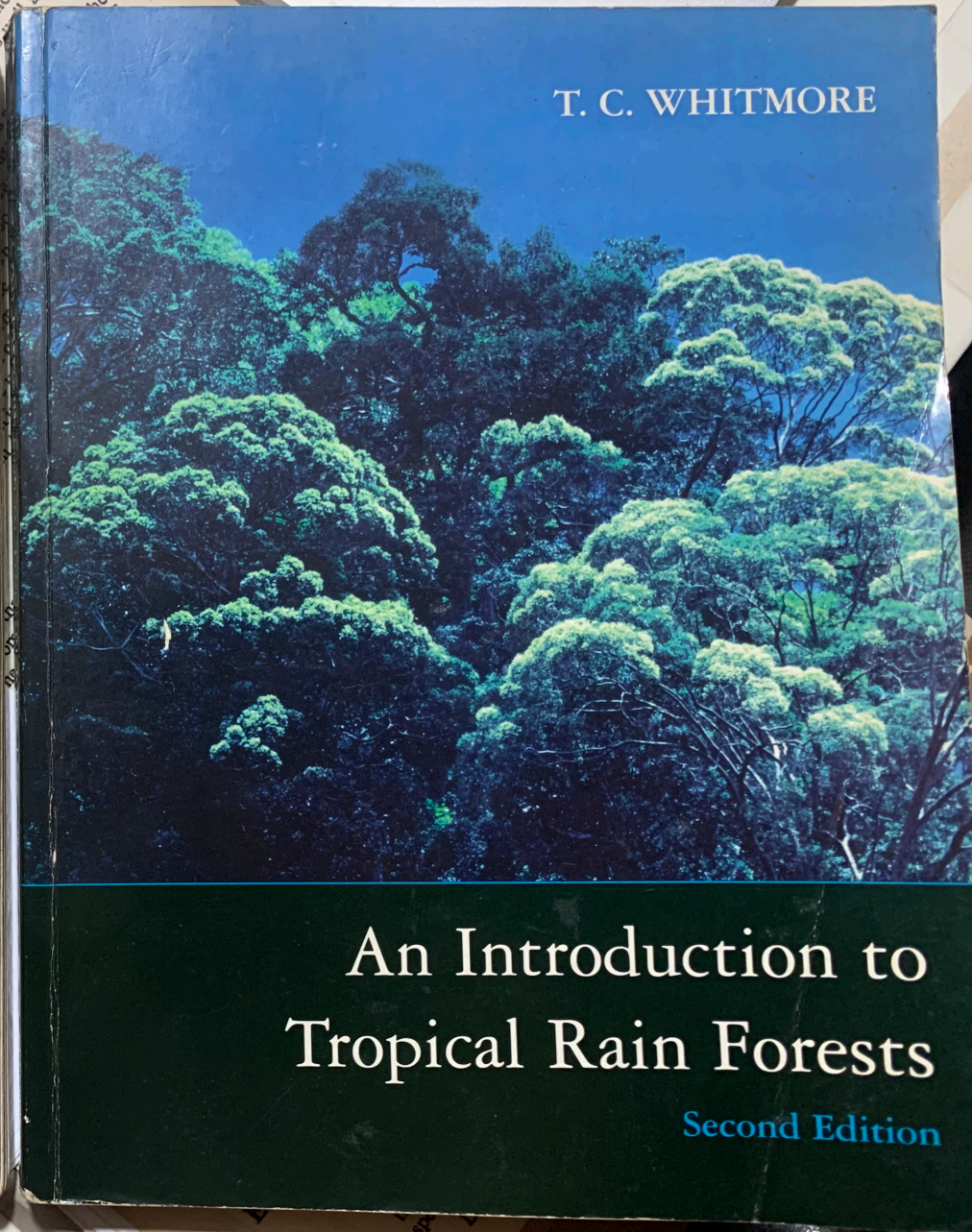
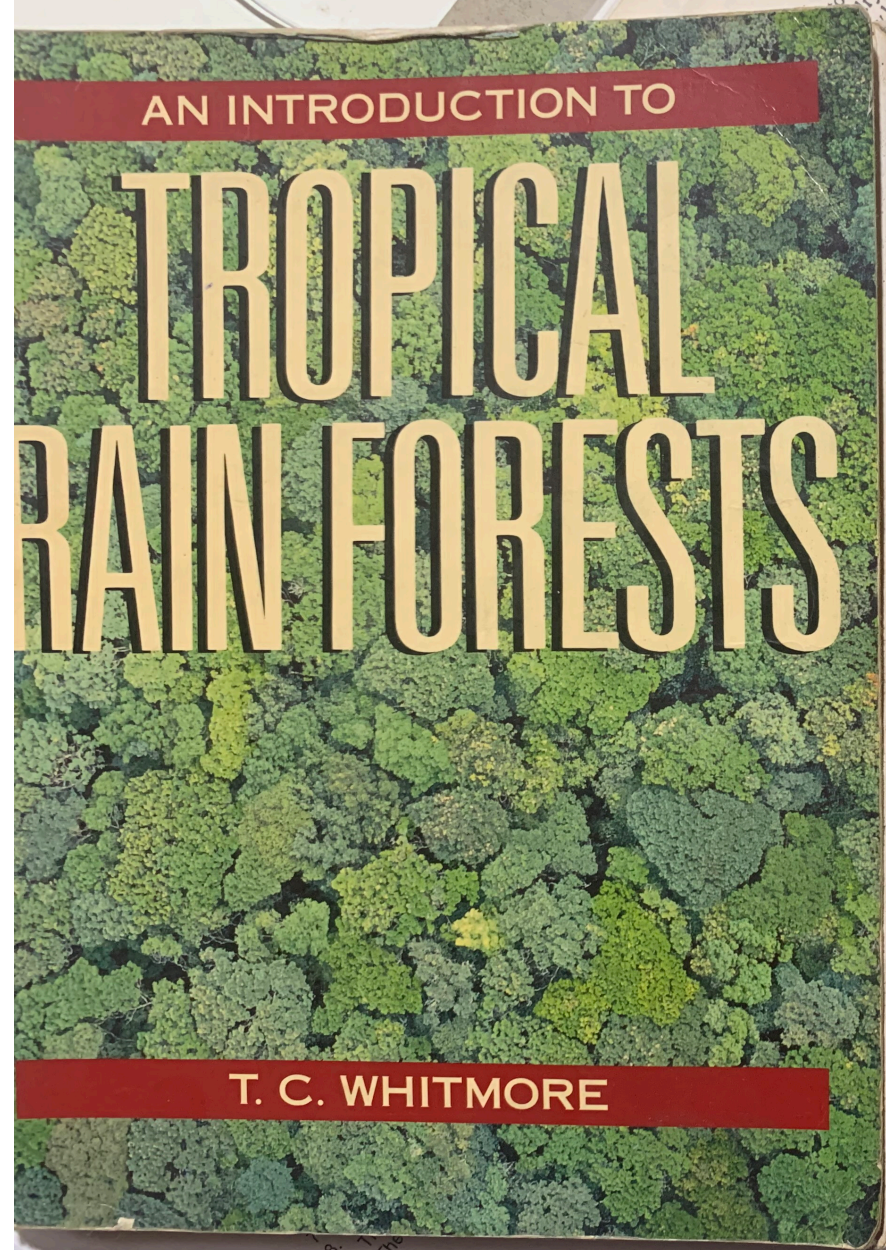


# Tropical Forest Ecology

## *Text Books:*

1. An Introduction to Tropical Rain Forests (2<sup>nd</sup> Edition, 1998). T.C. Whitmore. Oxford University Press. 282 pp
2. Tropical Rain Forests of the Far East (2<sup>nd</sup> Edition, 1984) T.C. Whimore. Oxford University Press. 352pp.
3. The Tropical Rain Forest (2<sup>nd</sup> Edition, 1996). P.W. Richards. Cambridge University Press. 575 pp.
4. Tropical Rain Forest Ecology (2<sup>nd</sup> Edition, 1992) D.J. Mabberley. Blackie. London. 300 pp.
5. Tropical Forest and Its Environment (2<sup>nd</sup> Edition, 1987) K.A. Longman & J. Jenik Longman. UK. 347pp.
6. The Tropical Rain forest. A First Encounter. Marius Jacobs 1988. Springer-Verlag. 295 pp.
7. Forest Ecology. A Foundation for sustainable Management. (2<sup>nd</sup> Edition. 1997) J.P. Kimmins. Prentice-Hall, Inc. 596 pp.
8. Tropical Rain Forest. A Wider Perspective F.B. Goldsmith (Editor). 1998. Chapman & Hall. 416 pp.







*Journals:*

1. Journal of Tropical Ecology
2. Journal of Forest Ecology and Management
3. Biotropica
4. Ecology
5. Restoration Ecology
6. Ecosphere
7. Journal of Ecology
8. Journal of Applied Ecology
9. Journal of Tropical Forest Science

1. The Malaysian Forester
2. The Sri Lanka Forester

## Restoration pathways for rain forest in southwest Sri Lanka: a review of concepts and models

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### Abstract

In the last 10 years the Sri Lankan government has changed its policy regarding its remaining rain forest from one that promoted commercial exploitation to one of conservation. The growing importance of uplands as catchments for water production, biodiversity conservation and other downstream services has been recognized by the Sri Lankan government. It is therefore timely that we review 15 years of research investigating rain forest dynamics of southwest Sri Lanka with the objective of using this knowledge for forest restoration. We provide six common principles for understanding the integrity of rain forest dynamics in southwest Sri Lanka. The principles are: (i) disturbances provide the simultaneous initiation and/or release of a new forest stand; (ii) that disturbances are generally non-lethal to the groundstore vegetation; (iii) disturbances are variable in severity, type and extent across rain forest topography; (iv) guild diversity (habitat diversity) is dependent upon “advance regeneration”; (v) tree canopy stratification is based on both “static” and “dynamic” processes; and (vi) canopy dominant late-successional tree species are site specialists restricted to particular topographic positions of the rain forest. These principles are applied to determine effects of two rain forest degradation processes that have been characterized as chronic (continuous detrimental impacts) and acute (one-time detrimental impacts). Restoration pathways are suggested that range from: (i) the simple prevention of disturbance to promote release of rain forest succession; (ii) site-specific enrichment planting protocols for canopy trees; (iii) sequential amelioration of arrested fern and grasslands by use of plantation analogs of old field pine to facilitate secondary succession of rain forest, and plantings of late-seral rain forest tree species; and (iv) establishment and release of successional compatible mixed-species plantations. We summarize with a synthesis of the restoration techniques proposed for reforestation using native vegetation on cleared conservation areas and parks, and for the stabilization of eroded upland watersheds. We conclude with a comparative analysis with restoration work done in other tropical forest regions. © 2001 Elsevier Science B.V. All rights reserved.

**Keywords:** Buried seed; *Clidemia hirta*; *Dicranopteris linearis*; Dipterocarps; Disturbance; Plantations; Secondary forest; Selective logging; *Shorea* spp.; Swidden; Tea cultivation

### 1. Introduction

Mixed dipterocarp forests comprise an important forest type that covers much of the upland hill, and

lowland regions of southeast Asia (Whitmore, 1990). This forest type, and the dipterocarps in particular, has provided much of the region’s timber for both local use and export to Europe, Japan and North America. After logging, many of the more accessible regions have either been converted to large scale rubber and oil palm plantation, or to small-holder subsistence gardens.

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## Where Are the Rain Forests?

Occur in about 30 different countries

- South & Central America
- Tropical Africa
- South- East Asia & Indian subcontinent

Total Area:  $6 \times 10^6$  -  $10 \times 10^6$  km<sup>2</sup>

Occur between 23° N and 23° S (between Tropics of Cancer and Capricorn)

- High rainfall (1700-3000 mm/year)
- High humidity (70-90%)

High temperatures (20-28 °C)

Estimates of timber Volumes:

Africa 5-35 m<sup>3</sup>/ha

Asia 50-120 m<sup>3</sup>/ha

Biomass (above ground)

*ca.* 100 t/ha (including about 10 t/ha litter)

Growth rate: *ca.* 2 m<sup>3</sup>/ha /year

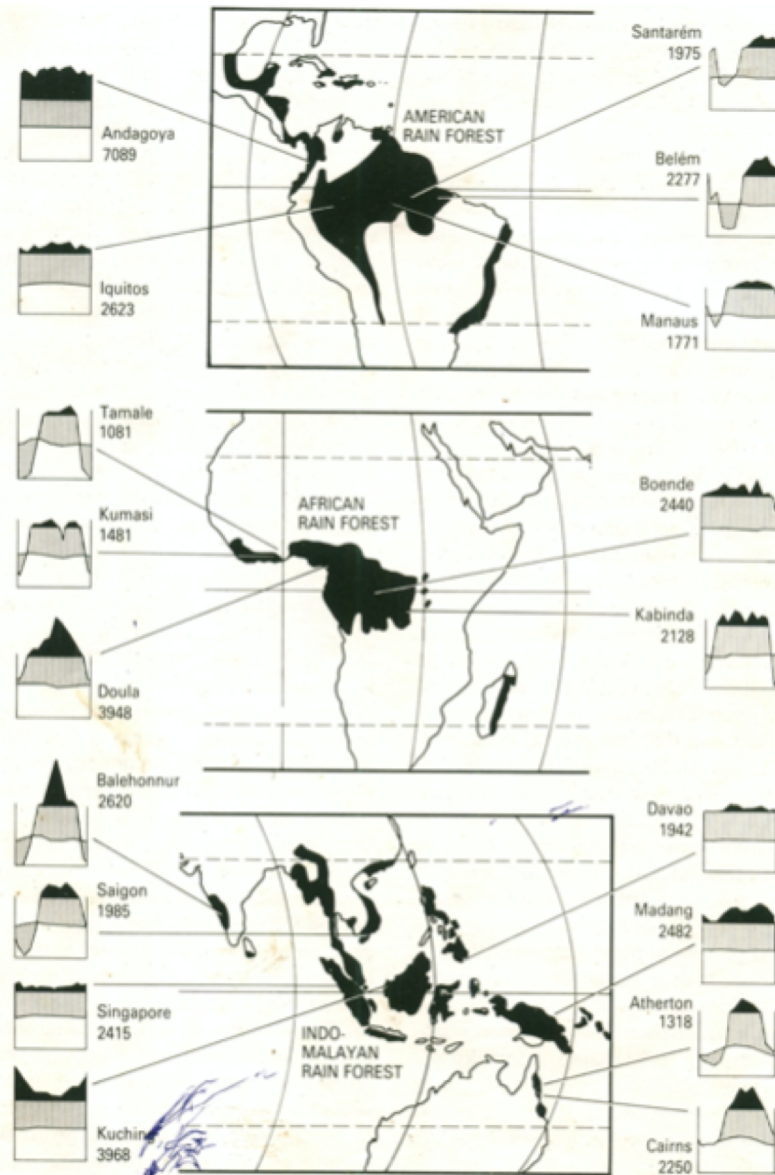
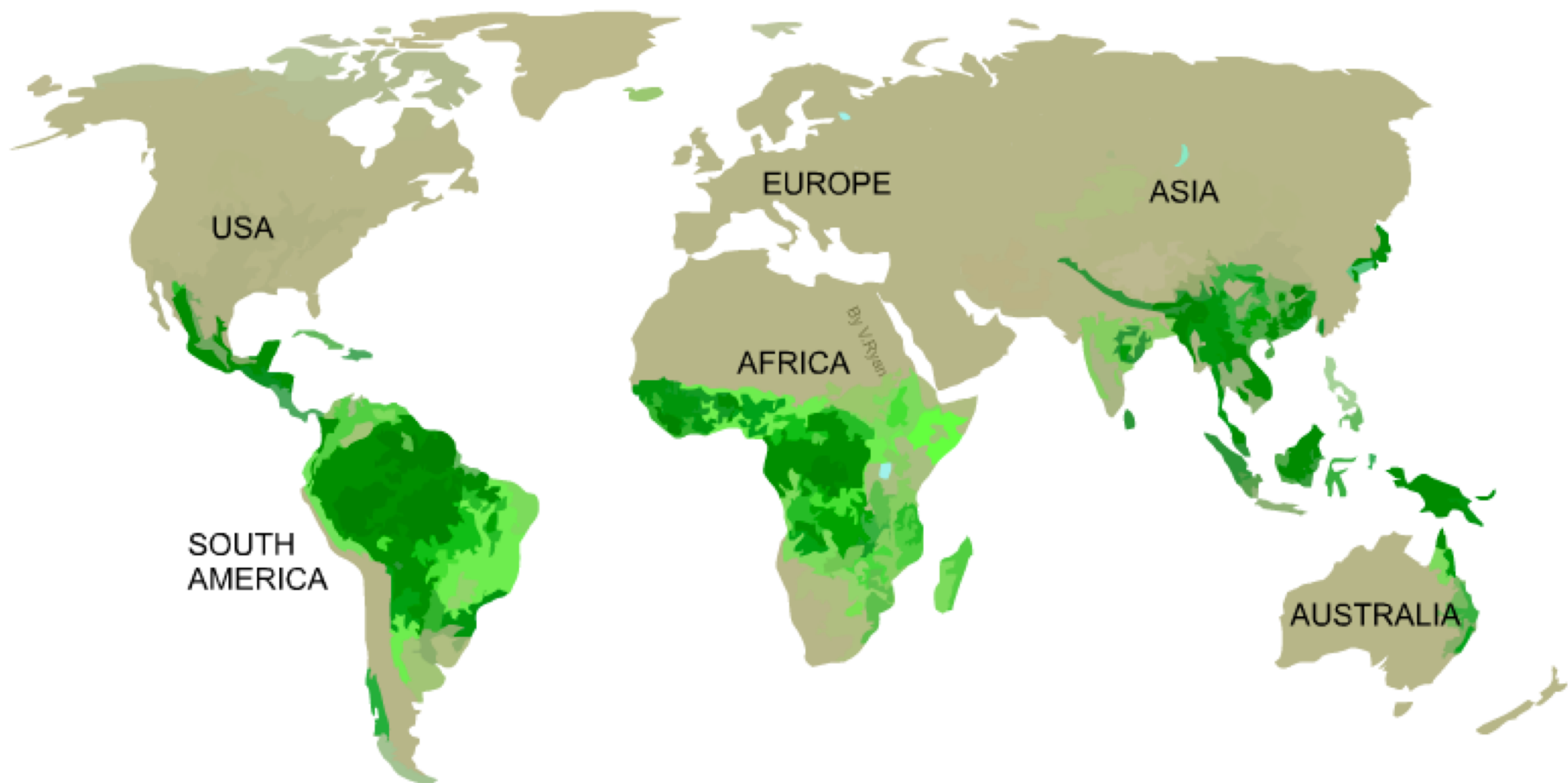


Fig. 2.1. Tropical rain forest, distribution and climate. (After White 1983; Whitmore 1984a; Walter and Lieth 1967.)

The Climate Diagrams show dry periods as dotted and rainy periods as hatched (or where monthly rainfall exceeds 100 mm shown black at 1/10 scale). Long-term mean annual rainfall (mm) is shown in figures. Dry periods which occur irregularly scattered through the year do not show up on these diagrams because they are based on long-term means.





## **The American Rain Forest** (Neotropical Rain forest)

The largest mass of rain forest in the world,  
ca. half the global total,  $4 \times 10^6$  km<sup>2</sup>

These occur in three parts

1. mainly in the Amazon and Orinoco basins (east to the Guianas and south to ca. 15° S in western Brazil and northern Bolivia)
2. Along the east coast of Brazil- a narrow strip (<50 km wide), the 'Atlantic forest'. This extends southwards from about 7-28°S in Rio Grande.
3. West of the Andes- rain forest extends northwards from about 0° 23'S in Ecuador through Colombia to Panama. This area is one of the wettest rain forest regions in the world.

The highest alpha diversity of rain forests is recorded in this region.

Cuyabeno Reserve, Ecuador 313 tree species/ha >10 cm dbh

Yanamomo, Peru 283 tree species/ha >10cm dbh

From Panama rain forest extends northwards to southern Mexico up to 19° N in Vera Cruz.

Also in large islands of Antilles *e.g.* Jamaica, Hispaniola, Puerto Rico, Dominica, Martinique and Trinidad

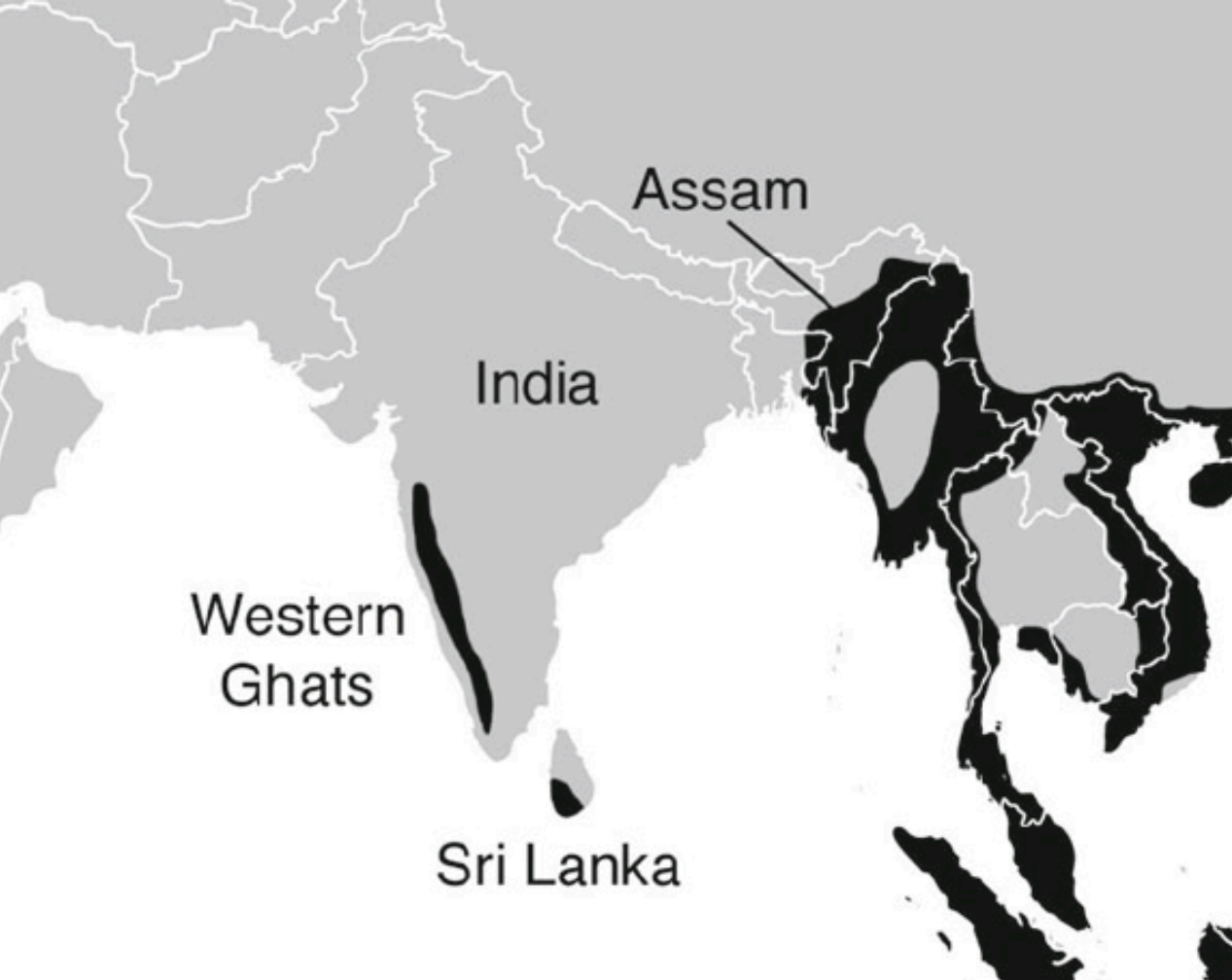




# The Indo-Malayan and Australian Rain forest

- Second largest block of rain forest  $2.5 \times 10^6 \text{ km}^2$
- In the eastern tropics rain forest is found from southern India and Sri Lanka to Thailand and southern China, extending southwards to Indo-China and through Malay peninsula to the islands of the Malay archipelago, The Philippines, New Guinea, the western pacific islands and Australia.
- The largest forest areas are in the Malay Peninsula, Sumatra and Borneo.
- True rain forest area is not very large in Burma, Thailand, Cambodia, and Vietnam.
- China- rain forest reaches about  $28^\circ \text{ N}$  on the mainland also in Yunnan province.
- Java- small area in the west, New Guinea- rain forest found everywhere in lowlands
- Australia- narrow band (ca. 160 km) in Queensland to New South Wales
- Rain forests are also found in Western pacific islands- (Solomons, New Hebrides, Fiji, Samoa, New Caledonia).

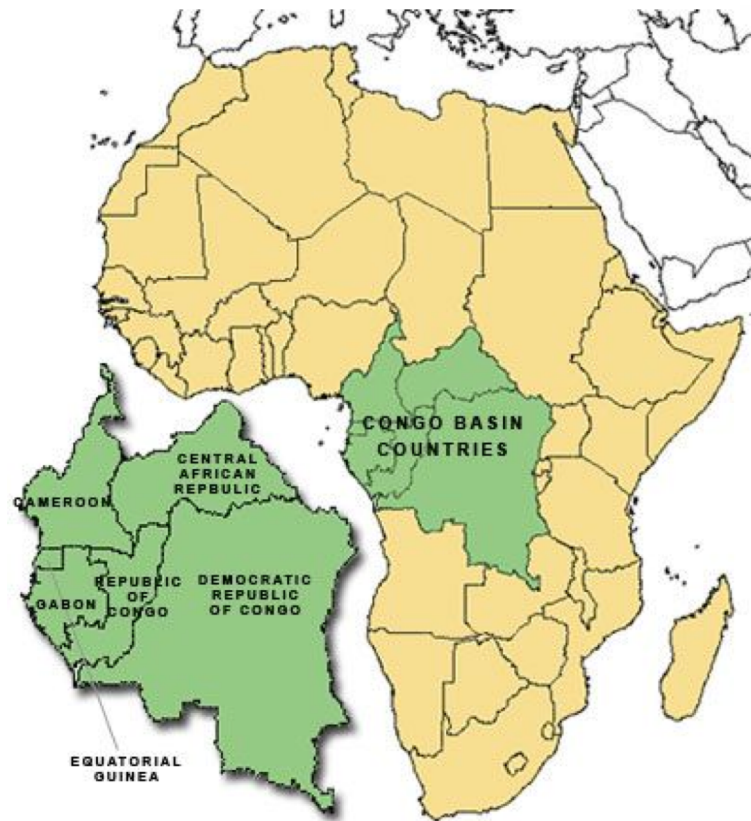




# **The African Rain forest**

- Less extensive than in tropical America  $1.8 \times 10^6 \text{ km}^2$
- Centered in Zaire (Congo) basin, forest continues westwards into Gabon and Cameroon.
- A narrow belt follows the coast of the Gulf of Guinea through Nigeria to Ghana and beyond finally ending in Guinea at  $10^0\text{N}$ .
- The area of continuous forest reaches western Uganda, western Kenya and northwestern Tanzania.
- There are tiny patches of rain forests on the east coast of Madagascar, and in the Mauritius and Reunion.





Rain Forest Region	Countries
The American Rain forest 4,000,000 km <sup>2</sup>	Brazil, Colombia, Ecuador, Peru, Venezuela, Guianas, Bolivia, Panama, Costa Rica, Mexico
The Indo-Malayan and Australian Rain forest 2,500,000 km <sup>2</sup>	India, Sri Lanka, Malaysia, Indonesia, Thailand, Myanmar, Philippines, Viet Nam, Laos, Cambodia, China, New Guinea, Fiji, Solomon Islands, Brunei
The African Rain forest 1,800,000 km <sup>2</sup>	Congo, Gabon, Cameroon, Nigeria, Ghana, Guinea, Cote d'Ivoire, Western Uganda, Zaire, Kenya, Tanzania, Madagascar

# Six major vegetation types in the Tropics (A.F. W. Schimper 1898, 1903)

## (Plant Geography upon an ecological basis)

### Woody Vegetation

Rain Forest	Tropical Moist Forests
Monsoon Forest	
Savanna Forest	
Thorn Forest	

### Non Woody vegetation

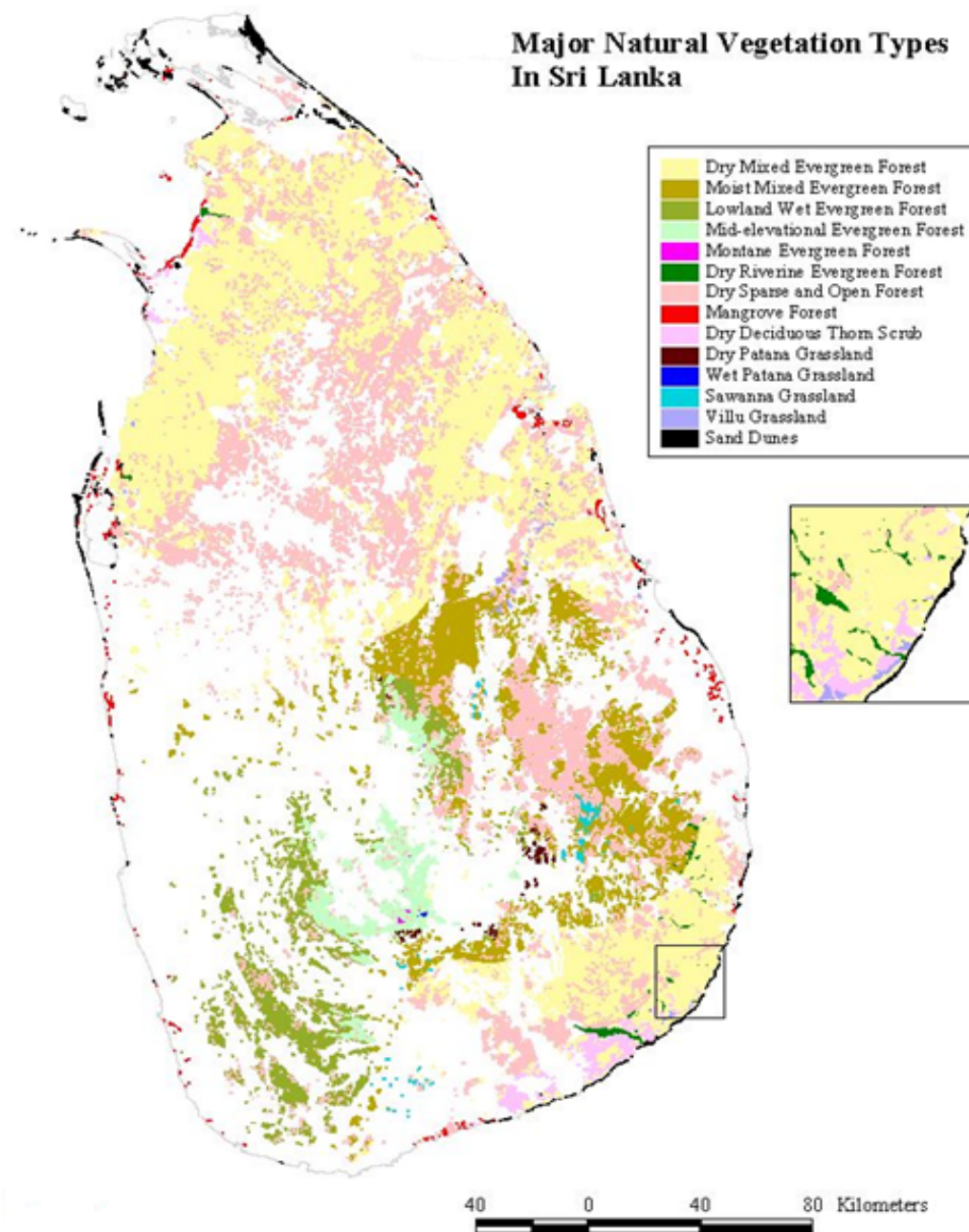
Tropical Grasslands
Deserts



# Tropical Moist Forest (TMF)

Tropical moist forest is a term used by Sommer (1976) and adopted by FAO to describe the closed high forest lying in the tropical belt of the world where the dry season is short (4 months) or nonexistent. TMF is a complex ecological system, poorly known and understood and includes both the dryland and wet rain forest formations, as well as the monsoon and mountain rain forests.

## Major Natural Vegetation Types In Sri Lanka



# Tropical Moist Forest and their Climates

## Climate

- **Temperature**

Constant High Temperature

Difference of less than 5 °C between the mean temperatures of the warmest and coldest months

- **Rainfall**

**Amount** and **distribution** throughout the year

Rain forests develop where every month is wet (with **100 mm** rainfall or more or there are only short dry periods which occur mainly as unpredictable spells lasting only a few days or weeks

Monsoon forest (or Tropical Seasonal Forest) exists where there are several dry months (**60 mm** rainfall or less) of regular occurrence

# Climate Map of Ceylon

scale 8 miles to the inch or  
1:506,880

## Explanation

Each climate diagram shows:

Station name above graph; the geographic location of the station is shown by the black dot nearest to each diagram.

Elevation above mean sea level in feet and meter below station name.

Mean annual temperature in degrees (°) Centigrade in center above graph beneath elevation; the number of years of temperature record are shown to the left of the mean annual temperature only for the stations with published temperature records; the temperature of other stations has been interpolated and adjusted for altitude from the nearest stations with published temperature records. (Reference: Dassanayake, D. T. E. 1955. Report on the Colombo Observatory with maps and statistics for 1953. Government Press, Ceylon).

Mean annual rainfall in millimeters to the right of the mean annual temperature value; all rainfall values are based on a 50-year period (1907-56). (Reference: Walker, R. L. 1962. The hydrometeorology of Ceylon, Part I: Rainfall and Runoff. Canada-Colombo Plan Project. Government Press, Ceylon). Mean deviation of rainfall in millimeters is shown on 1° diagrams as plus minus value beneath the mean annual rainfall figure.

(Reference: Thambyahpillay, G., 1960. Agro-climatological significance of the factor of rainfall variability in Ceylon. Agriculture 3: 13-30).

Temperature curve; monthly mean values are plotted with reference to the left ordinate showing degrees in Centigrade (°C). This ordinate shows 10-degree intervals. (Degrees Centigrade can be converted into Fahrenheit (°F) as follows:  $F = \frac{9}{5}C + 32$ ; thus 10 °C = 50 °F, 20 °C = 68 °F, 30 °C = 86 °F etc).

Rainfall curve; monthly mean values are plotted with reference to the right ordinate showing precipitation (Ppt) in millimeters (mm). This ordinate shows 20 mm intervals up to 100 mm. Above 100 mm the intervals are 200 mm. Rainfall exceeding 100 mm is shown by black fields. (Rainfall in inches equals rainfall in mm divided by 25.4, thus 100 mm approx. 4 inches). Wherever the rainfall curve undercuts the temperature curve at the demonstrated relation of 10 °C to 20 mm Ppt, a significant drought period is indicated (dotted fields).

Months through the year from January to January on the abscissa with July in center (elongated vertical dash).

<sup>1</sup>Adapted from the method of:

Walter, H. 1957. Wie kann man den Klimatypus anschaulich darstellen? Umschau Wiss. Tech. Heft 24: 751-753.

This map can be integrated with the Klimadiagramm - Weltatlas of H. Walter and H. Lieth. VEB Fischer Verlag Jena (1960). In this atlas Ceylon is shown at the scale of 1:3,300,000 with 6 climate diagrams each based on 30 years of rainfall.

Major vegetation zone boundaries transferred with permission from the 1:1,000,000 "International Map of the Vegetation" (1964) by H. Gaussen, P. Legras, M. Viart and L. Labrousse. Special sheet published by the Ceylon Survey Department.

The zones or series are based on the concept of "Potential Natural Vegetation".

A *Manilkara - Chloroxylon* series (represented twice, NW and SE Ceylon).

B *Chloroxylon - Berrya - Vitex - Schleicheria* series.

C *Filicium - Euphoria - Artocarpus - Myristica* transitional series.

D Includes 3 rain forest zones

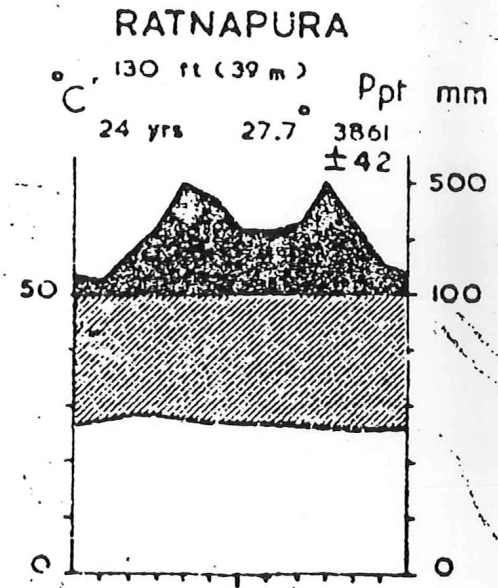
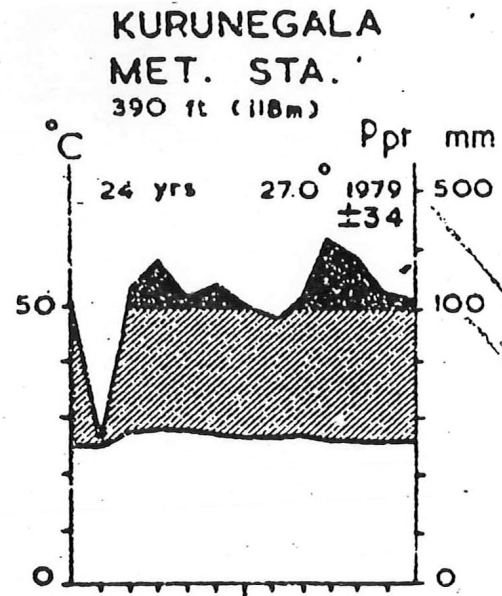
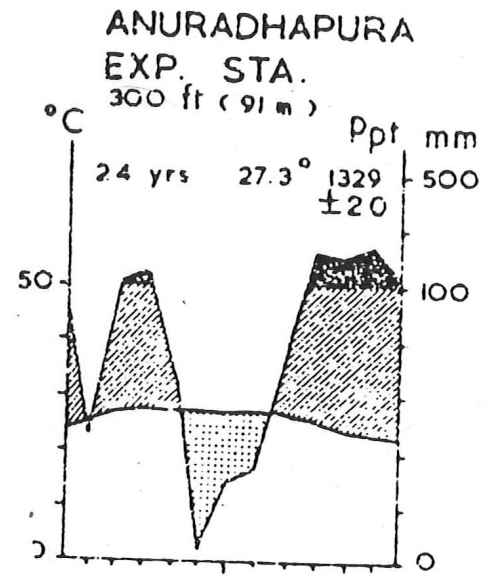
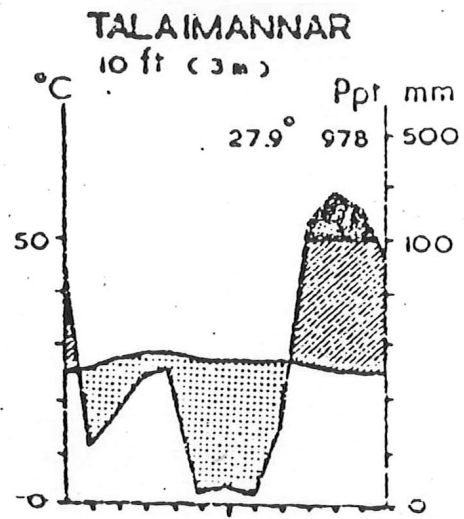
(a) lowland; *Doona - Dipterocarpus - Mesua* series.

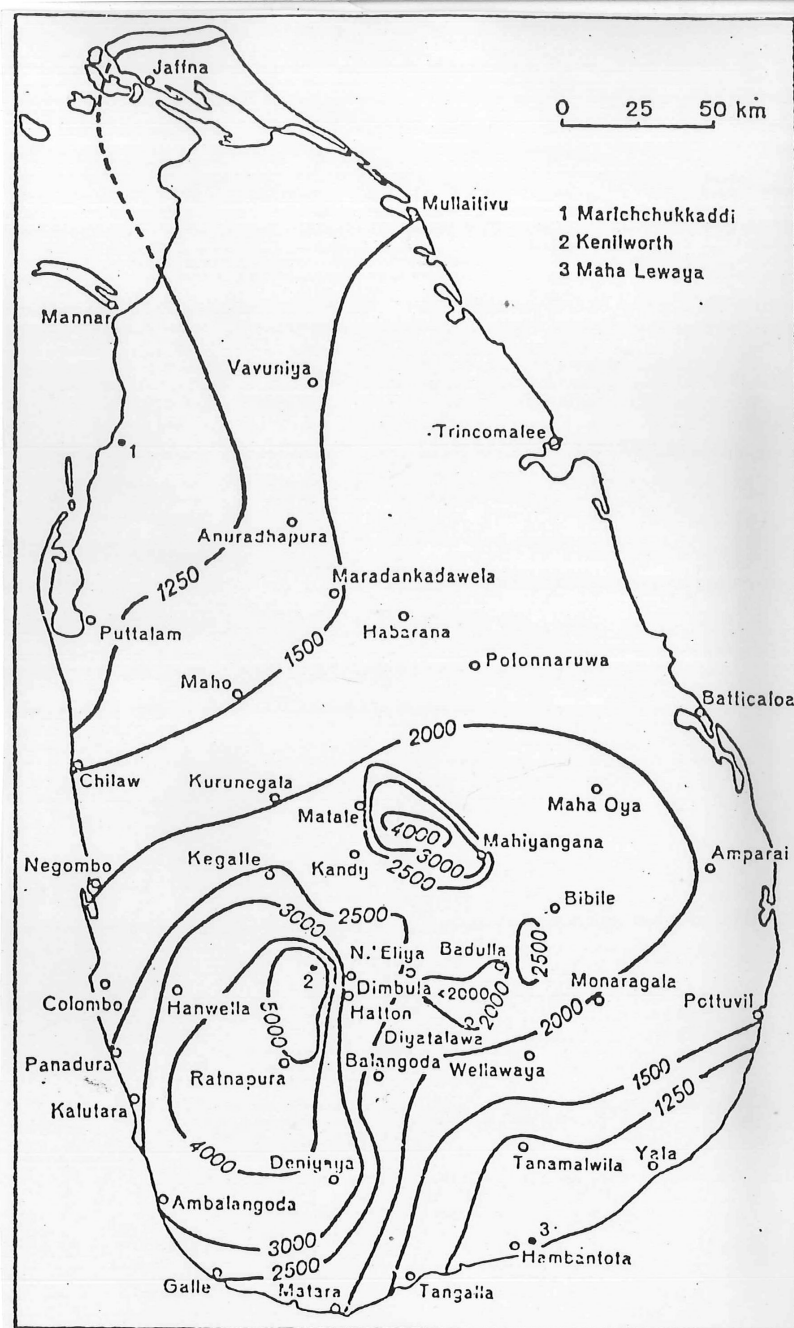
(b) mid-altitude; *Doona - Calophyllum - Syzygium* series (3000 - 5000 ft.)

(c) high altitude; *Syzygium - Gordonia - Michelia - Elaeocarpus* series (from 5000 feet up).

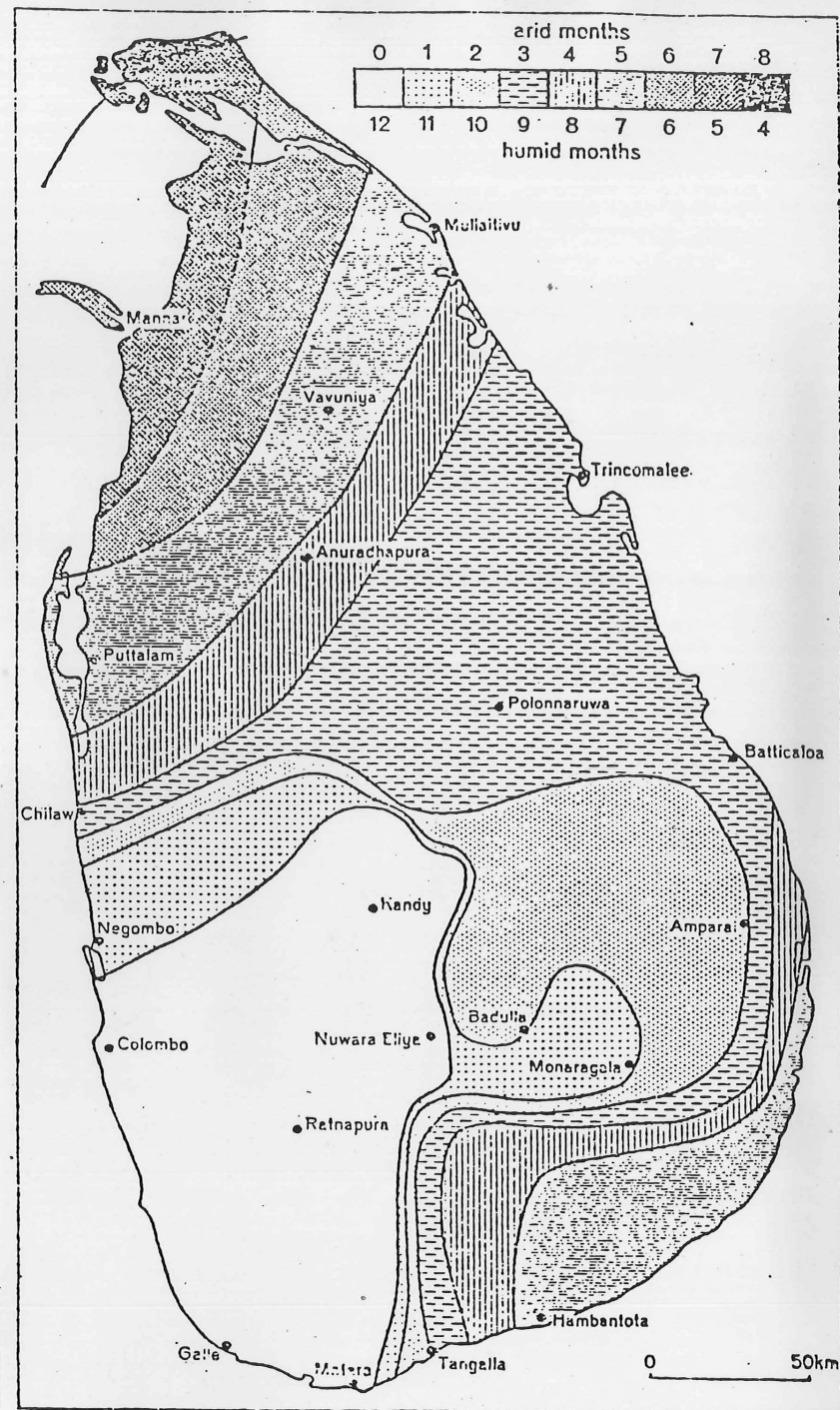
Topographic contour lines at 100, 500, 1000, 3000, 5000, and 7000 feet transferred from  
Walter, R. L. 1962. (See above under mean annual rainfall).







Annual average amount of rainfall in Ceylon, isohyets in mm, period from 1931 to 1960.



# A. Superwet Localities

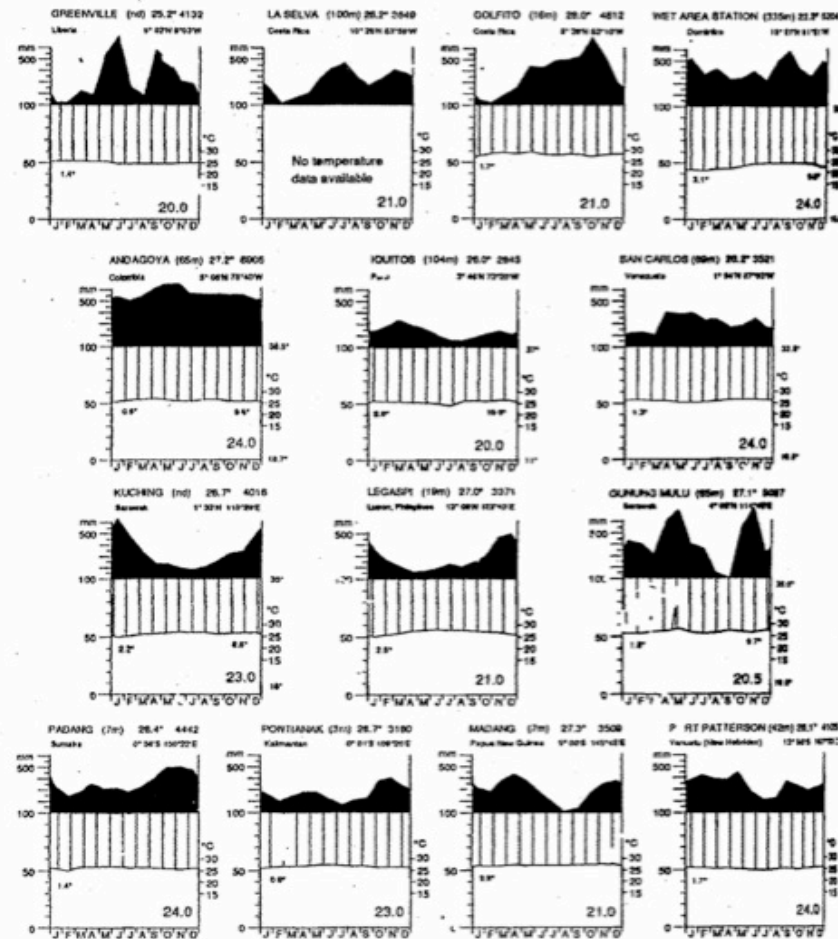


Fig. 7.2 Climate diagrams for tropical rain forest stations. Locations are shown in Figure 7.1. The diagrams mostly follow the conventions of Walter & Lieth (1960). The station name line also gives station altitude (m), mean annual temperature (°C) and mean annual rainfall (mm). The annual and mean daily ranges in temperature (°C) are shown towards the left and right, respectively, of the graph. The highest and lowest recorded temperatures are given (where available) above and below the temperature scale to the right of the graph. The perhumidex value (see text) is given in the bottom right-hand corner of the graph.



## B. Tropical Wet Localities

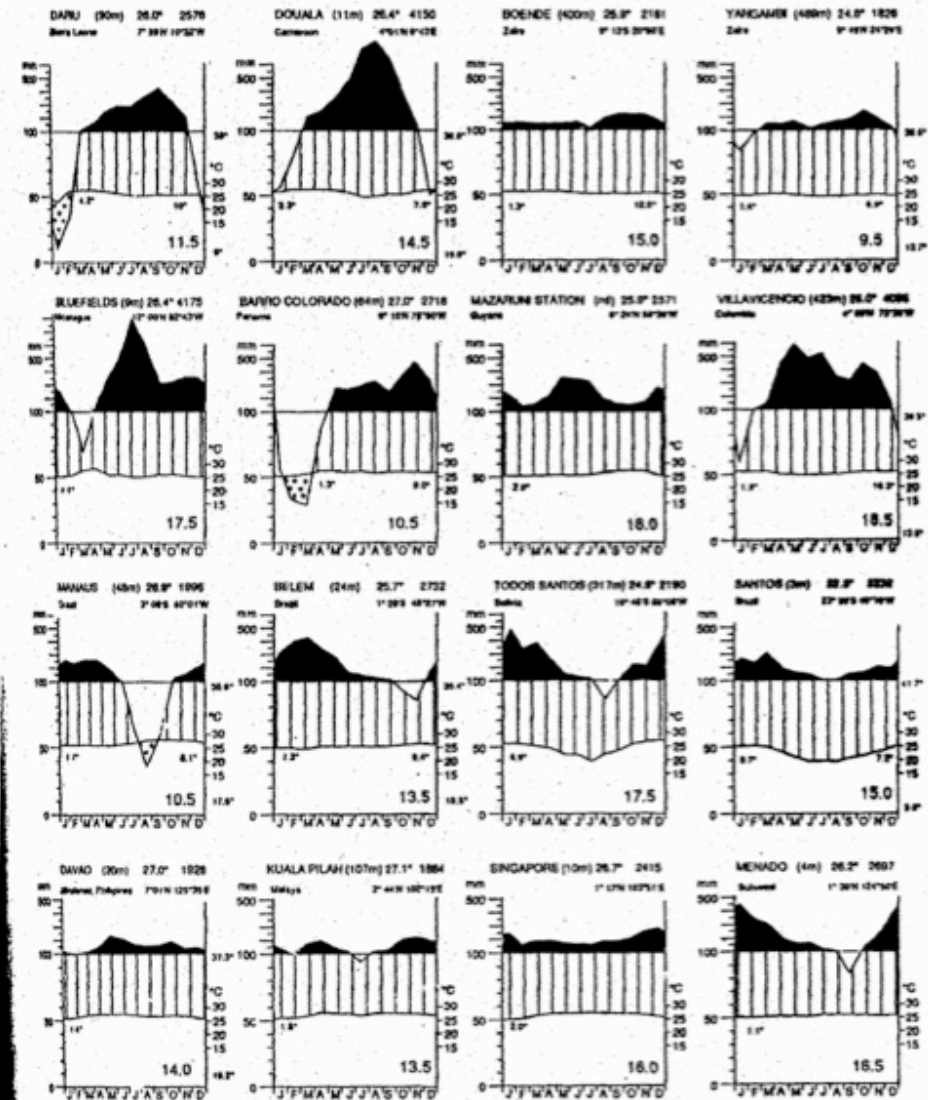
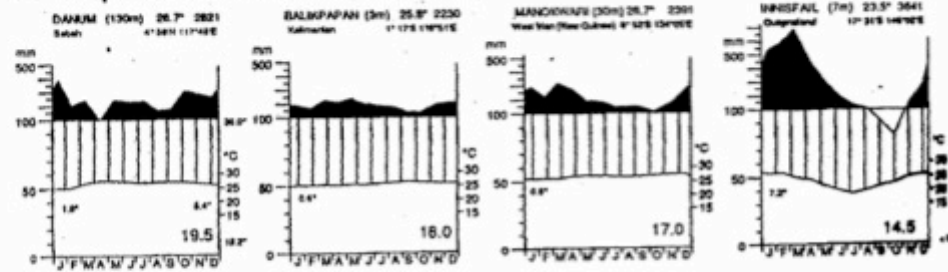


Fig 7.2 (cont.)

## B. Tropical Wet Localities (continued)



## C. Tropical Wet Seasonal (Rain forest marginal) Localities

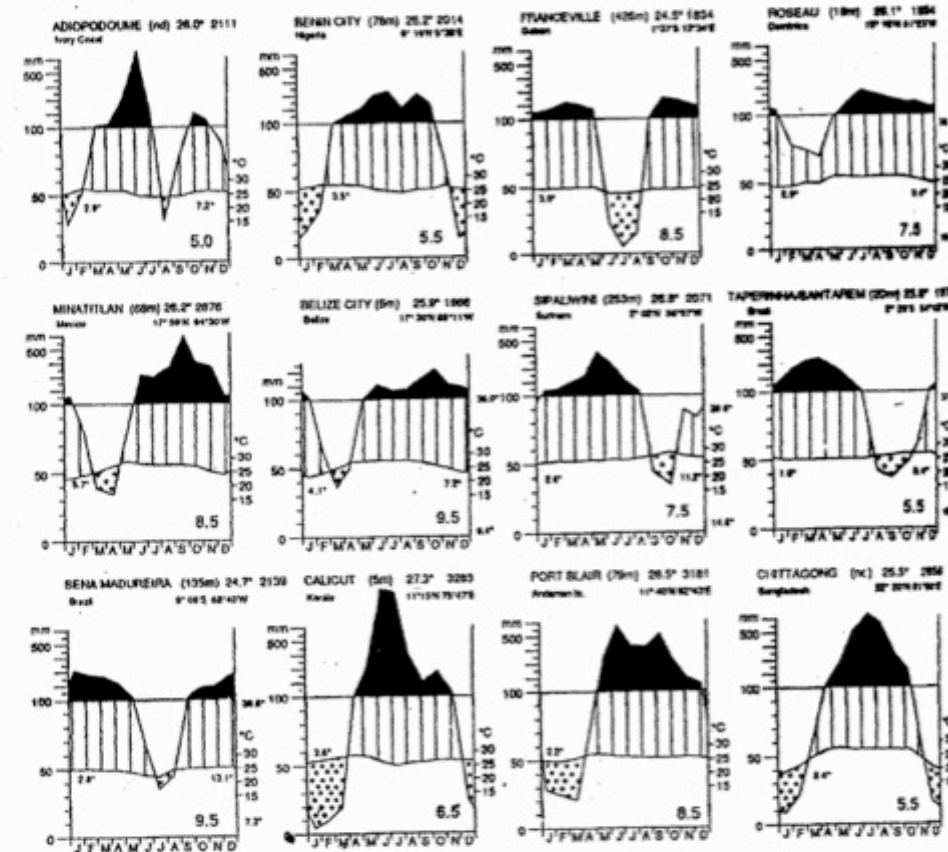
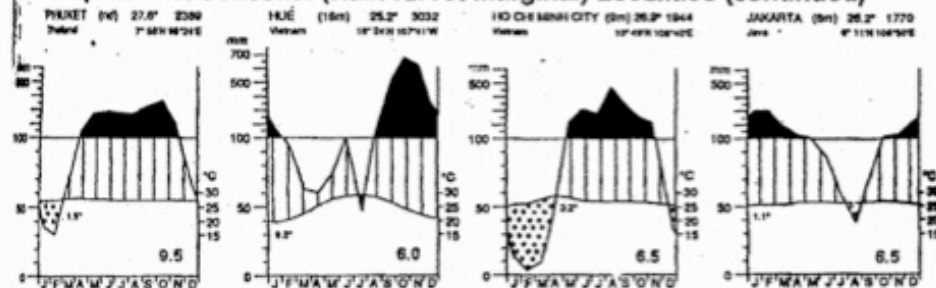
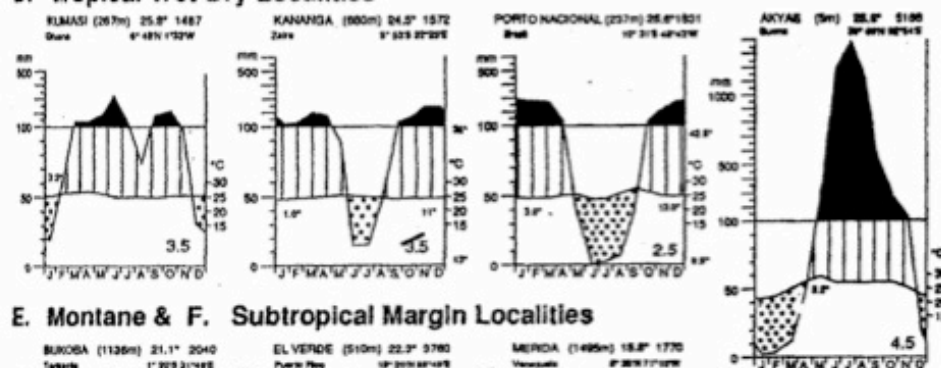


Fig 7.2 (cont.). For legend see p. 166.

### C. Tropical Wet Seasonal (Rain forest marginal) Localities (continued)



### D. Tropical Wet-Dry Localities



### E. Montane & F. Subtropical Margin Localities

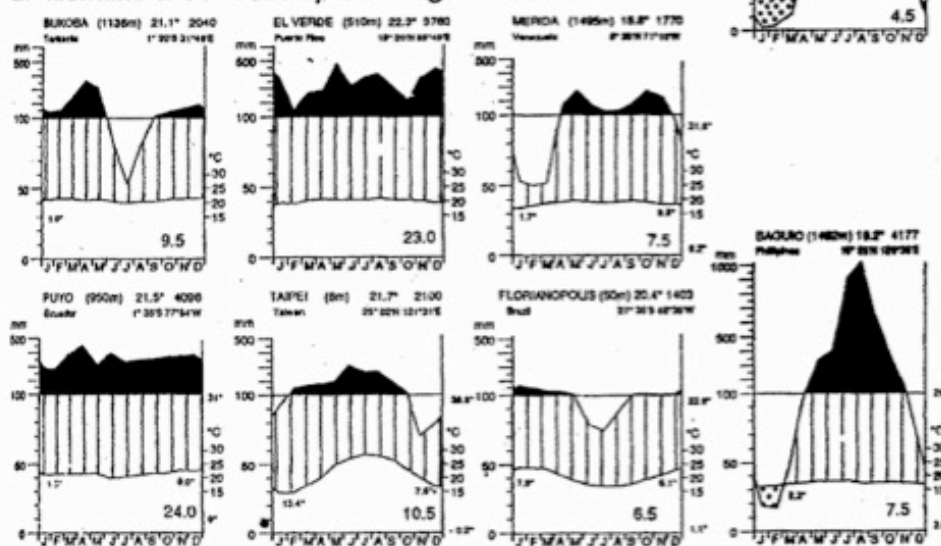
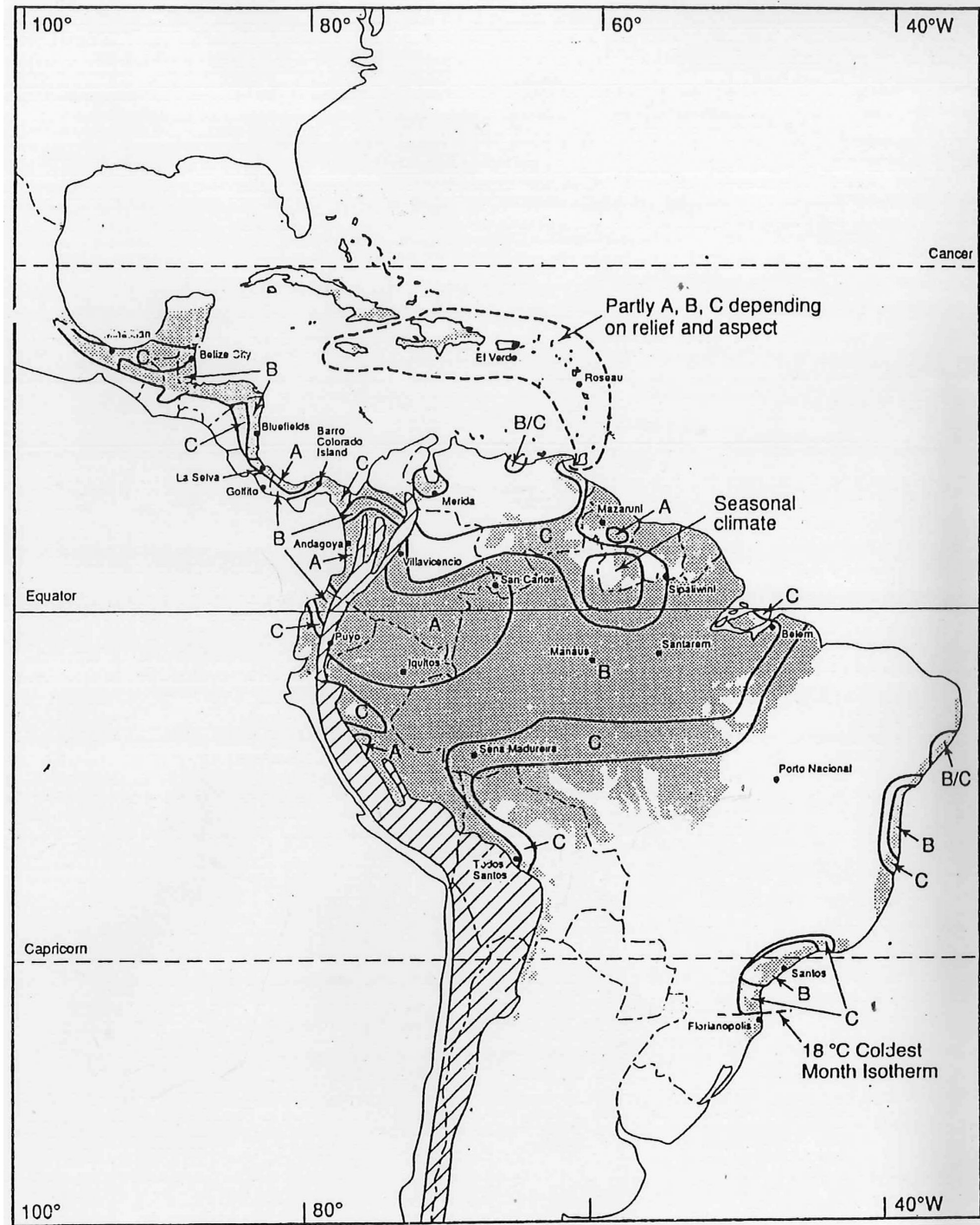
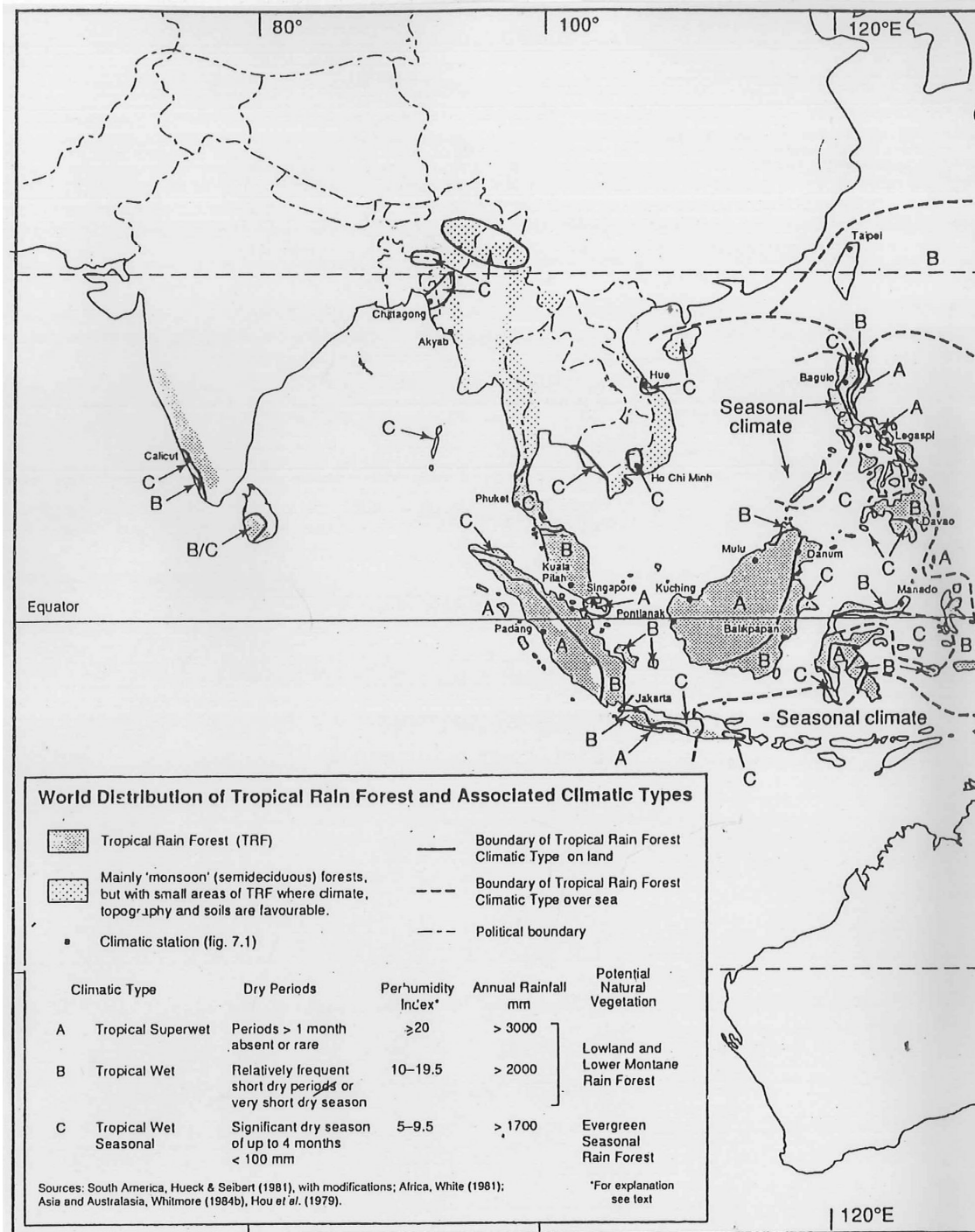
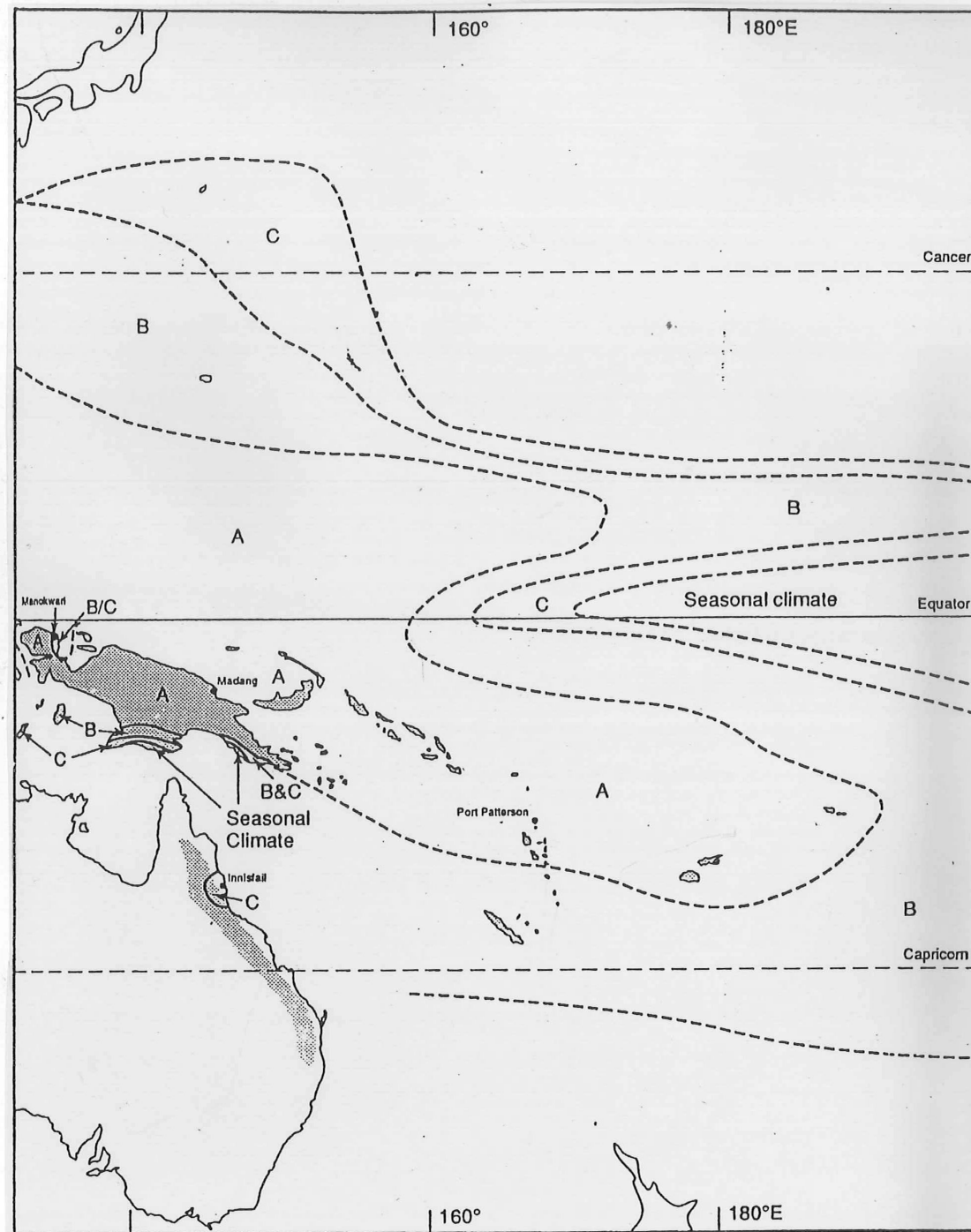


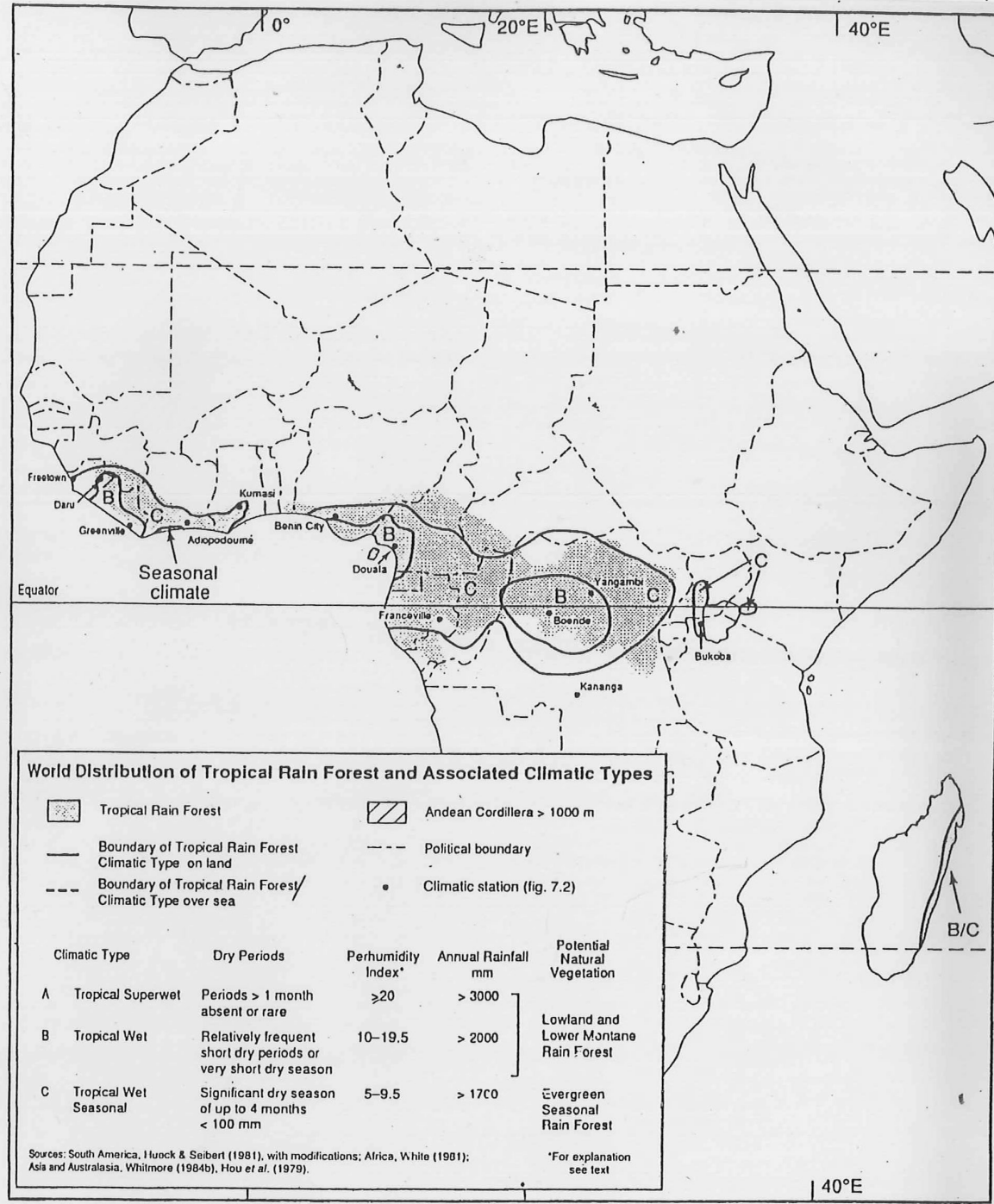
Fig 7.2 (cont.).











## **Vegetation Formations**

Defined on its Structure and on the Physiognomy

### **Structural Properties-**

Height of trees,

Crown in Layers (emergent, canopy, understory)

Climbers, Epiphytes

### **Physiognomic Properties**

Shape of Crown, Nature of Leaves (size, shape, thickness, margin)

Buttresses

Whether forest is evergreen, if not how strongly deciduous

Where on the trees flowers and fruits are borne (Cauliflory, Ramiflory)

