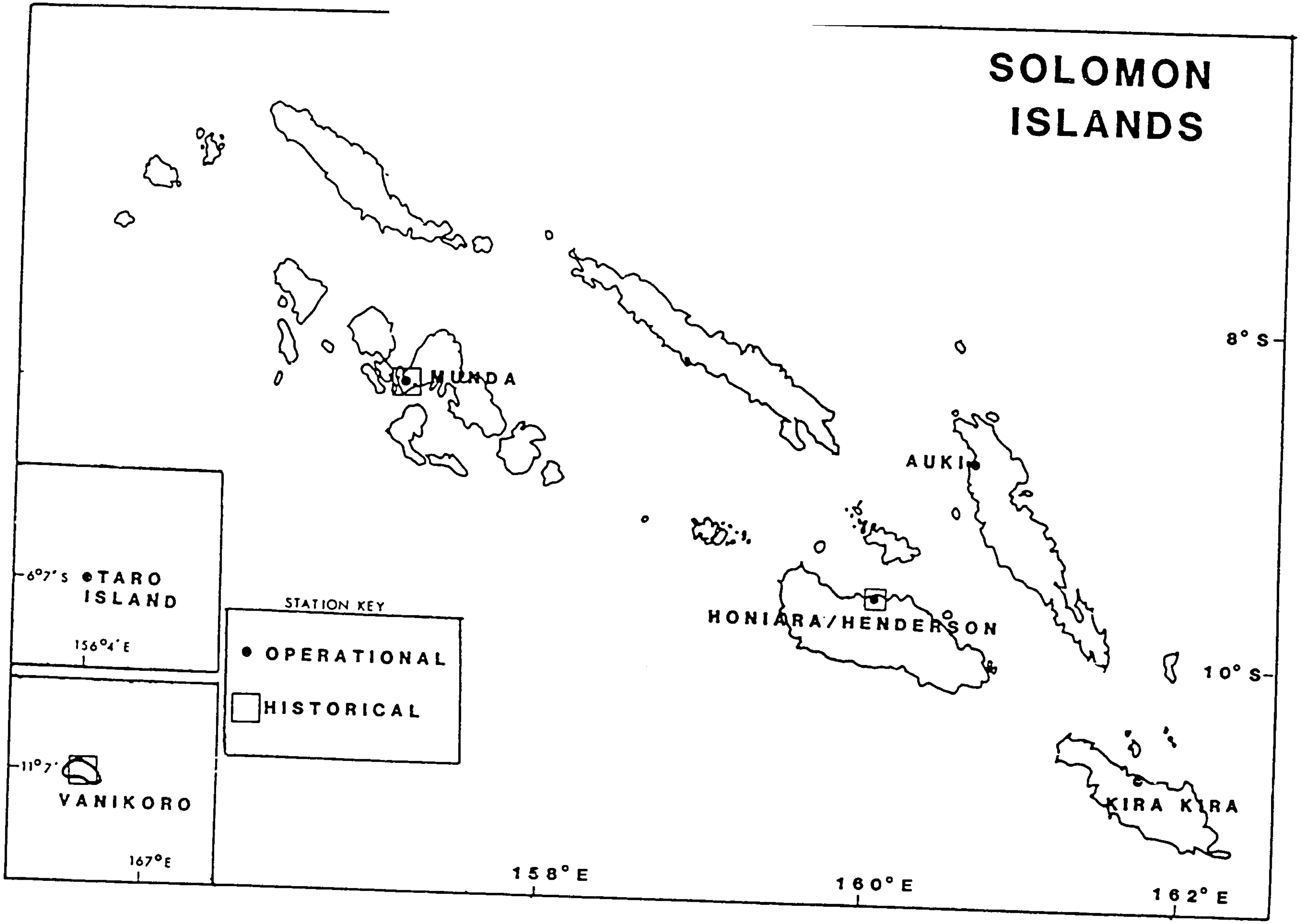

CAROLINE ISLANDS
3°N
TOBI ISLAND
131°E
10°N
YAP
FALALOP
NGASANG
KOROR
WOLEAI ATOLL
ANGUAR
PULUWAT ATOLL
TRUK
MOKIL ATOLL
PONAPE
LUKUNOR
PINGLELAP
SATAWAN ATOLL
NUKUORO ATOLL
KAPINGAMARANGI ATOLL
0°
STATION KEY
OPERATIONAL
HISTORICAL
140°E
150°E
5°N
KOSRAE
163°E


MARSHALL ISLANDS
11°N
ENIWETOK
162°E
UTIRIK ATOLL
10°N
WOTJE ATOLL
KWAJALEIN
AILINGLAPALAP ATOLL
MAJURO
6°N
JALUIT ATOLL
MILI ATOLL
STATION KEY
OPERATIONAL
HISTORICAL
168°E
170°E

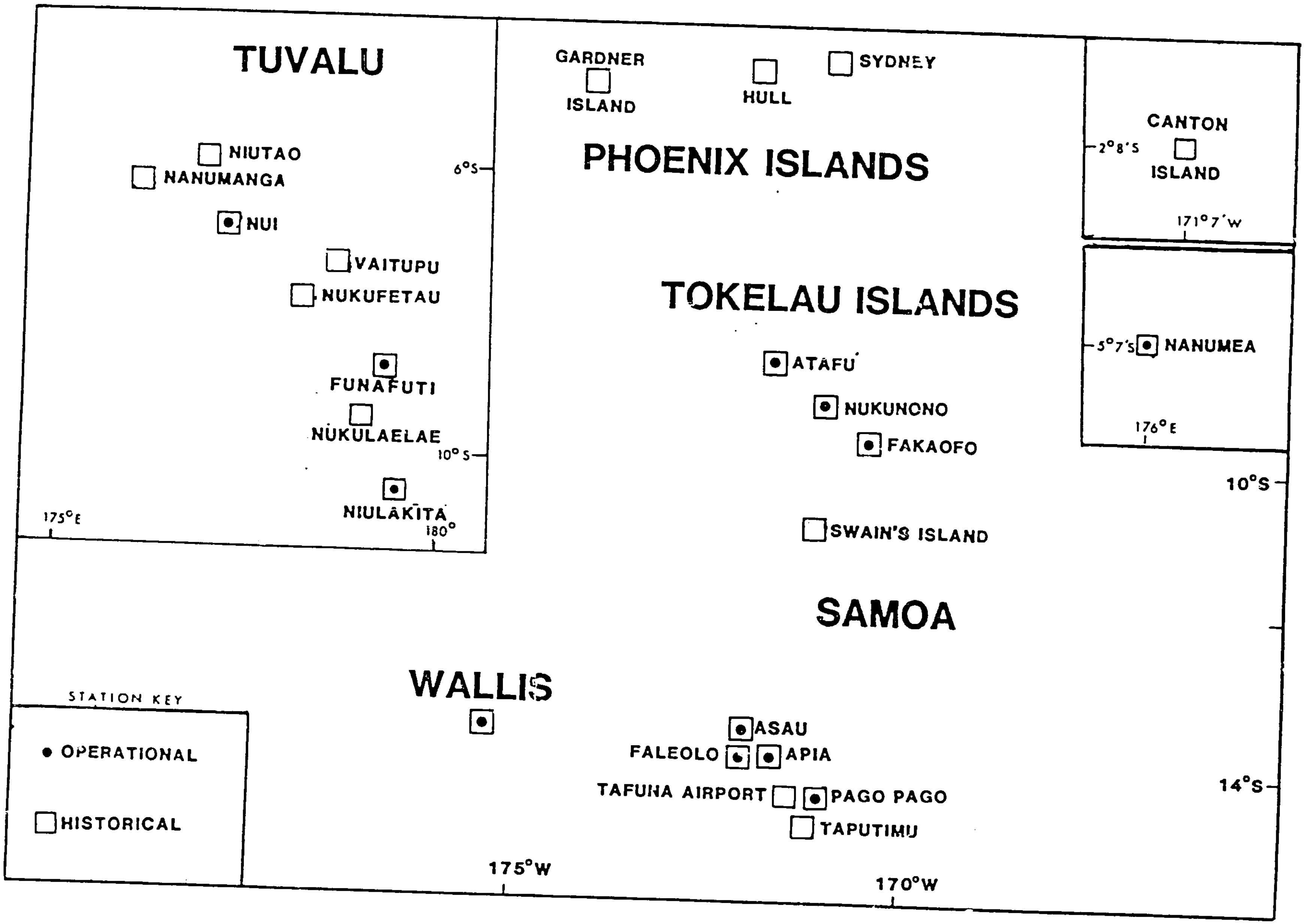

0°
NAURU
BANABA
1° S
167° E
170° E
STATION KEY
OPERATIONAL
HISTORICAL

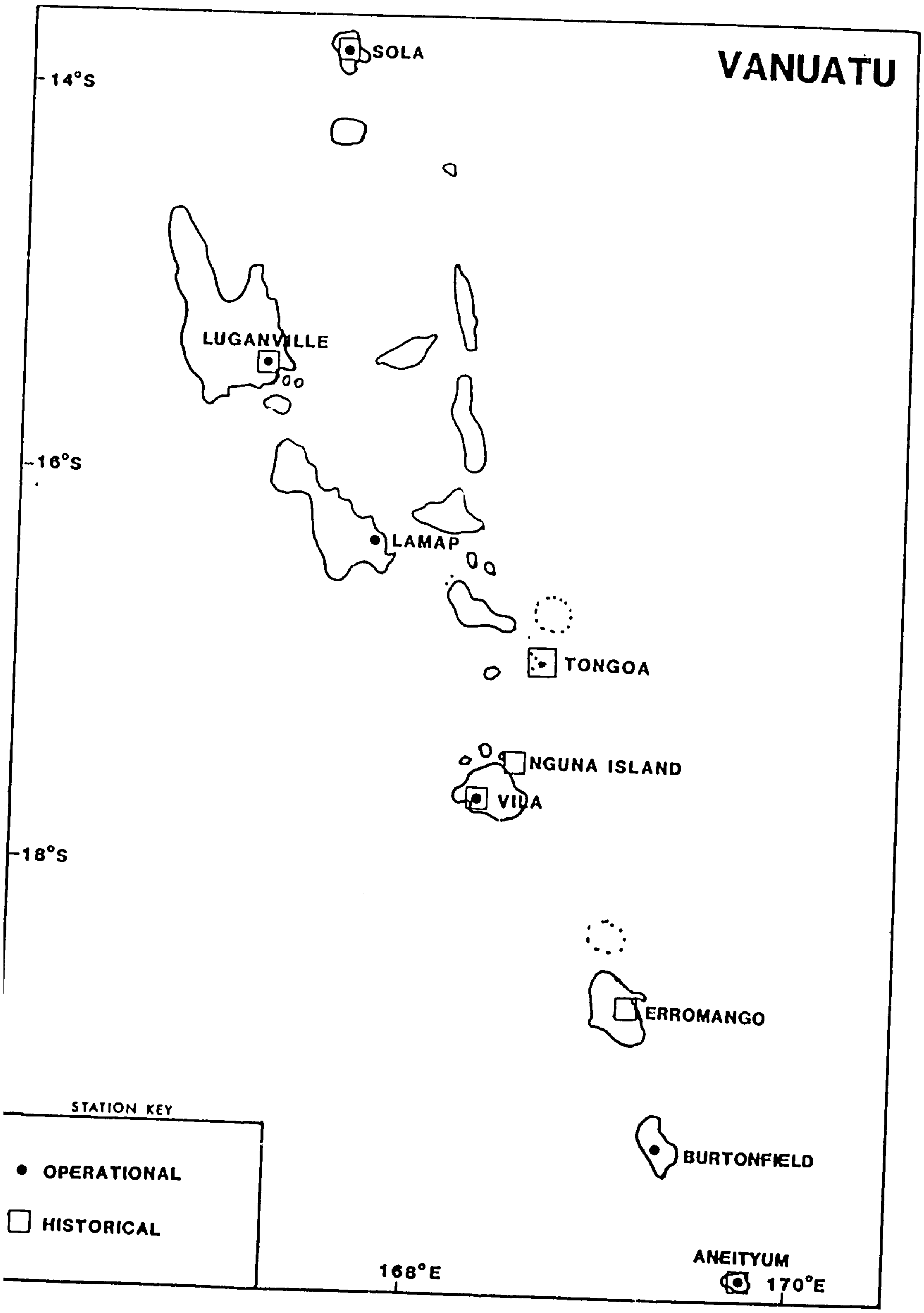

KIRIBATI
LITTLE MAKIN
3°N
BUTARITARI
MARAKEI
ABAIANG
TARAWA
MAIANA
ABEMAMA
KURIA
0°
ARANUKA
NONOUTI
N. TABITEUEA
BERU
S. TABITEUEA
NUKUNAU
ONOTOA
TAMANA
ARORAE
STATION KEY
OPERATIONAL
HISTORICAL
3°S
173°E
175°E
177°E

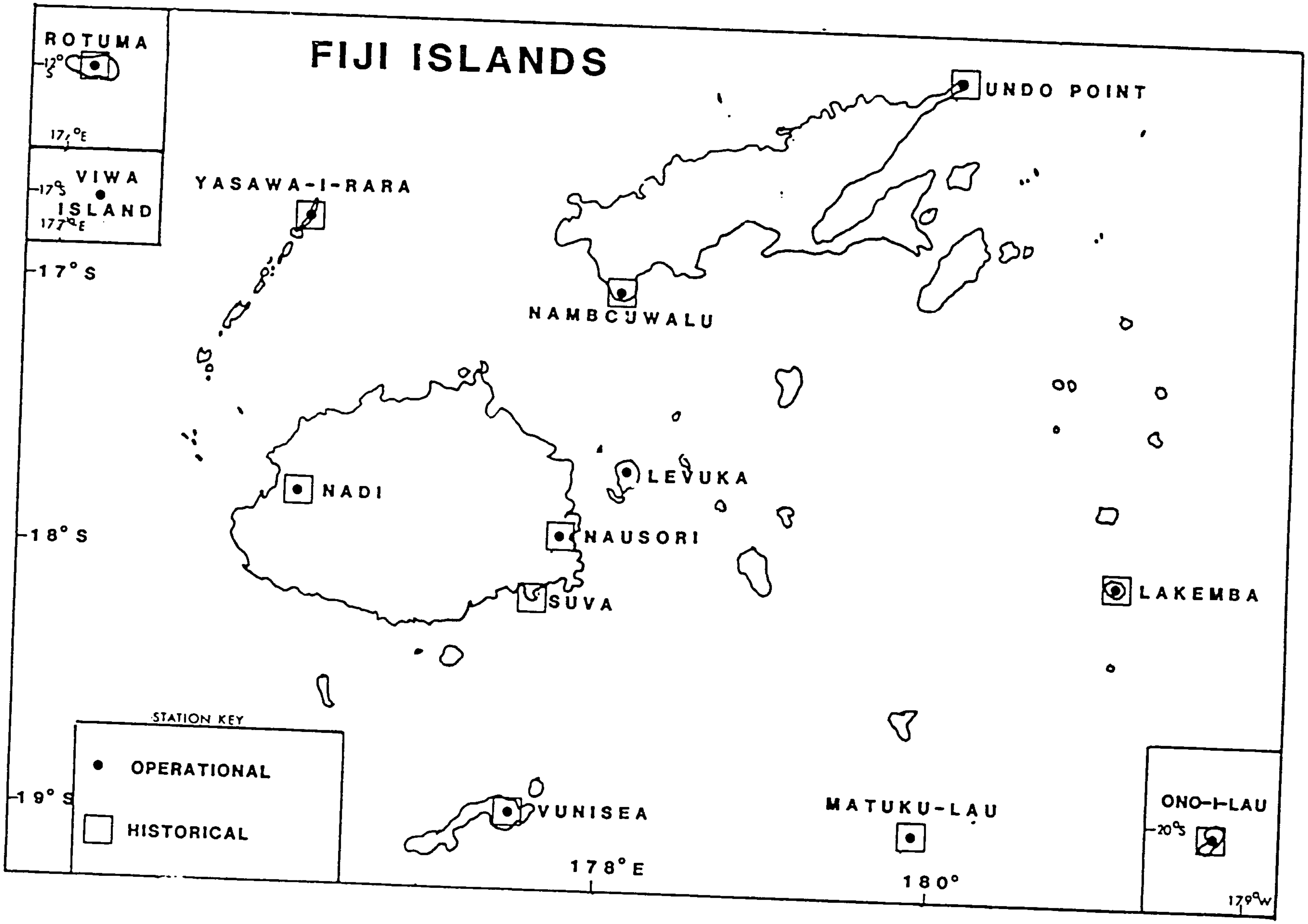

PAPUA NEW GUINEA
MOMOTE
RABAUL
MADANG
LAE
PORT MORESBY
MISIMA
4°S
8°S
144°E
152°E
STATION KEY
OPERATIONAL
HISTORICAL

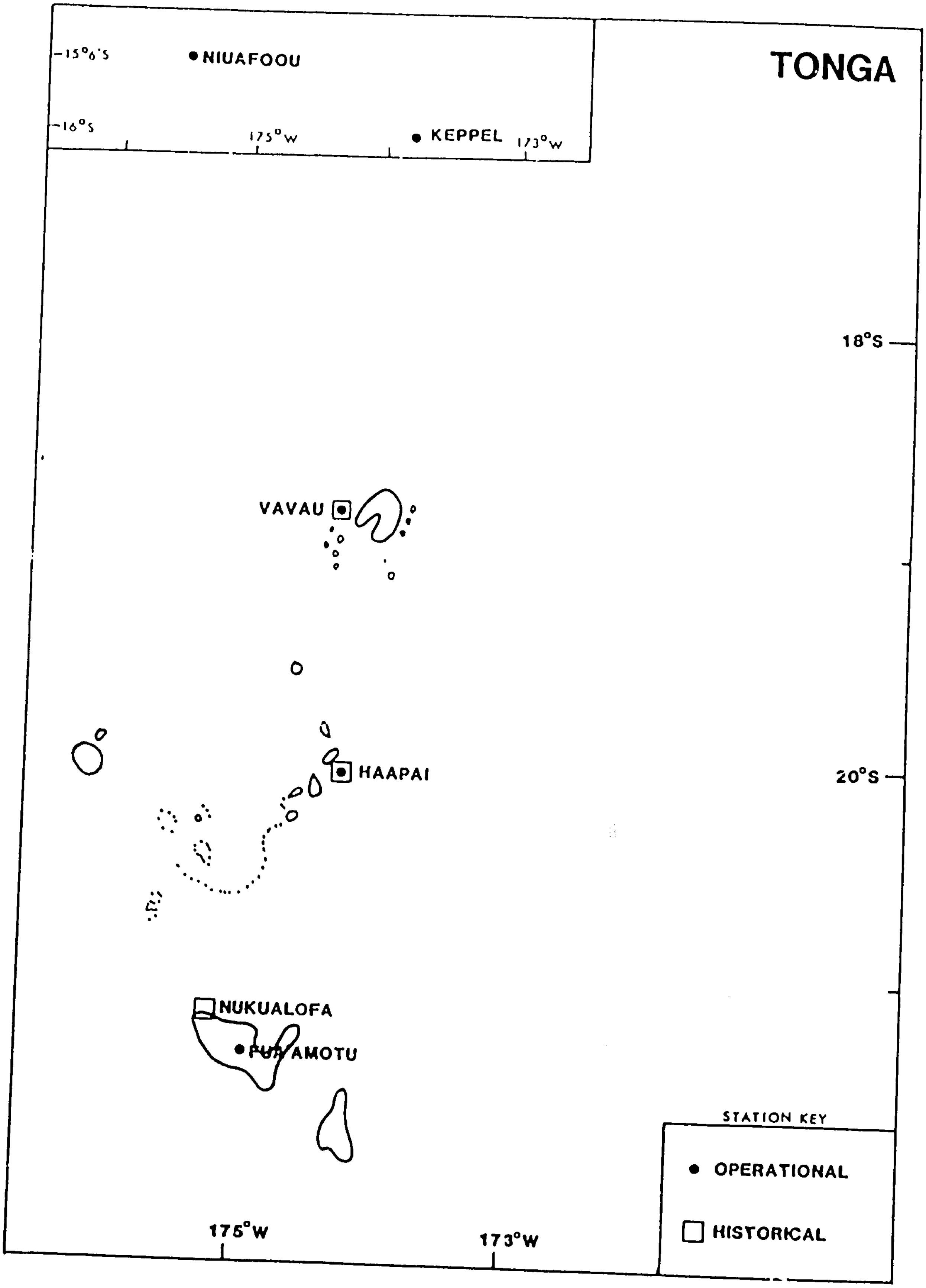


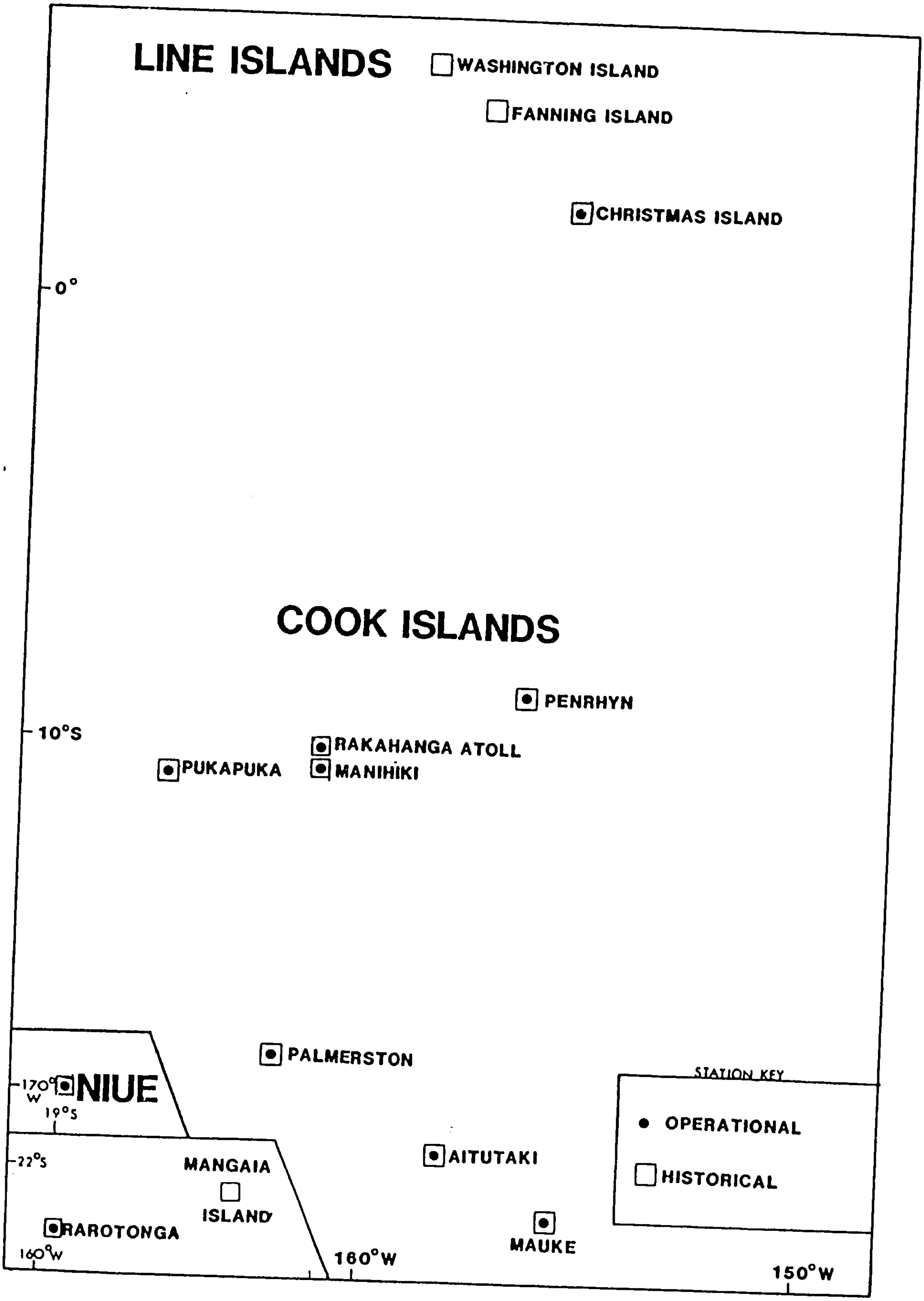
SOLOMON ISLANDS
MUNDA
AUKI
HONIARA/HENDERSON
KIRA KIRA
8° S
10° S
158° E
160° E
162° E
6°7' S
TARO ISLAND
156°4' E
11°7'
VANIKORO
167° E
STATION KEY
OPERATIONAL
HISTORICAL

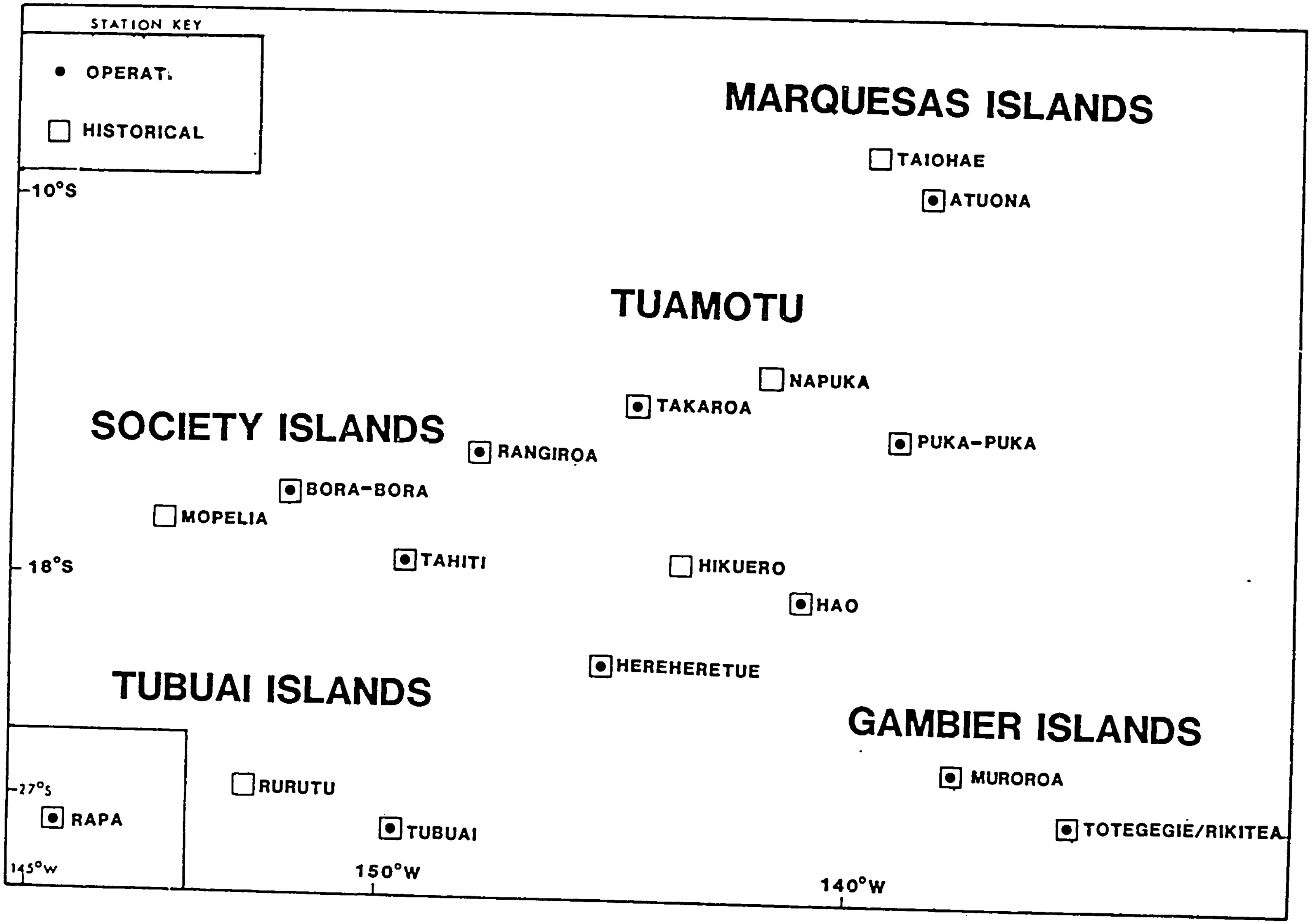

TUVALU
NIUTAO
NANUMANGA
6° S
NUI
VAITUPU
NUKUFETAU
FUNAFUTI
NUKULAELAE
10° S
NIULAKITA
175° E
180°
GARDNER
ISLAND
HULL
SYDNEY
PHOENIX ISLANDS
CANTON
2° 8' S
ISLAND
171° 7' W
TOKELAU ISLANDS
5° 7' S
NANUMEA
176° E
ATAFU
NUKUNONO
FAKAOFO
10° S
SWAIN'S ISLAND
SAMOA
WALLIS
STATION KEY
OPERATIONAL
HISTORICAL
ASAU
FALEOLO
APIA
TAFUNA AIRPORT
PAGO PAGO
TAPUTIMU
14° S
175° W
170° W

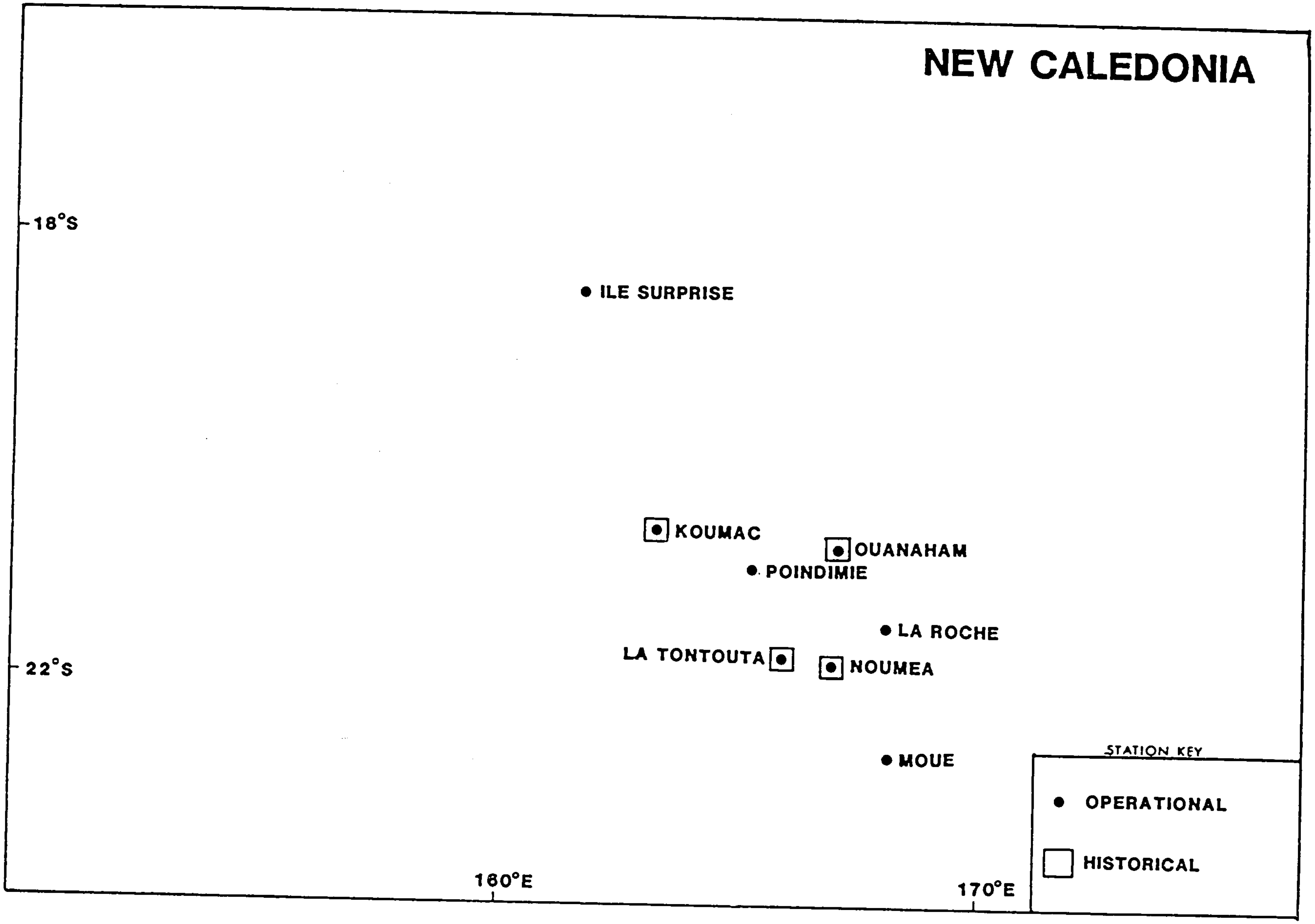

VANUATU
SOLA
14°S
LUGANVILLE
16°S
LAMAP
TONGOA
NGUNA ISLAND
VILA
18°S
ERROMANGO
STATION KEY
OPERATIONAL
HISTORICAL
BURTONFIELD
ANEITYUM
168°E
170°E


FIJI ISLANDS
ROTUMA
12° S
177°E
VIWA ISLAND
17°S
177°E
YASAWA-I-RARA
UNDO POINT
NAMBCUWALU
17° S
NADI
LEVUKA
NAUSORI
18° S
SUVA
LAKEMBA
STATION KEY
OPERATIONAL
HISTORICAL
19° S
VUNISEA
MATUKU-LAU
ONO-I-LAU
20°S
178° E
180°
179°W


TONGA
15°6'S
NIUAFOOU
16°S
175°W
KEPPEL
173°W
18°S
VAVAU
HAAPAI
20°S
NUKUALOFA
FUA'AMOTU
175°W
173°W
STATION KEY
OPERATIONAL
HISTORICAL

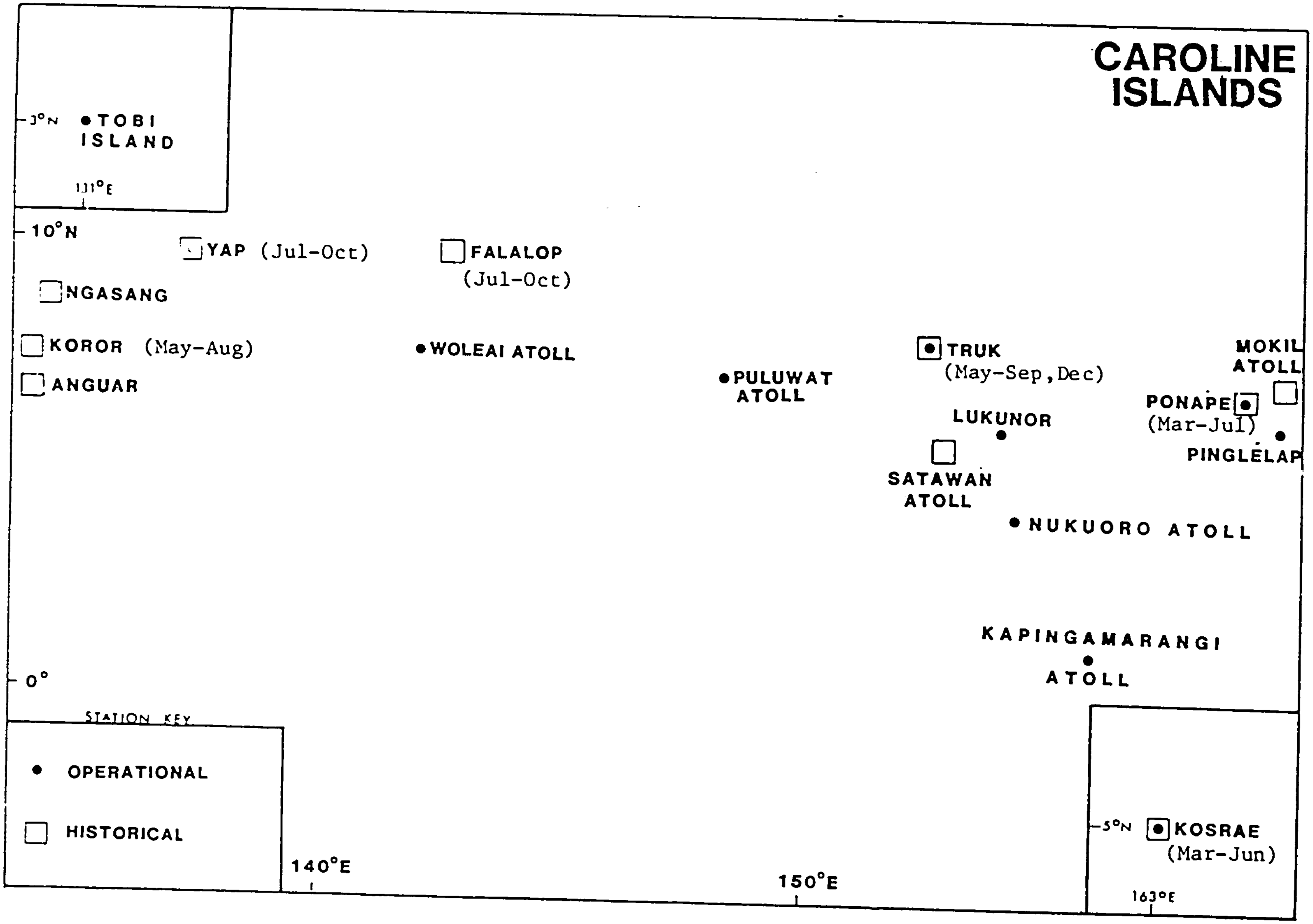

LINE ISLANDS
WASHINGTON ISLAND
FANNING ISLAND
CHRISTMAS ISLAND
0°
COOK ISLANDS
PENRHYN
10°S
RAKAHANGA ATOLL
PUKAPUKA
MANIHIKI
PALMERSTON
170° W
NIUE
19°S
22°S
MANGAIA
ISLAND
RAROTONGA
160°W
AITUTAKI
MAUKE
160°W
150°W
STATION KEY
OPERATIONAL
HISTORICAL

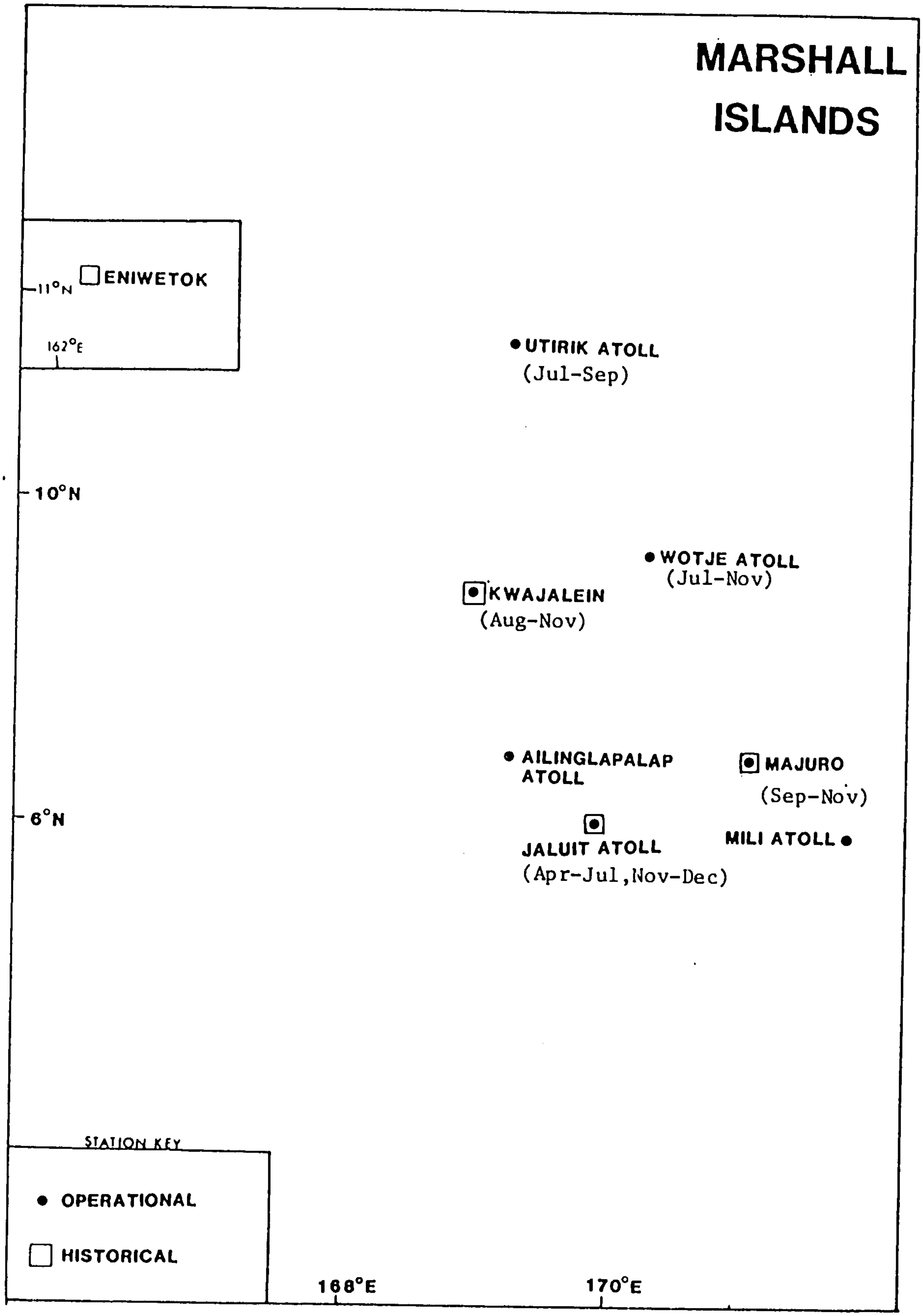

STATION KEY
OPERAT.
HISTORICAL
MARQUESAS ISLANDS
TAIOHAE
ATUONA
10°S
TUAMOTU
NAPUKA
TAKAROA
SOCIETY ISLANDS
RANGIROA
PUKA-PUKA
BORA-BORA
MOPELIA
18°S
TAHITI
HIKUERO
HAO
HEREHERETUE
TUBUAI ISLANDS
GAMBIER ISLANDS
27°S
RAPA
RURUTU
MUROROA
TUBUAI
TOTEGEGIE/RIKITEA
145°W
150°W
140°W

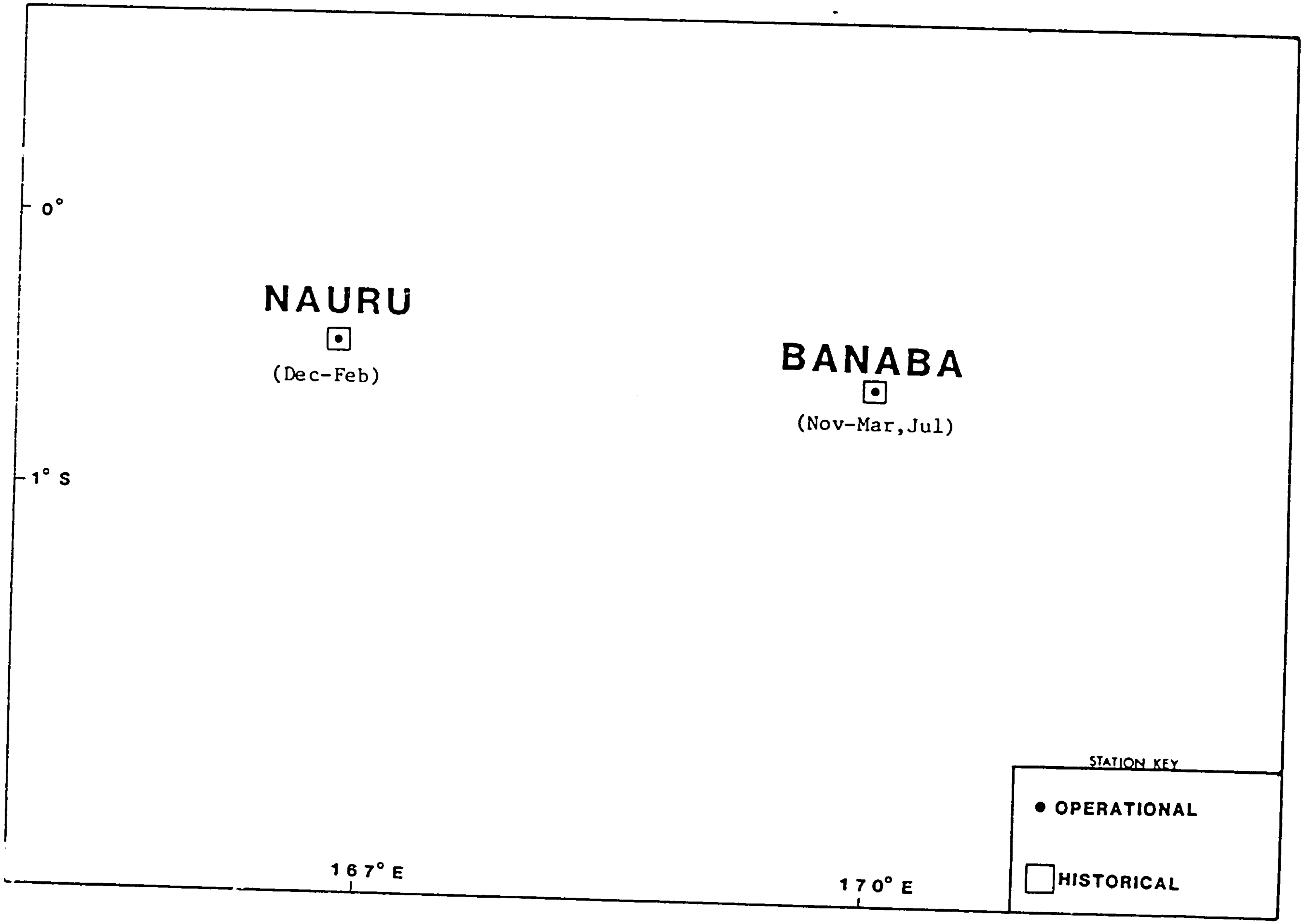

NEW CALEDONIA
18°S
22°S
160°E
170°E
ILE SURPRISE
KOUMAC
OUANAHAM
POINDIMIE
LA ROCHE
LA TONTOUTA
NOUMEA
MOUE
STATION KEY
OPERATIONAL
HISTORICAL

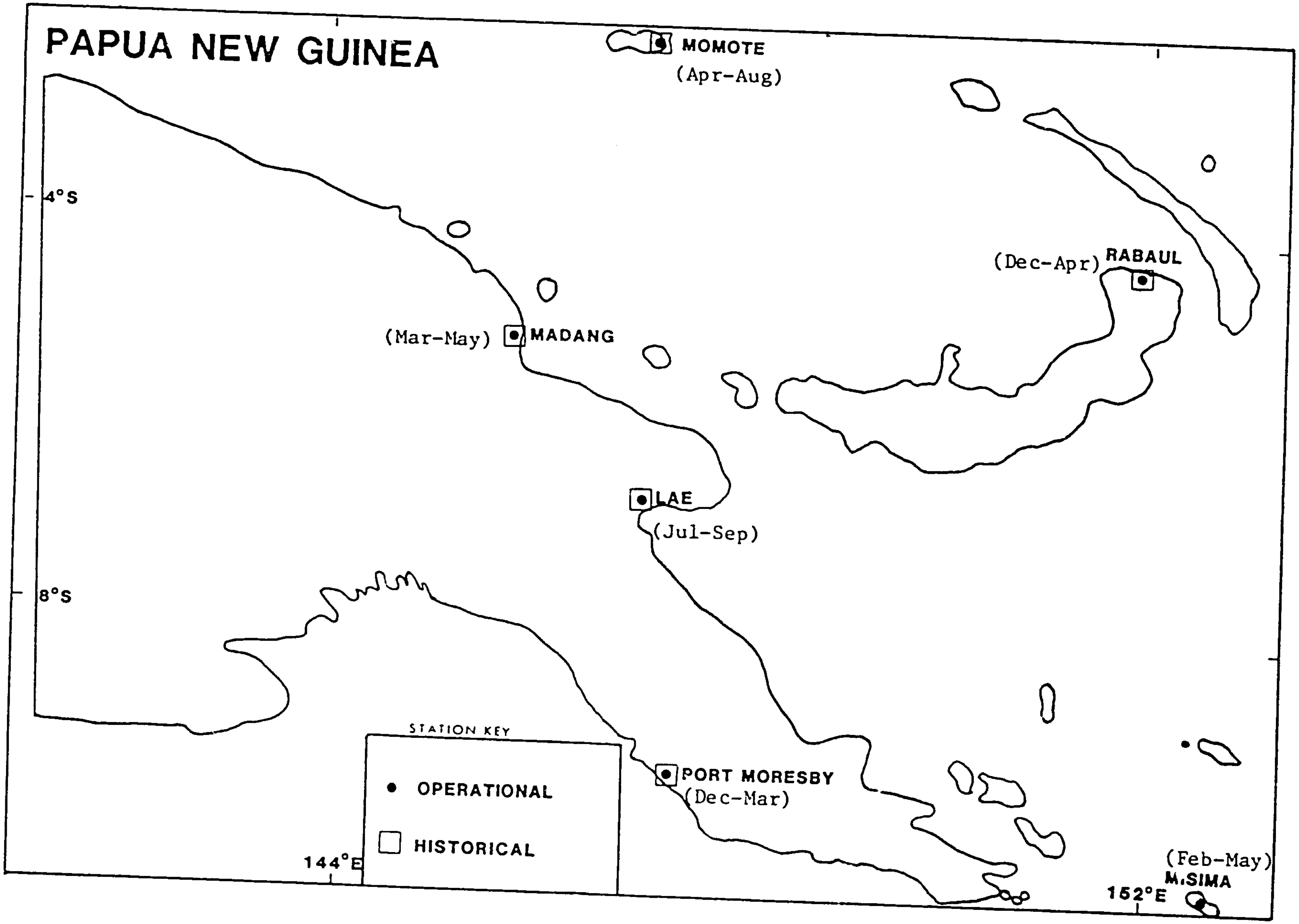
APPENDIX E

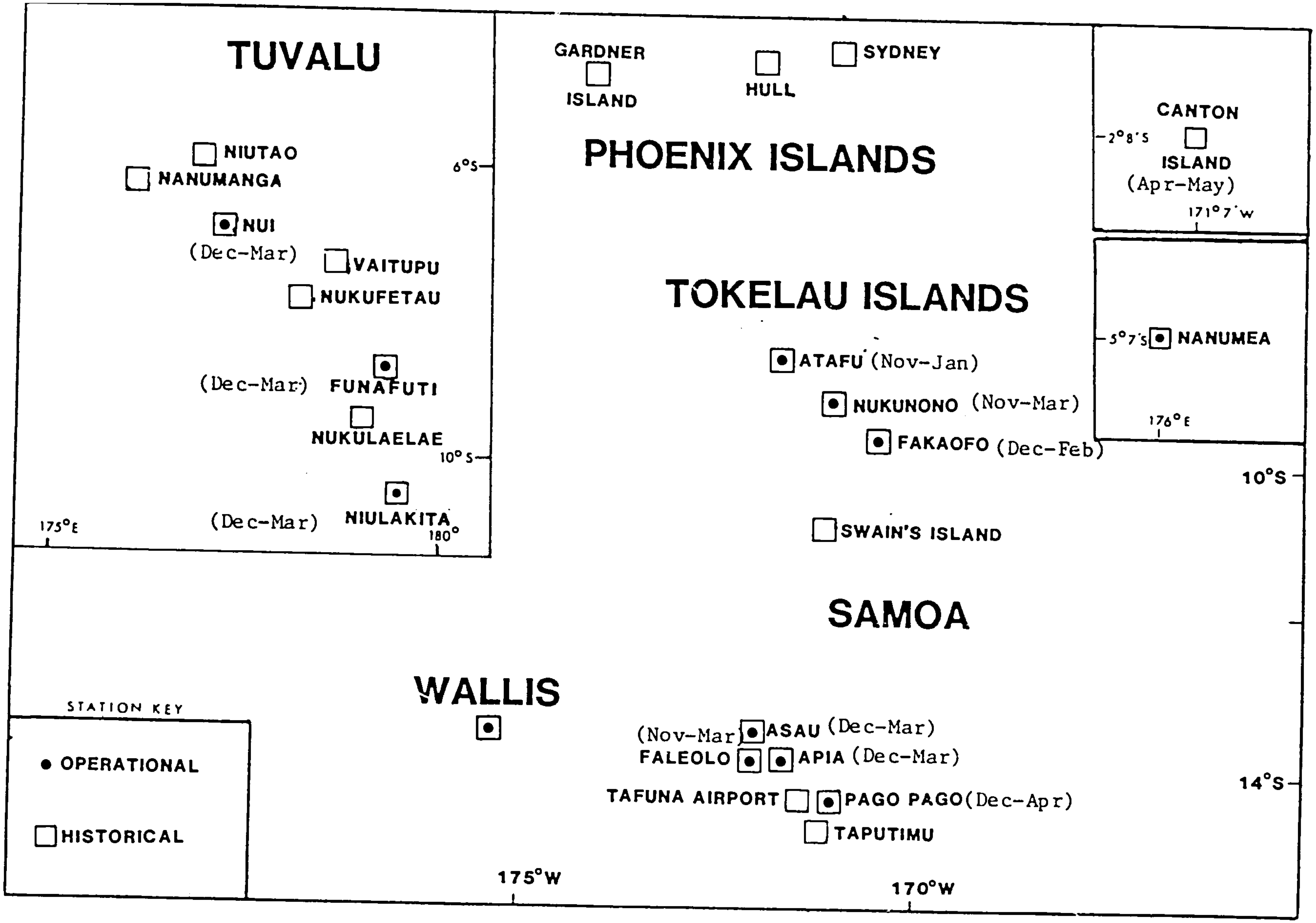
ASSESSMENT PERIOD FOR SOUTH PACIFIC ISLANDS

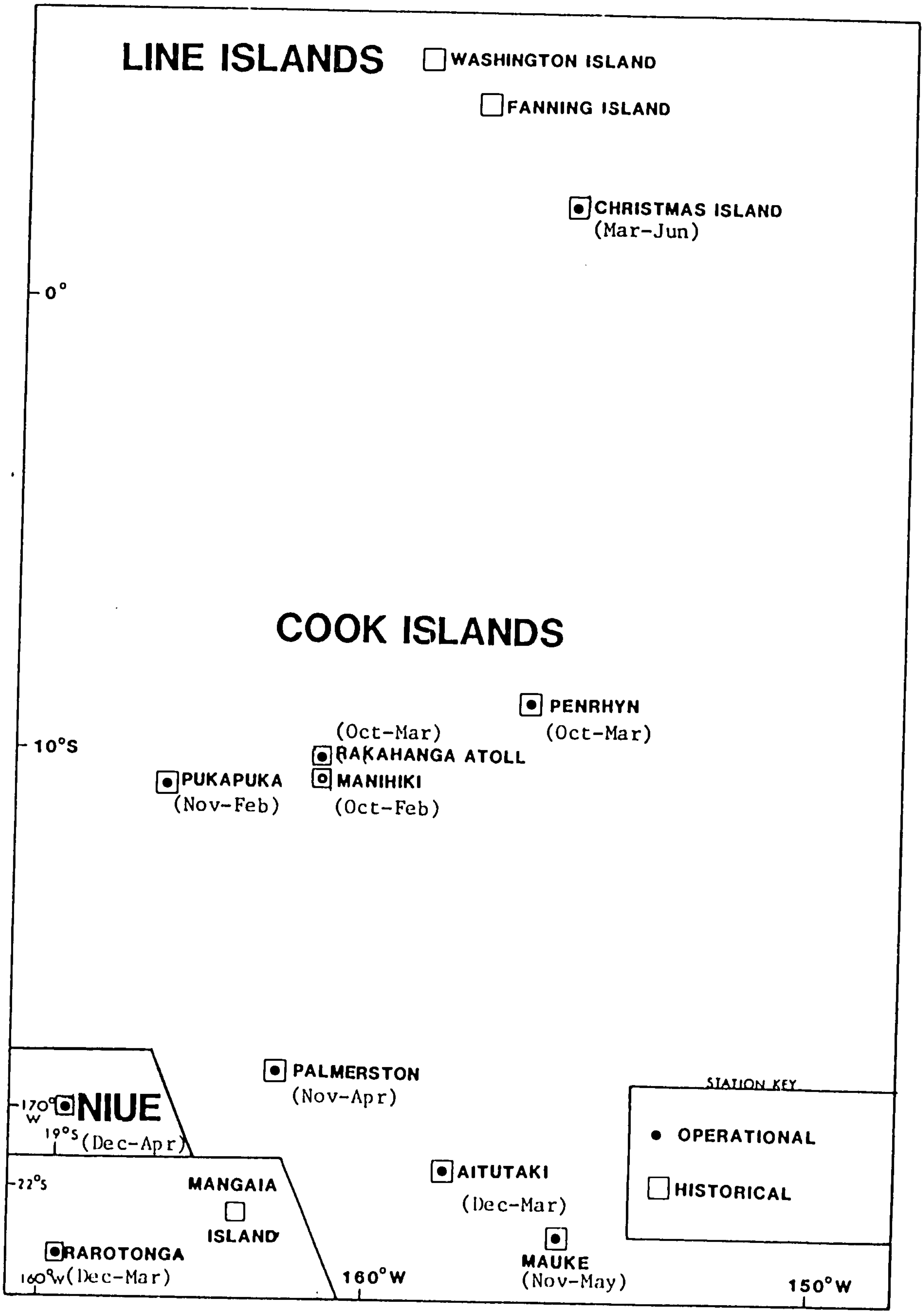

CAROLINE ISLANDS
3°N
TOBI ISLAND
131°E
10°N
YAP (Jul-Oct)
FALALOP (Jul-Oct)
NGASANG
KOROR (May-Aug)
WOLEAI ATOLL
ANGUAR
PULUWAT ATOLL
TRUK (May-Sep,Dec)
MOKIL ATOLL
PONAPE (Mar-Jul)
LUKUNOR
PINGLELAP
SATAWAN ATOLL
NUKUORO ATOLL
KAPINGAMARANGI ATOLL
0°
STATION KEY
OPERATIONAL
HISTORICAL
5°N
KOSRAE (Mar-Jun)
140°E
150°E
163°E

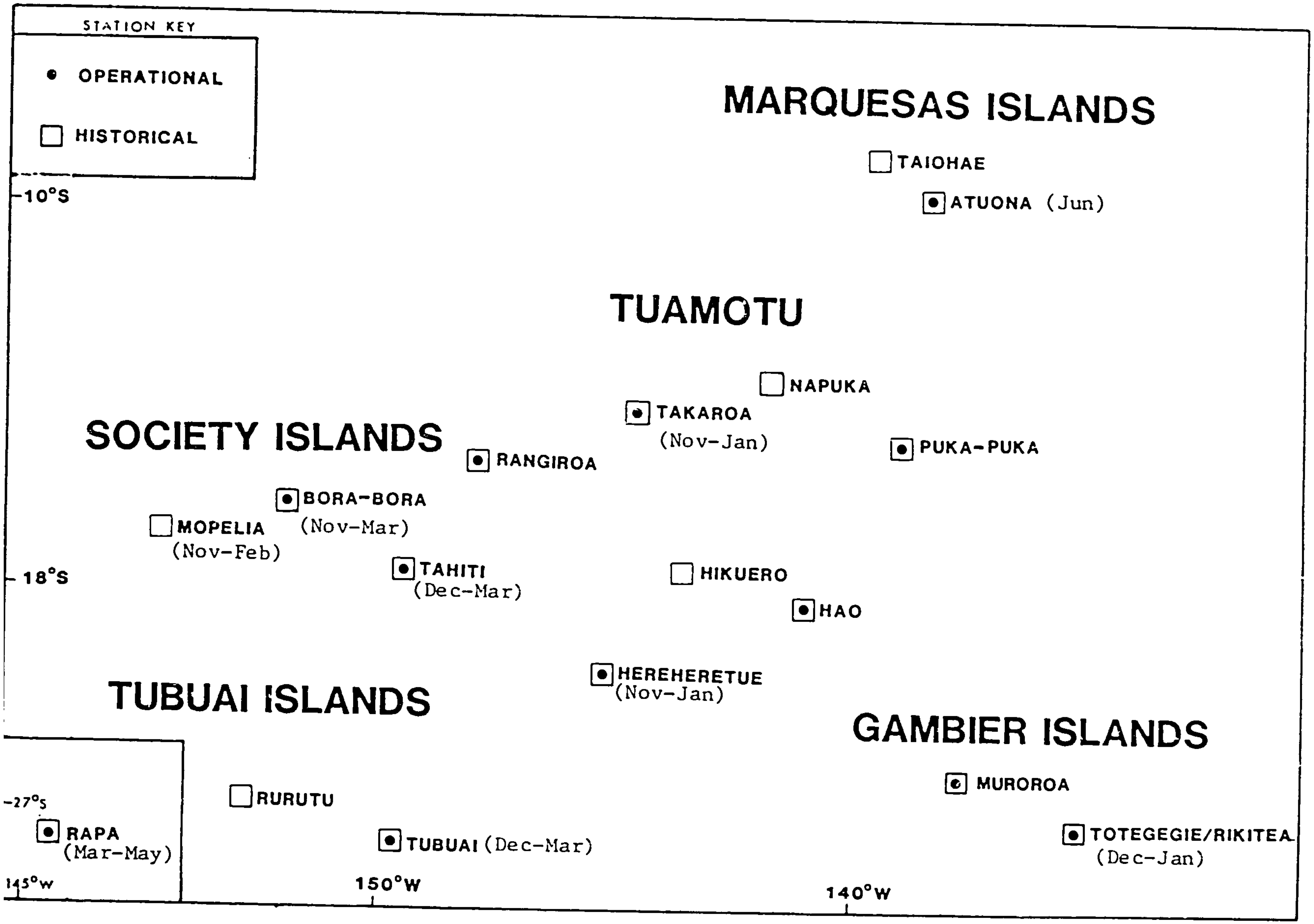

MARSHALL ISLANDS
11°N
ENIWETOK
162°E
UTIRIK ATOLL
(Jul-Sep)
10°N
WOTJE ATOLL
(Jul-Nov)
KWAJALEIN
(Aug-Nov)
AILINGLAPALAP ATOLL
MAJURO
(Sep-Nov)
6°N
JALUIT ATOLL
(Apr-Jul,Nov-Dec)
MILI ATOLL
STATION KEY
OPERATIONAL
HISTORICAL
168°E
170°E

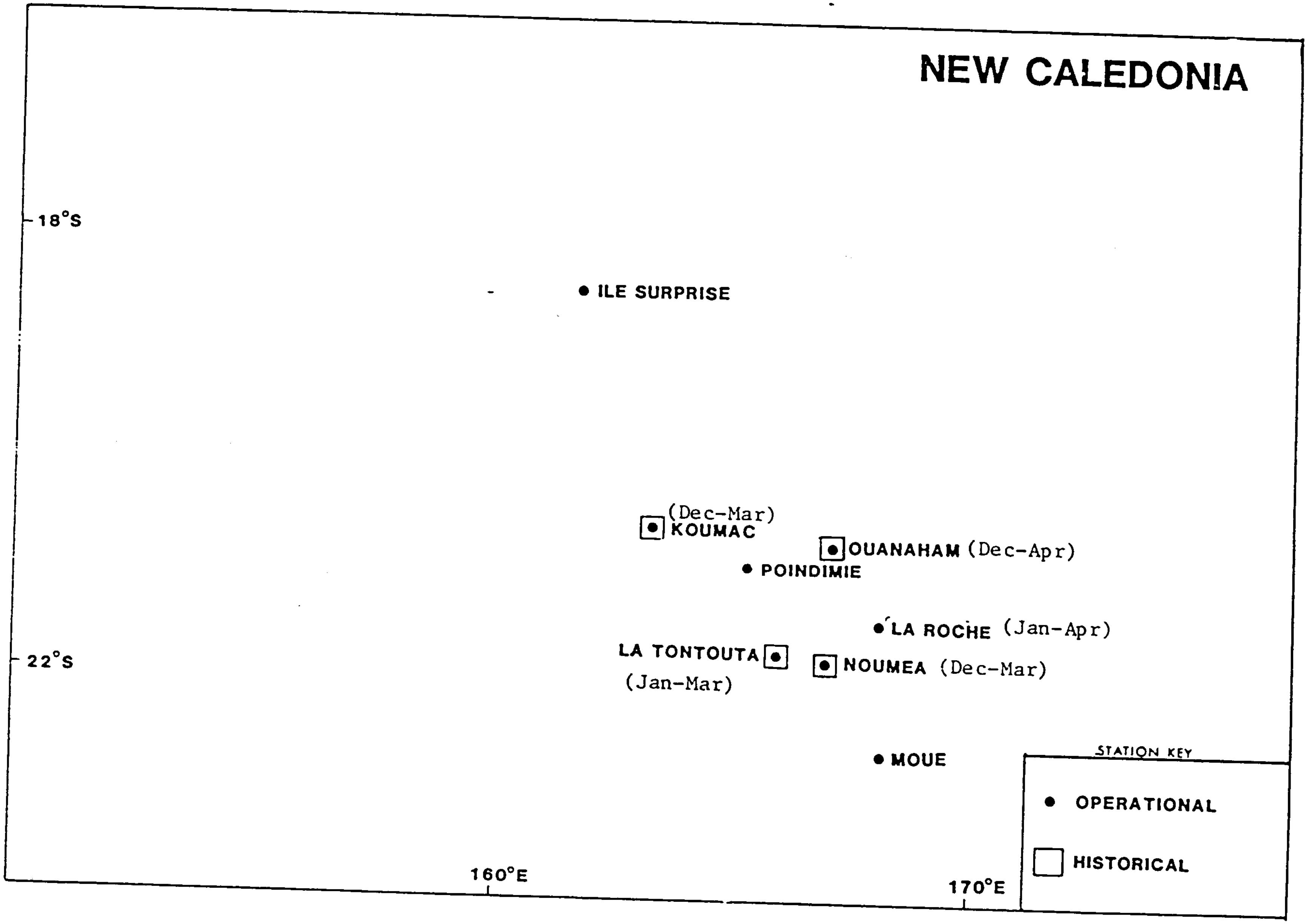

0°
1° S
NAURU
(Dec-Feb)
BANABA
(Nov-Mar,Jul)
167° E
170° E
STATION KEY
OPERATIONAL
HISTORICAL


PAPUA NEW GUINEA
MOMOTE
(Apr-Aug)
RABAUL
(Dec-Apr)
MADANG
(Mar-May)
LAE
(Jul-Sep)
PORT MORESBY
(Dec-Mar)
M.SIMA
(Feb-May)
4°S
8°S
144°E
152°E
STATION KEY
OPERATIONAL
HISTORICAL


TUVALU
NIUTAO
NANUMANGA
NUI
(Dec-Mar)
VAITUPU
NUKUFETAU
(Dec-Mar)
FUNAFUTI
NUKULAELAE
(Dec-Mar)
NIULAKITA
6°S
10°S
175°E
180°
GARDNER ISLAND
HULL
SYDNEY
PHOENIX ISLANDS
CANTON ISLAND
(Apr-May)
2°8'S
171°7'W
NANUMEA
5°7'S
176°E
TOKELAU ISLANDS
ATAFU (Nov-Jan)
NUKUNONO (Nov-Mar)
FAKAOFO (Dec-Feb)
10°S
SWAIN'S ISLAND
SAMOA
WALLIS
(Nov-Mar)
ASAU (Dec-Mar)
FALEOLO
APIA (Dec-Mar)
TAFUNA AIRPORT
PAGO PAGO (Dec-Apr)
TAPUTIMU
14°S
175°W
170°W
STATION KEY
● OPERATIONAL
HISTORICAL


LINE ISLANDS
WASHINGTON ISLAND
FANNING ISLAND
CHRISTMAS ISLAND
(Mar-Jun)
0°
COOK ISLANDS
PENRHYN
(Oct-Mar)
10°S
(Oct-Mar)
RAKAHANGA ATOLL
PUKAPUKA
(Nov-Feb)
MANIHIKI
(Oct-Feb)
PALMERSTON
(Nov-Apr)
STATION KEY
170° W
NIUE
19°S
(Dec-Apr)
OPERATIONAL
HISTORICAL
22°S
MANGAIA
ISLAND
AITUTAKI
(Dec-Mar)
RAROTONGA
160°W
(Dec-Mar)
MAUKE
(Nov-May)
160°W
150°W


STATION KEY
OPERATIONAL
HISTORICAL
10°S
18°S
-27°S
145°W
150°W
140°W
MARQUESAS ISLANDS
TAIOHAE
ATUONA (Jun)
TUAMOTU
NAPUKA
TAKAROA
(Nov-Jan)
PUKA-PUKA
SOCIETY ISLANDS
RANGIROA
BORA-BORA
(Nov-Mar)
MOPELIA
(Nov-Feb)
TAHITI
(Dec-Mar)
HIKUERO
HAO
HEREHERETUE
(Nov-Jan)
TUBUAI ISLANDS
GAMBIER ISLANDS
MUROROA
RURUTU
RAPA
(Mar-May)
TUBUAI (Dec-Mar)
TOTEGEGIE/RIKITEA
(Dec-Jan)


NEW CALEDONIA
18°S
22°S
160°E
170°E
ILE SURPRISE
(Dec-Mar)
KOUMAC
OUANAHAM (Dec-Apr)
POINDIMIE
LA ROCHE (Jan-Apr)
LA TONTOUTA
(Jan-Mar)
NOUMEA (Dec-Mar)
MOUE
STATION KEY
OPERATIONAL
HISTORICAL

APPENDIX F

1983 SOUTH PACIFIC ASSESSMENTS

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL ENVIRONMENTAL SATELLITE DATA, AND INFORMATION SERVICES
Assessment and Information Services Center
[illegible] Branch
Room 200 Federal Building [illegible]
Columbia, Missouri 65201

DATE: JULY 13, 1983

TO: MARGARET MCKELVEY, AID/OFDA

FROM: LOU STEYAERT, E/AI4

THRU: DOUGLAS LECOMTE, E/AI42

SUBJECT: PROPOSED CABLE ON SOUTH PACIFIC DROUGHT

FROM: SECSTATE WASHDC

TO: AMEMBASSY SUVA

INFO: AMEMBASSY MANILA
AMEMBASSY CANBERRA
AMEMBASSY WELLINGTON
AMEMBASSY PORT MORESBY

SUBJECT: NOAA/AISC DROUGHT ASSESSMENT FOR SOUTH PACIFIC
REF: A) STATE 187447

1. AS PROMISED BY REF A, THE NOAA/ASSESSMENT AND INFORMATION SERVICES CENTER (AISC) HAS PROVIDED THE FOLLOWING ADDITIONAL INFORMATION ON SOUTH PACIFIC DROUGHT IMPACT. THIS SUPPLEMENTS AISC'S RECENT ASSESSMENT FOR FIJI (REF A). ANALYSIS FOR REMAINING ISLAND GROUPS (MICRONESIA, MARSHALLS AND ISLANDS TO EAST OF DATE LINE) IS FORTHCOMING.

2. PRELIMINARY ANALYSES BASED ON SYNOPTIC WEATHER REPORTS (MAY 1982-JUNE 1983) SUGGEST SEVERE DROUGHT IMPACT WITHIN TONGA, FIJI, VANUATU, AND SOLOMONS ISLANDS GROUPS PLUS NAURU ISLAND. ALTHOUGH RECENT RAINS (MAY-JUNE, 1983) HAVE HELPED, THERE IS STILL THE POTENTIAL FOR LOCALIZED DROUGHT IMPACT IN NEW CALEDONIA, PAPUA NEW GUINEA, AND BANABA DUE TO ANTECEDENT DROUGHT (OCT-APR/83). IN CONTRAST, RAINFALL CONDITIONS IN TUVALU AND GILBERTS ISLAND GROUPS HAVE GENERALLY RANGED FROM ABOVE NORMAL TO EXTREMELY WET DURING PAST SEVERAL MONTHS.

3. REGIONAL DROUGHT GENERALLY BEGAN ABOUT OCTOBER/NOVEMBER 1982 AND HAS PERSISTED THROUGH JUNE 1983, EXCEPT AS NOTED ABOVE. AS INDICATED IN THE FOLLOWING TABLE, CUMULATIVE RAINFALL DURING THE MAIN RAINY SEASON (NOVEMBER THROUGH APRIL)

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WAS ABOUT 50 PERCENT NORMAL IN TONGA; 30 PERCENT NORMAL IN VANUATU; 60 PERCENT NORMAL IN NEW CALEDONIA; 10 PERCENT NORMAL IN THE SOLOMONS; 4 PERCENT NORMAL AT NAURU, 45 PERCENT NORMAL AT BANABA; AND 80-90 PERCENT NORMAL IN PAPUA NEW GUINEA. COMPARISON OF THESE 1982/83 SEASONAL RAINFALL TOTALS WITH AVAILABLE HISTORICAL DATA SHOWS THAT THE DROUGHT IS ONE OF THE WORST DURING THE PAST 20-30 YEARS. FOR EXAMPLE, PERCENTILE RANKS OF TOTAL SEASONAL RAINFALL IN FIJI ARE ABOUT THE THIRD PERCENTILE INDICATING ON A SCALE OF ZERO TO 100 THAT ONLY 3 YEARS OUT OF 100 YEARS WOULD BE EXPECTED TO BE AS DRY. SIMILARLY, THE PERCENTILE RANK FOR SEASONAL RAINFALL AMOUNT (OCT-APR) IS ABOUT 10 IN TONGA; 5 IN VANUATU; 5 TO 25 AT SOME LOCATIONS IN NEW CALEDONIA; 10 IN SOLOMONS; 5 AT NAURU; 25 AT BANABA; 20 AT NIULAKITA, TUVALU; 23 AT TARAWA, KIRIBATI AND 3 AT PORT MORESBY.

4. PRECISE ASSESSMENT OF THE DROUGHT IMPACT ON AGRICULTURE AND POTENTIAL FOOD SUPPLIES IS DIFFICULT BECAUSE INFORMATION ON CROP CALENDARS, AGRICULTURAL PRACTICES, IMPORTANCE OF FOOD IMPORTS, AND IMPACTS DUE TO PAST DROUGHT YEARS IS STILL BEING COLLECTED BY AISC. HOWEVER, IMPACTS SHOULD BE GREATER IN COASTAL AREAS THAN AT HIGHER ELEVATION LOCATIONS WHICH USUALLY RECEIVE MORE RAINFALL. POTENTIAL DROUGHT IMPACT IS MAGNIFIED BECAUSE THE DISTRIBUTION OF SEASONAL RAINS (E.G., TROPICAL STORMS IN FIJI) WAS NOT FAVORABLE FOR AGRICULTURE. AS A RESULT OF THE DROUGHT, DECREASED PRODUCTION LEVELS CAN BE EXPECTED FOR MAJOR RAINFED COMMERCIAL CROPS CURRENTLY BEING HARVESTED. THE PERSISTENCE OF DROUGHT INTO MAY AND IN SOME CASES JUNE, 1983, HAS EITHER DELAYED PLANTING OF SUBSISTENCE FOOD CROPS OR CAUSED MOISTURE STRESS IN NEWLY PLANTED CROPS. RAINFALL DURING JULY-SEPTEMBER WILL BE CRICIAL FOR THESE FOOD CROPS. RANGELAND AND LIVESTOCK GRAZING CONDITIONS ARE PROBABLY POOR. THERE IS THE POTENTIAL FOR DROUGHT IMPACT ON FRESH WATER SUPPLIES OR ANY HYDOELECTRIC POWER FACILITIES. BASED ON AISC'S PAST EXPERIENCE, THESE CONDITIONS CAN LEAD TO INCREASED FOOD PRICES WITHIN THE NEXT 2 MONTHS, POTENTIAL FOOD SHORTAGES WITHIN THE NEXT 3 TO 6 MONTHS DEPENDING ON THE LOCAL AVAILABILITY OF TRADITIONAL FAMINE FOODS, AND POTENTIAL POLITICAL PROBLEMS 6 TO 8 MONTHS FROM NOW.

5. PRELIMINARY RAINFALL AMOUNTS (MILLIMETERS) AND ASSOCIATED PERCENT OF NORMAL FOR INDICATED PERIODS IN 1982/83 AS FOLLOWS:

PERIOD:	NOV-APR/83		MAY/83		JUNE/83	
	AMOUNT	PERCENT	AMOUNT	PERCENT	AMOUNT	PERCENT
TONGA:						
KEPPEL	1112	69	99	53	58	54
VAVAU	765	50	73	66	20	17
HAAPAI	187	15	5	6	1	1
FUA'AMOTU	419	46	30	21	58	53
VANUATU:						
SOLA (VANUA LAVA)	793	39	114	32	97	43
ESPIRITU-SANTO	516	29	27	13	529*	331
VILA (EFATE)	479	35	23	16	55	41
BURTONFIELD (TANNA)	202	13	11	22	15	12
NEW CALEDONIA:						
KOUMOC	538	80	20	19	59	105
LA ROCHE	368	39	59	39	31	22
LA TONTOUTA	389	62	4	5	262	323
NOUMEA	394	64	30	32	59	62
SOLOMON:						
MUNDA	117	6	10	4	7	3
AUKI	72	4	2	1	6	3
PAPUA NEW GUINEA:						
MADANG	1909	90	349	93	142	52
LAE	1445	76	158	38	443	112
PORT MORESBY	334	43	83	127	17	53
MOMOTE	1478	93	217	95	312	93
RARAUL	1212	88	358	341	208	171
MISIMA	1068	66	85	29	111	48
NAURU AND BANARA ISLANDS:						
NAURU	47	4	5	9	-	-
BANARA IS.	581	47	167	164	94	99
TUVALU:						
NUI	2025	105	178	102	239	1[illegible]7
FUNAFUTI	1929	91	23[illegible]	107	145	58
NIULAKITA	1530	77	435	198	46	21
GILBERTS:						
TARAWA	590	61	243	204	282	254
BERU	477	31	85	125	255	405
ARORAE	1128	160	-	-	195	224

* SUSPECT DATA

6. ACTION REQUEST: AS NOTED IN REF A, AISC IS CURRENTLY DEVELOPING CLIMATE IMPACT AND DROUGHT/FOOD SHORTAGE ASSESSMENT MODELS FOR THE SOUTH PACIFIC THROUGH AID/OFDA SUPPORT. ALTHOUGH WORK HAS BEEN ACCELERATED TO PROVIDE THESE PRELIMINARY ASSESSMENTS EACH MONTH, AISC REQUESTS YOUR ASSISTANCE. INFORMATION IS REQUIRED ON LOCAL CROP CALENDARS FOR SUBSISTENCE AND COMMERCIAL CROPS (PLANTING AND HARVEST PERIODS), RECENT REPORTS ON AGRICULTURAL PRACTICES, TIME-SERIES DATA ON AGRICULTURAL STATISTICS SINCE 1960 (AREA PLANTED, PRODUCTION, AND YIELD PLUS IMPORT/EXPORT DATA), METEOROLOGICAL REPORTS CONTAINING MONTHLY RAINFALL AT AVAILABLE STATIONS FOR THE PERIOD SINCE 1950, AND NAMES/ADDRESSES OR PERSONS WITH ACCESS TO SUCH INFORMATION AND DATA. REPORTS, DATA AND OTHER INFORMATION SHOULD BE AIRMAILED TO: DR. LOUIS STEYAERT, NOAA/AISC, FEDERAL BUILDING/ROOM 200, 600 CHERRY ST. COLUMBIA, MISSOURI 65201.

CC. MALCOLM REID
RUSS AMBROZIAK
PAUL KRUMPE

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL ENVIRONMENTAL SATELLITE, DATA, AI
INFORMATION SERVICES
Assessment and Information Services Center
CIAD/Models Branch
Room 200 Federal Building 600 E. Cherry
Columbia, Missouri 65201

DATE: September 22, 1983

TO: Doug LeComte

FR: Lou Steyaert

SUBJECT: Update Assessment for South Pacific

FM SECSTATE WASHDC

TO AMEMBASSY SUVA

AMEMBASSY PORT MORESBY

AMEMBASSY PARIS

INFO AMEMBASSY MANILA

AMEMBASSY CANBERRA

AMEMBASSY WELLINGTON

SUBJECT: NOAA/NESDIS/AISC DROUGHT ASSESSMENT UPDATE FOR SOUTH PACIFIC

REF (A) STATE 187447 (NOTAL); (B) STATE 197727

1. The NOAA/NESDIS Assessment and Information Services Center (AISC) has provided the following update on South Pacific Drought. This update covers the period June-August, 1983 and supplements REFTELS. Region of coverage is extended to Island Groups located to east of international date line. Analysis primarily based on daily synoptic weather reports received by NOAA from regional communications network.

2. Impact Assessment. Large-scale drought conditions persisted through August 1983 and are impacting island groups within the latitudinal zone of 10-25 degrees south. This drought has severely damaged food crops planted during June-August or delayed planting of crops. Ratoon and newly planted sugar cane is experiencing water stress. Water supplies have been reduced and pastures for grazing damaged. Drought impacted island groups include Solomons, Vanuatu, New Caledonia and adjacent islands, Fiji, southern Tuvalo, Tonga, Samoa, southern Cook Islands, Bora Bora in Society Group and possibly Southern Tuamotu. Region of most severe impact appears to be to the west of the Cook Islands. In contrast, island groups located between the equator and 10 degrees south latitude continue to receive normal to above normal rainfall. Although September data are not yet available for analysis, August rainfall did improve at some locations. These include above normal rainfall on Western Fiji (Nandi, Nausori, Vunisea and Matuku), Sumoa (Faleolo) and Society (Tahitifaaa). Otherwise, June, July and August rainfall was generally only 40-50 percent of normal each month throughout most of the impacted region.

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3. Action Requested. NOAA/NESDIS/AISC requests that U.S. Missions obtain monthly rainfall normals for all available stations in Island Groups listed in Para 1. Please forward data by cable to NOAA/NESDIS/AISC, attention Dr. Louis T. Steyaert, Program Manager. Monthly rainfall normals (averages based on 10-30 years of historical data) will significantly improve assessment cables. and AISC services to missions. Regular updates will be forthcoming.

cc: Fred Cole
Paul Krumpe

DATE: June 29, 1983

TO: Margaret McKelvey, AID/OFDA

FROM: Lou Steyaert E/AI41

LTS

SUBJECT: Proposed Cable on FIJI as Follows

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL ENVIRONMENTAL SATELLITE, DATA, AN
INFORMATION SERVICES
Assessment and Information Services Center
CIAD/Models Branch
Room 200 Federal Building 600 E. Cherry
Columbia, Missouri 65201

FROM: SECSTATE WASHDC

TO: AMEMBASSY SUVA

SUBJECT: NOAA/AISC Drought Assessment for FIJI

REF: SUVA 2252

1. Preliminary analysis by the NOAA/Assessment and Information Services Center (AISC) supports REFTEL statements on 1982/83 sugar cane crops and indicates that drought impact also extends to other commercial and subsistence agriculture crops throughout FIJI. Drought beginning in October 1982 and extending through May 1983 impacted sugar cane and rice crops planted in 1982. Persistent dry conditions through June 1983 have either delayed normal planting of annual crops (maize, millet/sorghum, groundnuts, beans and sesame) or damaged new plantings. Recent drought has also impacted perennial crops such as sugar cane (ratoon crop). Cumulative monthly rainfall statistics based on synoptic weather reports from indicated stations are provided in the following table.

FIJI rainfall total (millimeters) and associated percent normal for indicated periods in 1982/83 as follows:

	October-May		January-- May		April		May		June	
	actual	percent	actual	percent	actual	percent	actual	percent	actual	percent
Rotuma	1908	72	742	43	133	48	95	36	1	1
Undu Point	1166	56	740	51	84	37	22	15	13	10
Yasawa-I-Rara	683	42	336	28	18	11	16	15	2	2
Nausori	1324	54	900	55	70	21	90	35	4	2
Vunisea	627	37	398	32	45	18	41	20	2	2
Matuku	606	42	446	42	46	24	51	34	21	18
Ono-I-Lau	402	29	254	25	5	3	10	7	8	7
Lakemba	1120	71	690	62	34	15	48	31	10	10
Nambowwalu	854	40	603	40	139	51	20	10	9	7
Nandi	513	31	288	23	2	1	3	3	1	1

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3. FYI: NOAA/AISC is currently developing drought/disaster early warning models for South Pacific Island Groups at the request of AID/OFDA. In 1984, AISC will begin routine test assessments including biweekly reports on recent weather and assessment of climate impact on agriculture. These assessment reports will be similar to those in the operational early warning program for Africa, Southern Asia, Caribbean Basin and Latin America. Verification based on ground truth information from AMEMBASSY and UN/FAO sources shows that reliable information on drought impact can be provided 30-60 days before beginning of crop harvest. This usually represents a 3-6 month alert before occurrence of economic impacts particularly food shortages. AISC is also working with AID to transfer assessment technology to developing countries.

cc.

Doug LeComte
Russ Ambroziak
Paul Krumpe