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Forestry in the tropics

1.1 Introduction

Tropical forests have always attracted the world's attention because of their magnificence and potential for economic exploitation. For centuries, they catered to the people's livelihood needs for timber, fruits, firewood, medicinal plants etc., and also, indirectly, animal meat. The native people lived in harmony with the forest as their populations were small and their demands did not exceed the forest's capacity to regenerate. The situation changed drastically in the colonial era between the mid seventeenth and mid twentieth centuries. During this period, large areas of tropical forests were cleared for human settlement and large-scale cultivation of agricultural and estate crops like sugar cane, tea, coffee, rubber and wattle. Forests were also logged for selective extraction of valuable timbers such as teak and rosewood in Asia, mahogany in Latin America and khaya in Africa, mainly for export. By the mid eighteenth century, forest plantation technology had developed and the natural forests were increasingly replaced by plantations. After the Second World War, forest plantation programmes received a further boost in the newly independent nations due to international exchange of information and availability of international development funds (Evans, 1992). Exotic, fast-growing eucalypts and pines were raised in the tropics on a large scale during this period. As industrialization progressed, more extensive plantations were established, mostly with exotic fast-growing species, and on land cleared of natural forests. Most of these were intended to produce pulpwood for paper, rayon and fibreboard. As a result, vast stretches of natural tropical forests across the continents were destroyed or degraded.

While tropical deforestation was thus progressing steadily, the environmental value of tropical forests was also being slowly recognized worldwide, particularly after the 1960s. The role of natural forests in maintaining the climate, soil, hydrological regime, biodiversity, the global carbon balance and the overall security of the local people's livelihood was recognized. Campaigns against the indiscriminate destruction of tropical forests gathered momentum. A large number of local and international voluntary organizations were established to push the cause of conservation, with particular emphasis on tropical forests. Although many of them had a negative agenda, opposing all sorts of developmental activities, their dramatic and emotional campaigns helped to create wide public awareness of the ecological importance of tropical forests. As a result, national governments and international bodies such as UN agencies took initiative in conservation action. For example, roughly 10% of the world's tropical forests are now set aside as national parks or undisturbed reserves. In some places like the hilly State of Kerala in India, for instance, as much as 25% of about one million ha of forest has been designated as wildlife sanctuaries and national parks. In spite of this awareness, deforestation in the tropics continues, albeit at a slower pace, driven by the profit motive of pulpwood industries and the gullibility of the governments of economically stressed tropical countries. As Whitmore (1998) observed, 'logging proceeds as fast as ever and moves on to fresh countries'. The tropical forests of South and Southeast Asia have been heavily depleted and the timber lobby is now focussing on Latin America.

Although the progress of deforestation was concomitant with the growth of the human population, and some of it was essential to ensure civilization, recent decades have witnessed an unprecedented destruction of tropical forests with the growth of the pulp and paper industry. Can we continue to destroy the tropical forests at the current rate of 17 million ha annually, and degrade much of the remaining area, without endangering our own future survival? Can we manage the remaining tropical forest, or at least a reasonable chunk of it, in a sustainable manner so that we will continue to be sustained by it? What is unique about tropical forests? It is beyond the scope of this book to answer all these questions, on which there is a vast literature. For details on the state of the world's forests the reader is referred to the periodic reports of the Food and Agriculture Organization of the United Nations (FAO) (2005), which are updated every two years. Whitmore (1998) gives a balanced account of the tropical rain forests and discusses the key tropical forestry issues. What is attempted here is a brief overview of the broad features of tropical forests to facilitate an appreciation of the role and importance of the forest insects.

1.2 The tropics

Although the tropics can be easily defined as the geographical area lying between the tropic of Cancer and the tropic of Capricorn (latitudes 23° 27' north and south, respectively, of the equator), it is not possible to discuss tropical forestry exclusively within these geographical limits. For one thing, the distribution of many tropical forest tree species does not coincide with the limits of the tropics; it often extends beyond. For example, the natural distribution of *Eucalyptus tereticornis* extends from 9° S to 38° S, and that of the dipterocarp *Shorea robusta*, from 18° N to 32° N, covering both tropical and subtropical zones. Teak (*Tectona grandis*) has a natural distribution mostly confined to the tropics (25° N to 9° N), but is also planted widely in the subtropics (e.g. Bhutan, Japan, Korea, Nepal, Pakistan, Turkey). Even the tropical rain forest, the most characteristic forest formation of the tropics, extends, for example, into southern China at 26° N, with ill-defined change into subtropical rain forest (Whitmore, 1998). Secondly, most information related to forestry is available according to country, and countries known as tropical countries do not fall neatly within the tropics either. According to the FAO definition, if more than 50% of the area of a country falls within the tropics, it is designated as a tropical country. Thus India, situated between latitudes 8° 4' N and 37° 6' N, is a tropical country but has a substantial area outside the tropics. And a non-tropical country such as China or Taiwan has areas that fall within the tropics. Thirdly, even within the tropics, temperate conditions are obtained on high mountains. For example, Honduras in Central America lies between latitudes 13° N and 16° N and the climate is tropical, but most forests lie in the cooler highlands (plateaus) where the mean annual temperature is about 21.1 °C. These forests are dominated by oak and pine, while the coastal regions are warmer, with a mean annual temperature of 26.7 °C (Simon and Schuster, 1999). Because of these overlaps, in general, the term 'tropics' is loosely used. The regions lying not only between but also *near* the tropics of Cancer and Capricorn are usually included under the tropics. In this book, we will use the term in a similar broad sense. This will allow us to deal with insects associated with predominantly tropical trees even when these trees' natural or planted distribution extends into the subtropical zone. In fact, strict distinction into tropics based on the imaginary latitudinal lines is artificial, because the tropics merge imperceptibly into the subtropics, often termed 'warm temperate'.

What distinguishes the tropics more easily from other parts of the world is the consistently warm atmospheric temperature, with no drastic difference between seasons and all months without frost. Climatically, the tropical zone is characterised by annual and monthly average temperatures above 20 °C and a

difference of not more than 5 °C between the mean monthly temperatures of the warmest and coolest months. This permits biological activity almost throughout the year except where seasonal drought limits the activity.

The tropics encompass many continents – parts of Asia, Australia, Africa, North America and South America, and several islands in the Pacific, Atlantic and Indian oceans. Conventionally, the tropical countries are grouped under three major regions, that is Asia-Pacific, Africa and Latin America. The countries that fall within the tropics are listed in Table 1.1. Together, these tropical countries cover a substantial portion of the earth's land surface, nearly 37%, comprising about 4800 million ha.

Table 1.1. *List of tropical countries/areas*[a]

Africa	Asia-Pacific	Latin America
Angola	Bangladesh	***Central America***
Benin	Brunei Darussalam	Belize
Botswana	Cambodia	Costa Rica
Burkina Faso	Fiji	El Salvador
Burundi	India	Guatemala
Cameroon	Indonesia	Honduras
Central African Rep.	Lao People's Dem. Rep.	Mexico
Chad	Malaysia	Nicaragua
Comoros	Myanmar	Panama
Congo	New Caledonia	
Côte d'Ivoire	Papua New Guinea	***The Caribbean***
Dem. Rep. Congo (Zaire)	Philippines	Antigua and Barbuda
Equatorial Guinea	Samoa	Bahamas
Ethiopia	Singapore	Barbados
Gabon	Solomon Islands	Cuba
Gambia	Sri Lanka	Dominica
Ghana	Thailand	Dominican Republic
Guinea	Vanuatu	Grenada
Guinea-Bissau	Vietnam	Guadeloupe
Kenya		Haiti
Liberia		Jamaica
Madagascar		Martinique
Malawi		Puerto Rico
Mali		St. Kitts and Nevis
Mauritania		St. Lucia
Mauritius		St. Vincent and the Grenadines
Mozambique		Trinidad and Tobago
Namibia		

Table 1.1. (cont.)

Africa	Asia-Pacific	Latin America
Niger		***South America***
Nigeria		Bolivia
Réunion		Brazil
Rwanda		Colombia
Senegal		Ecuador
Seychelles		French Guinea
Sierra Leone		Guyana
Somalia		Paraguay
Sudan		Peru
Togo		Suriname
Uganda		Venezuela
United Rep. Tanzania		
Zambia		
Zimbabwe		

[a]Countries more than 50% of whose area falls between the tropic of Cancer and tropic of Capricorn. It must be noted that smaller parts of other countries also fall within the tropics.

1.3 The tropical forests

As per recent estimates (FAO, 2001b), about 47% of the world's total forests (1818 million ha out of 3870 million ha) lie in the tropics and 8% (323 million ha), in the subtropics, together making up 55% of the total. Of the tropical forests, the largest portion is in Latin America (52%), centred on the Amazon river basin; followed by Africa (28%), centred on the Congo river basin; and the rest in the Asia-Pacific (19%), where it is more scattered (Fig. 1.1).

1.3.1 Characteristics of tropical forests

In general, tropical forests are characterised by high species diversity, in comparison to temperate and boreal forests. The composition varies considerably across the tropics, mainly depending on the temperature and moisture regimes, the soil and the geological history. The richest in species are those in Latin America, followed by those in Asia-Pacific and Africa. Between these three regions, there is very little similarity in the tree species present, although there are some common genera and similarities at family level. Some plant families are unique to certain regions. For example, Dipterocarpaceae, an important family of timber-yielding trees, is characteristic of Asia-Pacific where they are particularly abundant in Southeast Asia (Indonesia, Malaysia, Philippines). Similarly, Australian forests (excluding rain forests) are dominated by the tree

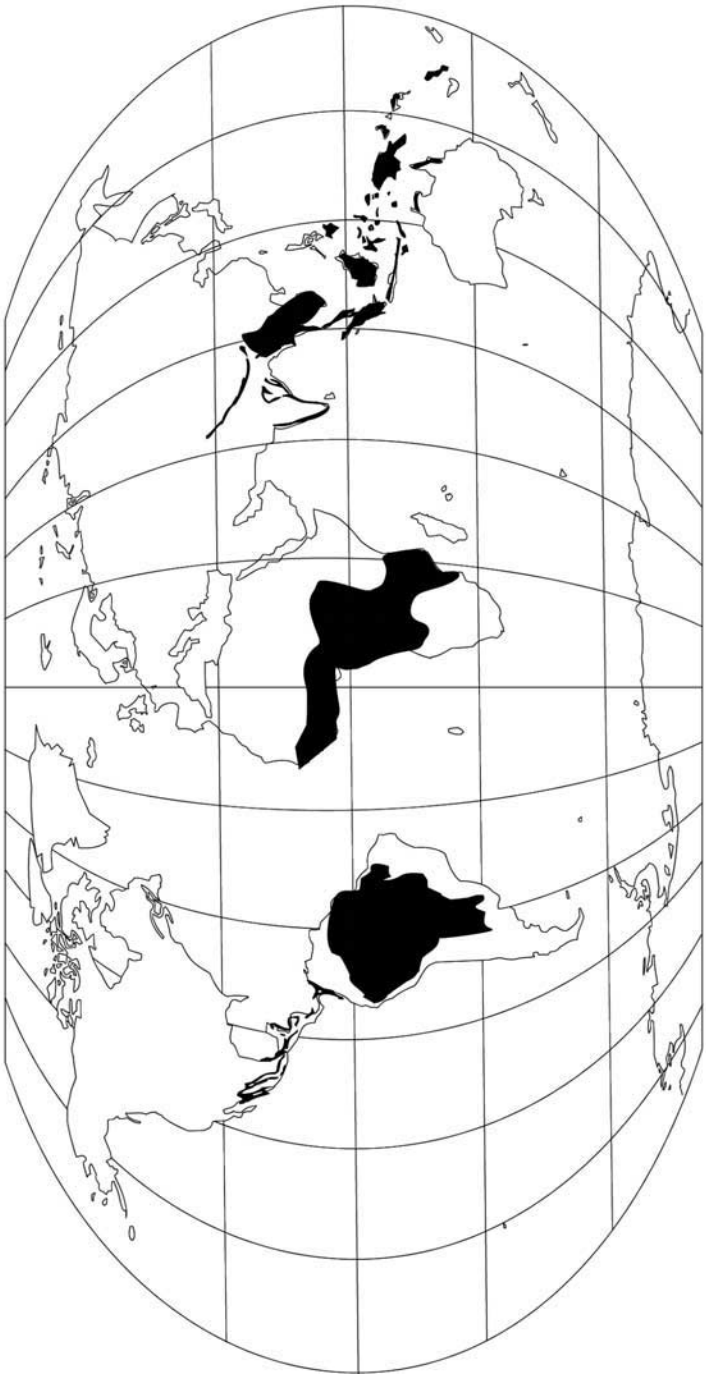

Fig. 1.1 Distribution of the world's tropical forests. The figure gives only a rough indication, as the scale does not permit depiction of small forest areas and the density of the forest cover is not represented. Based on FAO (2001b).

genus *Eucalyptus*. Africa is generally poor in flora. For instance, there are only four species of bamboos in mainland Africa (Whitmore, 1998), compared to 87 species in India alone within Asia-Pacific and about 1250 species worldwide. Africa is also characterised by the presence of savannas, plant communities dominated by grasses which may also contain scattered populations of trees that do not form a closed canopy. There are also differences within each region. For instance, within the Asia-Pacific, the natural distribution of teak is confined to two disconnected patches, one in peninsular India and the other covering most of Myanmar, northern Thailand and a small part of northwest Laos.

In spite of these differences between and within the tropical regions, in comparison to temperate forests, there are some broad features that can be considered as characteristic of tropical forests. These include high species diversity, year-round growth, existence of crown tiers, presence of lianas and understorey palms, development of buttresses on tree trunks and cauliflory (trunk-borne flowers). The major characteristic traits are discussed briefly below.

Species diversity

The diversity of life forms present in tropical forests, both of plants and animals, is staggering, and has not yet been fully scientifically documented. The number of species in a small spatial unit (generally one hectare or less) is usually referred to as 'alpha' diversity. It represents diversity within the community or local diversity, as compared to diversity among different communities on a larger spatial scale, referred to as 'gamma' diversity. The alpha diversity for tree species in tropical forests, particularly the tropical rain forests, is high. Typically, between 120 and 180 tree species (stems 10 cm or above in diameter) are present per ha in most tropical rain forest sites in the Far East (Whitmore, 1998). On the higher side, 307 tree species per ha were recorded at Cuyabeno in the western Amazon in Ecuador, while on the lower side, in Nigeria there may be only 23 per ha. Species numbers rise with increasing plot area. For example, 830 tree species were recorded in a 50-ha plot at Pasoh, Malaysia. Such high species diversity is in striking contrast to what is observed at higher latitudes.

In general, tree species diversity falls with increasing latitude (Fig. 1.2). Whitmore (1998) notes that the whole of Europe, north of the Alps and west of Russia has only 50 indigenous tree species and Eastern North America has only 171. Similarly Finland, a country with more than two-thirds of its land area under forest cover, lying between latitudes 60°N and 70°N in the boreal forest zone, has only 23 natural tree species in about 20 million ha of forest area, with Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*) and birch (*Betula pendula* and *B. pubescens*) accounting for 97% of the forest's growing stock (Hakkila, 1995).

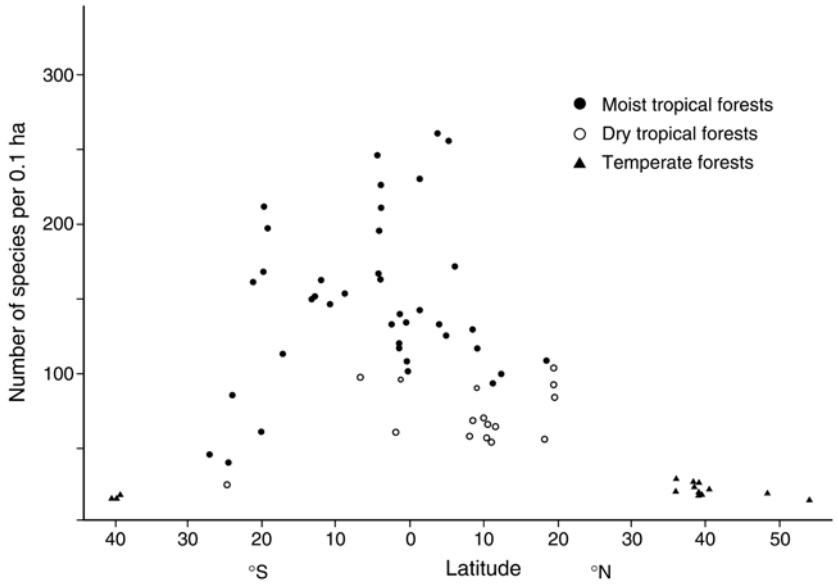

Fig. 1.2 Relationship between number of tree species and latitude. The number of tree species per standardized 0.1 ha plots at various latitudes is shown. Note that the species richness falls with increasing latitude on both sides of the equator. Reproduced, with slight modification, from *Annals of the Missouri Botanical Garden* (Gentry, 1988).

By comparison, the Kerala State in India, lying between latitudes 8°N and 13°N in the tropical zone, has 740 native tree species (Sasidharan, 1997) in about one million ha of forest. Gentry (1988) noted that in standardised 0.1 ha sample plots, temperate forests generally have 15–25 species, tropical dry forests 50–60 species and moist and wet tropical forests an average of about 150 species.

Some plant families like Myristicaceae are distributed only in the humid tropical climates while some others like Annonaceae, Musaceae and Ebenaceae are mostly concentrated there, with a few temperate outliers (Whitmore, 1998). The high species diversity of tropical forests is attributable mainly to environmental stability and possibly higher levels of speciation due to year-long biological activity. At higher latitudes, trees had to face great climatic variations during recurrent ice ages in the past and only a limited number of species were able to survive under such harsh conditions or recolonize from warmer areas.

Because of high species diversity, the number of individual stems of a species present per unit area (i.e. species density) is usually low. Often, the most abundant species do not make up more than 2.5% of all stems (He, Legendre and LaFrankie, cited by Kellman and Tackaberry, 1997) and many species are

present at a density of less than one tree per ha. For instance, a density of one mature tree per ha represents the upper limit of density for mahogany (*Swietenia macrophylla*) in Brazil although its density may vary widely between regions. Thus, one to two mature trees of *S. macrophylla* per ha have been recorded in Mexico, four to eight trees per ha in Venezuela and 20–60 in Bolivia (Mayhew and Newton, 1998). There are exceptions to the general trend of low species density of tropical forests. As we proceed along the moisture gradient from wet evergreen to dry deciduous tropical forests and along the temperature gradient from lower to higher latitudes, some species become more abundant and in some cases lead to monoculture-like stands, as in higher latitudes. For example, teak (*Tectona grandis*) may constitute 10% to nearly 100% of the tree species present in the moist to dry deciduous forests in different parts of India. Similarly, sal (*Shorea robusta*) often occurs in high density stands in central and northern India. Many other dipterocarp species also occur in high densities in lowland evergreen forests of Southeast Asia. Monocultures tend to develop when competing species are eliminated mainly by climatic factors. For example, the northern limit of natural teak in India is 25° N latitude, beyond which sal takes over, because teak seedlings, unlike sal, cannot survive frost. In Finland, pure stands of spruce develop in areas prone to harsh winters. In winters with heavy snowfall, the load of ice and snow on trees can be as much as 100–150 kg/m of stem. Spruce withstands the load, but pine and birch are easily broken (Hannelius and Kuusela, 1995). Snow thus promotes the development of pure spruce stands. Tree species diversity and density have implications for pest outbreaks, as will be discussed later.

Forest structure

In tropical forests, tree growth is luxuriant and the stand is usually dense. The stem density (trees 10 cm or above in diameter) has been estimated at 497.4 ± 135.0 per ha for tropical lowland evergreen forests (Meave and Kellman, cited by Kellman and Tackaberry, 1997). Woody lianas are common and a few monocots such as canes and reed bamboos are sometimes present. Trees often harbour ferns, aroids, orchids, mosses and lichens, their presence and density varying with the moisture regime. At least three crown layers can often be distinguished. The chief, middle layer, may be between 15 and 35 m above ground, depending on the forest subtype. The top layer is formed by dominant species whose crowns may reach up to 40–45 m. Usually these trees are buttressed at the base, have unbranched, cylindrical boles and possess an umbrella-shaped top crown. The bottom layer consists of shade-tolerant trees, less than 15 m in height. A 'profile diagram' is generally used to depict the vertical layering of the trees in tropical forests (Fig. 1.3). Stratification of

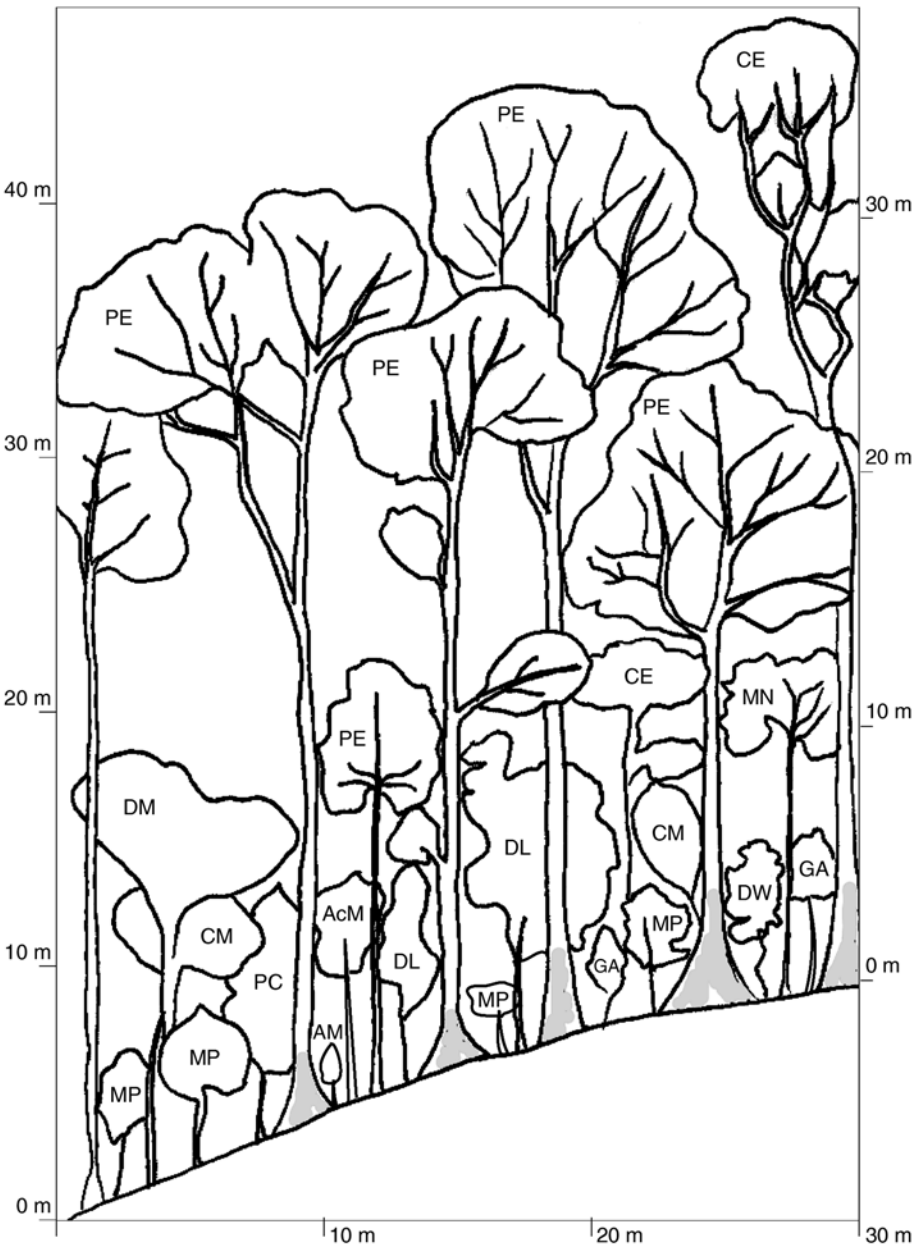

Fig. 1.3 Profile diagram of a tropical evergreen forest at Pothumala in Nelliampathy Forest Range, Kerala, India. Courtesy: U.M. Chandrashekara, Kerala Forest Research Institute.

AcM, *Actinodaphne malabarica*; AM, *Antidesma manasu*; CM, *Cinnamomum malabatrum*; CE, *Cullenia exarillata*; DL, *Dimocarpus longan*; DM, *Dysoxylum malabaricum*; DW, *Drypetes wightii*; GA, *Garcinia morella*; MN, *Mesua nagassarium*; MP, *Meiogyne pannosa*; PC, *Polyalthia coffeoides*; PE, *Palaquium ellipticum*