

(*Asteranthos*, *Gustavia*, *Grias*, *Allantoma*, and *Cariniana*). Fl. Neotrop. Monographs, vol. 21. New York: The New York Botanical Garden.

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Monsoon Forests (Southern and Southeast Asia)

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Introduction

Tropical forests are of two major types – rainforest and monsoon or seasonal forest, close to the equatorial region. Monsoon forests are also known as mixed forests, along the borders or part of tropical rainforests in southern and southeastern parts of Asia. The forest type is characterized by a dry period of 3–5 months, when plant growth is limited by water stress, whereas in typical tropical rainforests this phenomenon does not exist. In general, monsoon forests are more nanic in stature than typical rainforests and many tree species in the forest formation remain leafless during the dry season; this is otherwise known as deciduous species. Because of this, more sunlight reaches the understory, promoting the growth of rich heliophilous ground flora, in addition to several lianas. However, woody epiphytes are comparatively few in number in monsoon forests, compared to rainforests. The monsoon vegetation of South and Southeast Asia is subject to much degradation, especially due to fire in the drought season, as well as shifting cultivation and several other factors. In order to conserve the forest type and its bio-

diversity, protected areas have been established in almost all countries in the region.

Definition and Terminology

In the early twentieth century, based on climatic and vegetational parameters, monsoon forests were described as more or less deciduous or leafless during the dry season and tropophilous in nature, i.e., alternating in hygrophilous and xerophilous characters, regulated by the monsoon climate. In typical rainforest areas of the Asian continent there is evenly distributed and heavy rainfall throughout the year, whereas in certain countries within the continent (Cambodia, India, Myanmar, Sri Lanka, Thailand and Vietnam), rainfall is seasonal with an annual dry period of about 3–5 months. In those countries, monsoon forests are quite common, apart from the evergreen and semievergreen rainforests. Due to the dry period and consequent deciduous nature of many tree species constituting the upper story of the vegetation, the subcanopy flora is fairly rich with woody climbers, shrubs, and herbaceous ground flora. At the same time, because of the dry climate and the deciduous nature of the forest formation, monsoon forests are poor in biomass content as compared to rainforests. Monsoon forests are also subjected to seasonal fire, promoting the development of savannas or grasslands, containing thorny or unarmed, stunted trees and shrubs. Because of the complex nature of monsoon forests, they are also designated as mixed forests, and vegetation types like moist and dry deciduous forests, savannas, scrubs, and thorn forests all belong to this category. Often, tropical rainforests merge or penetrate into monsoon forest formations, especially along water courses and wet habitats and the continuity of the two forest types is also restricted by repeated fire, resulting in the formation of savannas, which separate the two forest types. Such extensions of rainforests into monsoon forests are called gallery forests. **Figure 1** shows different categories of tropical forests in South

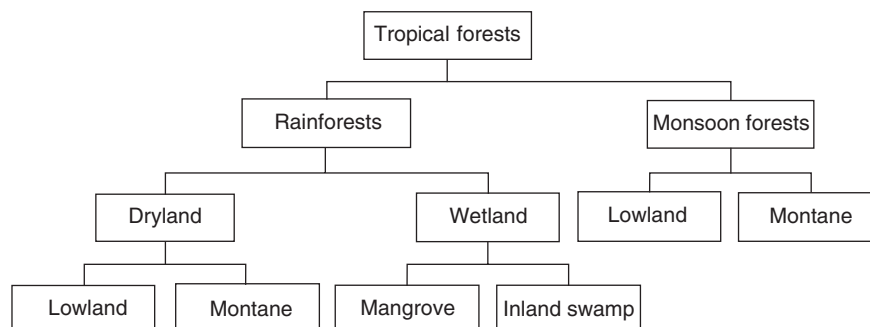


Figure 1 Categories of tropical forests in South and Southeast Asia.

and Southeast Asia. It may be noted that both rainforests and monsoon forests are distributed in lowlands and high mountains, and it is the climate which plays the major role in the development of the two different forest types within the same phyto-geographical region.

Based on the duration of the dry period, monsoon forests may be open-canopy deciduous woodlands, closed-canopy thorn forests, scrubs, grasslands, or desert formations. Within the forest type, there are also different localized formations, varying in physiognomy and species composition, depending mainly upon soil, topography, and climate.

Monsoon Forest Environment

In tropical South and Southeast Asia, monsoon forests are mostly developed in rain shadow areas where there is seasonal drought for 3–5 months. During this period, average rainfall seldom exceeds 100 mm and, consequently, dry-weather conditions prevail there. As a result, the vegetation becomes tropophilous in character with deciduous and thorny plants dominating the formation. There are also local variations in monsoon climate. In Myanmar, the forest formation is distributed in areas receiving 400–800 mm rainfall; wherever precipitation exceeds 800 mm, rainforests are more common.

The soil types harboring the monsoon forests differ in different countries of the region. In peninsular

India, they are developed in loamy, rocky, and similar uncharacteristic soil types, poor in nutrient content and water retention. However, in the north-eastern part of the country and also Bangladesh, sal *Shorea robusta* – dominated forests are common in alluvial soils along the deltas. In Cambodia, Laos, Myanmar, and Vietnam, both alluvial and dry and rocky soils harbor the vegetation type. In China and Southeast Asian countries (e.g., the Philippines), the forest formation is more common on limestone soils, as in the case of China.

Distribution and Extent of Monsoon Forests

In South and Southeast Asia, monsoon forests are distributed in Bangladesh, Cambodia, China, India, Indonesia, Laos, Myanmar, Philippines, Sri Lanka, Thailand, and Vietnam (Figure 2). The estimated area occupied by this forest type in different countries and the percentage of the area of total forest cover are given in Table 1. Brunei, Java, Kalimantan, Peninsular Malaysia, Sabah, Sarawak, Singapore, Sumatra, and Taiwan, do not have significant areas of monsoon forests. Among the different countries with monsoon forests, Sri Lanka has the greatest percentage (88%) of total forest area. This is followed by India (70%), China (66%), Cambodia (42%), and Vietnam (34%). Indonesia is predominantly under rainforest with less than 3% of total forest area classified as monsoon

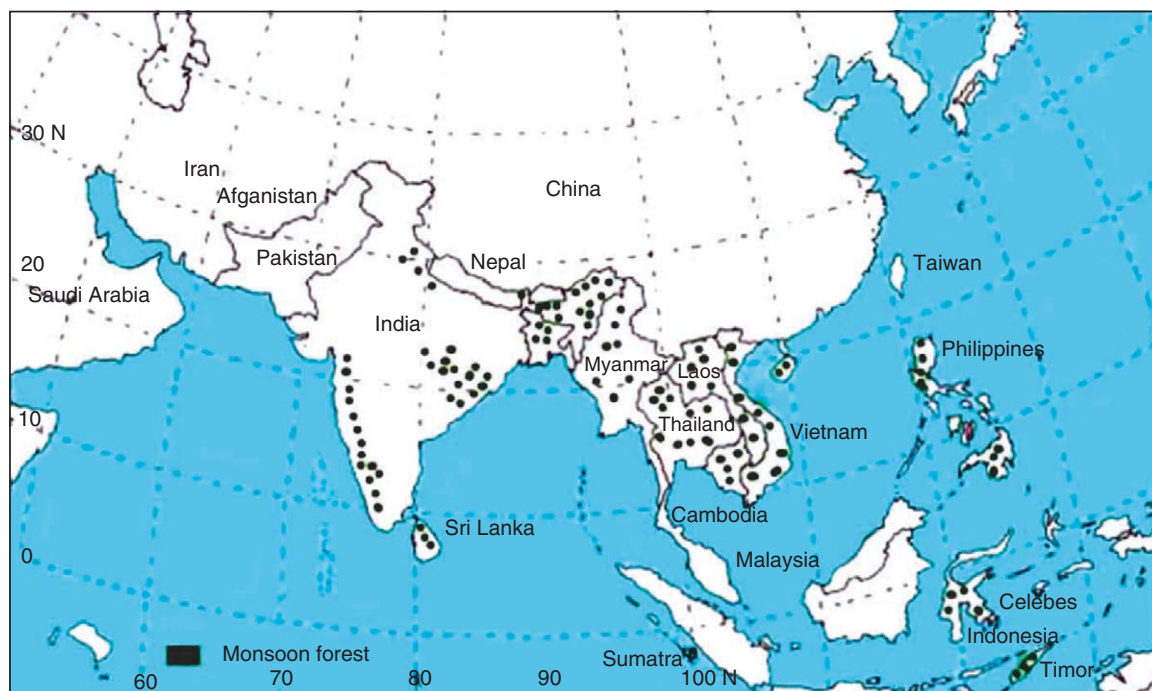


Figure 2 Distribution of monsoon forests in South and Southeast Asia.

Table 1 Total forest area, monsoon forest area and its percentage in different South and Southeast Asian countries

Country	Total forest area (km ²)	Monsoon forest area (km ²)	Percentage
Bangladesh	14 042	645	4.6
Cambodia	113 250	47 750	42.16
China	24 200	17 050	70.5
India	228 330	158 950	69.6
Western Ghats	38 610	18 410	47.6
NE India	82 490	38 780	47.0
Andaman and Nicobar Islands	6 840	3 620	52.9
Other parts	100 390	98 140	97.8
Indonesia	1 179 140	30 740	2.8
Lesser Sunda Islands	14 590	13 690	93.8
Sulawesi	11 240	8 120	72.2
Moluccas	56 070	8 930	15.9
Laos	124 600	25 810	20.7
Myanmar	311 850	88 460	13.4
Philippines	66 020	15 280	23.1
Sri Lanka	12 260	10 820	88.3
Thailand	106 900	31 500	29.5
Vietnam	5 680	19 510	34.4

forest. This is because Java, Kalimantan, and Sumatra, are devoid of this forest type, even though about 90% of the total forest area of the Lesser Sunda Islands is covered by monsoon vegetation. With regard to China, even though 70% of the total forest area of the country is occupied by monsoon vegetation, only a very limited part of it is located in South Asia. In the case of Bangladesh, mangrove forests are well represented, with approximately 4.6% of the total forest area occupied by the much-degraded monsoon vegetation. The Pacific island of Papua New Guinea, beyond the limit of Southeast Asia, is also very poor in representation of monsoon forests, with less than 1% of the total forest area of the country belonging to this vegetation type. On the whole, approximately 57% of the total forest area in different countries of South and Southeast Asia comprises monsoon forests.

In Sri Lanka in the Indian Ocean, more than 88% of total forest area is occupied by monsoon forests. Tropical rainforests of the evergreen and semievergreen types, common in neighboring peninsular India, are rather restricted to the southwest corner of the island, where annual rainfall ranges between 4000 and 5000 mm and the altitude exceeds 1000 m above msl. The monsoon vegetation of Sri Lanka is distributed in the northern, northwestern, and eastern rain shadow parts of the country (Figure 3). Degraded thorn and scrub forests are common here. Human interventions in the forest area have drastically transformed the original vegetation of the country and the establishment of tea plantations is one of the major reasons for this. Remnants of mangrove forests are also represented in the island (about 10% of the total forest area).

**Figure 3** Distribution of monsoon forests in Sri Lanka.

Southern and northeastern parts of India and the Andaman and Nicobar Islands contain monsoon forests, often sharing or merging their borders with the rainforests (Figure 4). In peninsular India, monsoon forests are distributed along both the western margins and eastern side of the Western Ghats, where rainfall is very meager or absent for a few

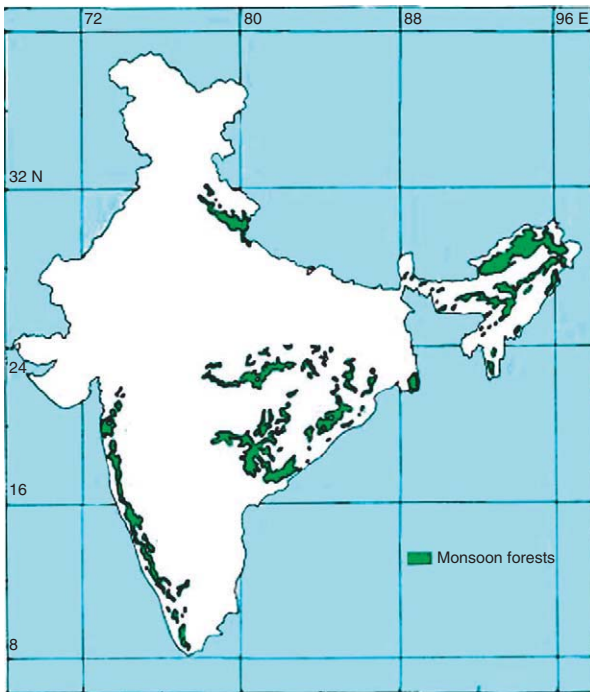


Figure 4 Distribution of monsoon forests in mainland India.

months. In the northeastern part of the country, bordering Bangladesh and Myanmar, monsoon sal forests are common, often restricted or degraded by the Jhum or shifting cultivation. In the case of the monsoon forests of the southern part of India, degradation is taking place mainly due to encroachments and conversion of forest areas for nonforestry purposes, as well as the unregulated exploitation of timber and nontimber resources, of both plant and animal origin. The monsoon forests of Bangladesh are a continuation of the forest type in northeastern India and are restricted to the inland plains of the country, mainly distributed in the Madhupur tract. Also, relicts of the forest type occur in Dhaka, Mymensingh, and Tarigail forest tracts in the northern part of the country. Sal forests dominated by *Shorea robusta* trees characterize the vegetation type in Bangladesh, which at present is in a highly degraded condition. The major forest type of the country is the Mangals (mangrove forests), distributed along the estuaries and seashores.

Rainforests dominate the vegetation types of Myanmar, distributed along the west-facing slopes of the south–north running mountains, in the western and eastern frontiers of the country, either as evergreen or semievergreen formations. In the rain shadow Irrawaddy plains, on the western side of Myanmar, the characteristic vegetation type is dry deciduous woodlands, dominated by dipterocarp trees, interspersed by thorn forests. Surrounding this

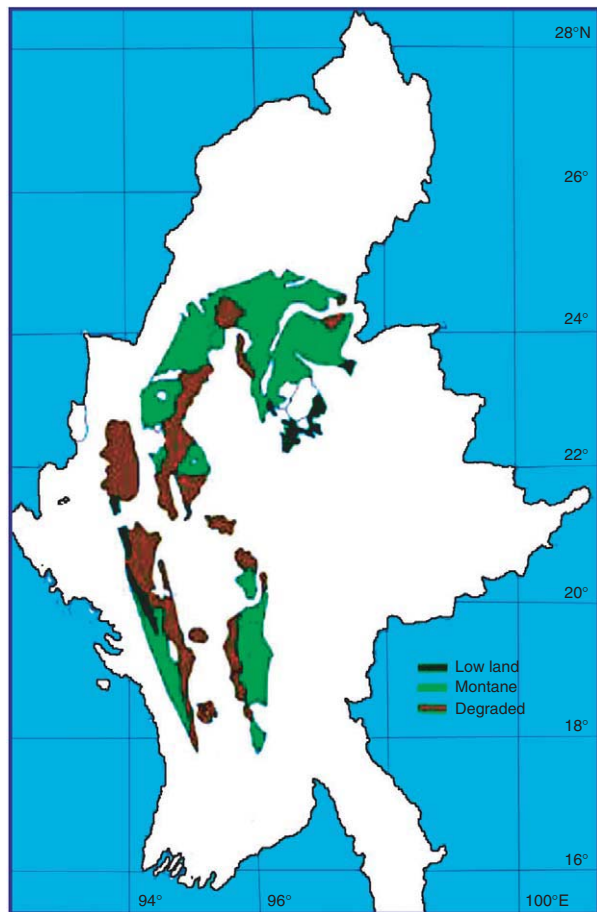


Figure 5 Distribution of monsoon forests in Myanmar.

zone, monsoon forests are distributed along the eastern flanks of Arakan Yoma and the Chin Hills (Figure 5). In the Shan Plateau also, the forest type is distributed towards the east of Salween and towards the south, covering the hills bordering Thailand. Adjoining Myanmar, in the southern part of the mainland of the People's Republic of China, monsoon forests are distributed in areas of limestone substratum, in southern Guangxi. The Island of Taiwan close to the Chinese mainland is devoid of monsoon forests and rainforests are quite prevalent there. However, in the island of Hainan, within the South Asian region, monsoon forests are well represented. Moreover, approximately 70% of the total forest area of China is comprised of monsoon forests; the remaining 30% is composed of lowland and montane rainforests (Figure 6). However, most of the monsoon forest areas of mainland China fall in central Asia and not in the southern part of the continent.

In Indochina, along the eastern side of the Mekong river and in the northern part of Tonle Sap, extending to the border of Thailand and the Laos PDR, monsoon forests are distributed in

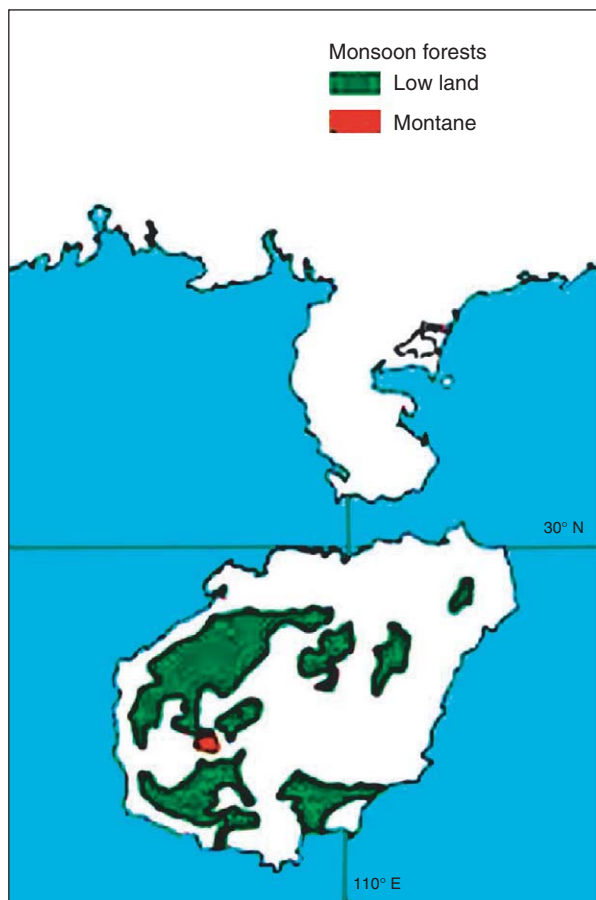


Figure 6 Distribution of monsoon forests in Hainan (PR China).

Cambodia (Figure 7). A variety of dense, dry, deciduous and semideciduous woodlands represents the forest formation of the country. The monsoon forests of Cambodia are in a badly devastated and degraded state due to shifting agriculture and fire which transformed the vegetation into open savannas and woodlands. In Laos PDR, monsoon forests are distributed in areas north and west of Mekong and are characterized by the dominance of teak trees of high timber value (Figure 8). In the past, more than 50 000 km² of the forest area of the country was occupied by monsoon forests, covering the drier parts where 5–6 months of dry weather prevail. However, more than 70% of the natural forests of Laos are constituted by rainforests of both evergreen and semievergreen types which, in many areas, are replaced by monsoon forests due to human and other disturbances, including shifting cultivation. In Vietnam, dipterocarp-dominated lowland evergreen forests are more common in the southern parts of the country, whereas monsoon forests are distributed towards its northern side (Figure 9). Almost 45% of the total forest area of Vietnam comprises monsoon forests, where deforestation is a serious problem

consequent to migration of people, plantation forestry, and war damage. The rich mangrove wealth of the country, including the *Melaleuca* forests, was also devastated during the much-prolonged Vietnam war and only their remnants remain at present, along the banks of the Red river. Application of the devastating herbicide Agent Orange was highly detrimental to the natural forests of the country, for both mangroves and land vegetation.

Towards the southeastern part of the Asian continent, namely Thailand, monsoon forests are common in the northern parts, bordering Myanmar. However, the adjoining peninsular Malaysian region is predominantly covered by typical rainforests of both evergreen and semievergreen types. At present, the monsoon teak forests of Thailand are in a highly degraded condition (Figure 10). Dry deciduous woodlands with species of dipterocarp also occur in the northern and eastern parts of the country. Heath forests, limestone vegetation, freshwater swamps, and beach forests are other vegetation types of Thailand, apart from the complex and very varied montane rainforests, dominated by genera of temperate plants like *Castanopsis*, *Lithocarpus*, and *Quercus*. The Himalayan species *Betula alnoides* is also common in the rainforests of Thailand.

In the Lesser Sundas, Sulawesi and Malacca near to Irian Jaya, which is the southeastern limit of the Asian continent, about 30 000 km² of monsoon forests are distributed. However, in Java, Kalimantan, Sumatra, and also Irian Jaya, the forest type is not very prevalent. In the northeastern part of Java, monsoon forests were seen in the past, in a highly disturbed state. In the Lesser Sunda Islands, monsoon forests and grasslands are restricted to the south-facing sides of the mountain, where sandalwood (*santalum album*) forests are common, similar to that of the dry deciduous forest tracts of southern peninsular India (Figure 11). In Sulawesi, the forest type is fairly well represented in the southern part and in Irian Jaya eucalyptus forests and grasslands are more common. Beyond the Southeast Asian limit, in the Pacific Islands of Papua New Guinea, less than 1% of the total forest area is occupied by the monsoon forests; this is the eastern limit of the forest type of the world. In the chain of the Philippine islands, the northernmost Luzon Island contains monsoon forests along the centrally located Mount Data, running in a north–south direction. Also, in Zambales, along the Carapello mountains, towards the western side of the island, disturbed patches of this forest type occur. In southernmost Mindanao also, degraded monsoon forest patches are common towards its western side (Figure 12). Both lowland and montane types of forest formations are common

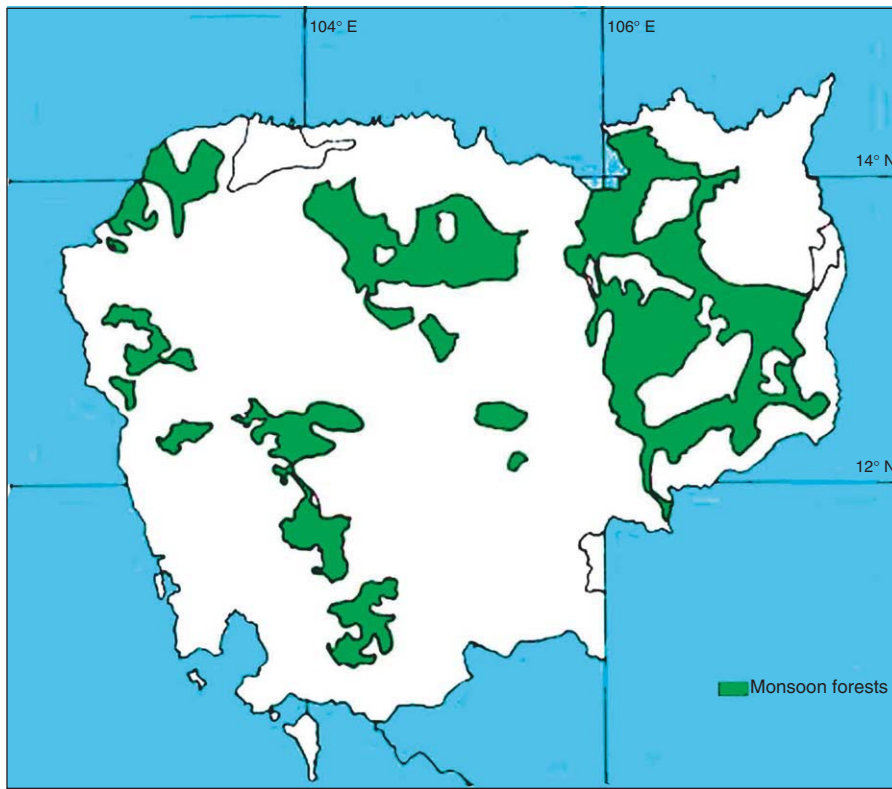


Figure 7 Distribution of monsoon forests in Cambodia.



Figure 8 Distribution of monsoon forests in Laos.

in these islands, dominated by two species of pine (*Pinus kesiya* and *P. menkusii*). Forests of Molave are also, in general, monsoon formations, developed in well-drained limestone soil, behind the beach or

mangrove formations. The forest type here is characterized by the preponderance of *Vitex* trees belonging to the teak family (Verbenaceae).

Structure and Composition of Monsoon Forests

In South and Southeast Asia, both lowland and montane monsoon forests occur. Also, there are different local formations within the forest type, depending on topography, climate, and soil. The structural and floristic composition of the monsoon forests of South and Southeast Asia differs greatly from the adjoining rainforests of the region. If lofty trees of dipterocarps dominate the rainforests of Southeast Asia, this type of tall tree is less frequent and more stunted in nature in the monsoon forests there. The typical tree species in the monsoon forests of Southeast Asia belong to genera such as *Acacia*, *Albizia*, *Borassus*, *Butea*, *Caesalpinia*, *Cassia*, *Corypha*, *Dalbergia*, *Dichrostachys*, *Feronia*, *Garuga*, *Homalium*, *Lannea*, *Melia*, *Schleichera*, *Stereospermum*, *Tectona*, and *Tetrameles*. Australian plants, including species of *Banksia*, *Eucalyptus*, and *Grevillea*, are also common in the monsoon forests of the Lesser Sunda Islands. *Santalum album* and *Melaleuca leucodendron* are other Australian elements found

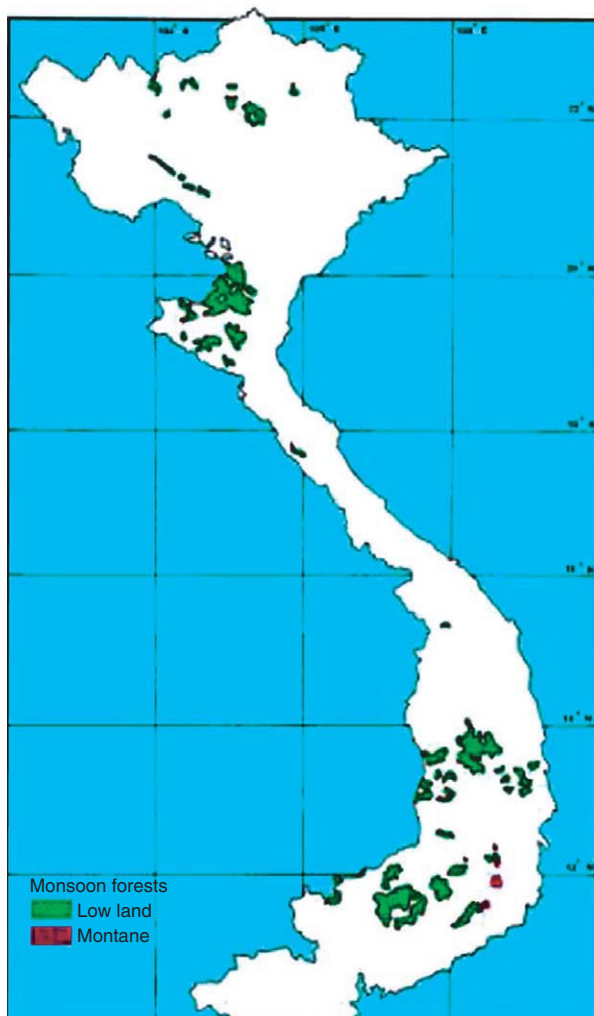


Figure 9 Distribution of monsoon forests in Vietnam.

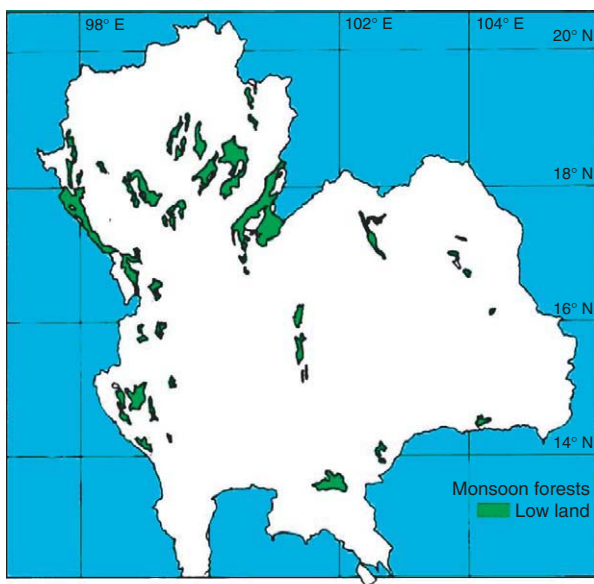


Figure 10 Distribution of monsoon forests in Thailand.

in the monsoon forests of the Lesser Sunda Islands and the former is also common in peninsular India. There are also several endemic species in the monsoon forests, e.g., species of *Semicardium* in Malaysia and *Dalbergia* in peninsular India. However, many plants in the monsoon forests in South and Southeast Asia enjoy wider ranges of distribution from India to Australia or even beyond, as in the case of the tamarind tree (*Tamarindus indica*), distributed in both African and Asian continents. In the monsoon forests of the region, there are also plant species which prefer wet conditions, e.g., fern species belonging to the genera *Dicranopteris* and *Gleichenia*, and the moss flora on the mountains clothed with monsoon forests. However, drought-resistant species dominate the forest type and, apart from the cultivated sugarcane which needs only seasonal dryness, several drought-hardy members of the family Fabaceae are quite prevalent in the forest formation. Due to the highly fragmented nature of monsoon forests, stemming from climatic and degradation factors, many plant groups characteristic of the forest type show regional or national breaks in their total range of distribution, resulting in the phenomenon called disjunctive distribution. For the same reason, many endemic plants are also common in the forest type. Extensions of many species beyond their regional range is mainly due to the fact that the forest type itself was of much greater extent in the past, favoring the distribution of xerophytic plants between countries or regions such as India in South Asia and Indonesia in the southeastern part of the region. Euphorbiaceous plants (e.g., species of *Blackia*, *Melanolepis*, and *Phyllanthus*) are also common in the seasonal dry parts of Southeast Asia, including Kalimantan. Therefore seasonal drought is one of the major factors that influence the distribution of plants, especially those species characteristic of the monsoon forests.

In South Asia, moist deciduous forests are prevalent in India, especially in the northeastern and peninsular regions. The forest type is also common in Myanmar, western Thailand, and in the central part of the Philippines. The formation has its characteristic teak (*Tectona grandis*) trees in Myanmar and Thailand, in association with species of *Lagerstroemia*, *Pterocarpus*, and *Terminalia*. In Myanmar, depending on the altitude, upper moist deciduous forests are identified on the flat plains above flood level, composed of species like *Homalium tomentosum*, *Tectona grandis*, and *Xylia dolabriformis*. The lower-level moist deciduous forests of the country, developed in rich soils, are in a devastated state, mainly due to the cultivation of paddy (rice). Unlike the upper moist deciduous forests, low-level



Figure 11 Distribution of monsoon forests in Lesser Sunda Islands and adjacent islands (Indonesia and East Junor).

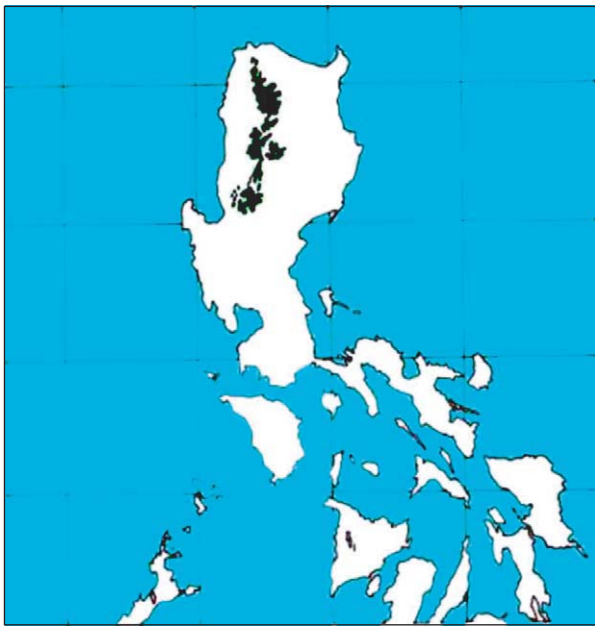


Figure 12 Distribution of monsoon forests in the Philippines.

monsoon forests, in general, are devoid of bamboo species, even though the climbing bamboo *Oxytenanthera* is common to both formations. In the southern part of Myanmar, moist deciduous riverine forests and moist clay-soil forests of quite different floristic compositions are distributed. In the Indian subcontinent and Sri Lanka, moist deciduous forests dominate all other monsoon forest types, even though, in Bangladesh, mangrove forests are more widely distributed. Teak forest is a very notable formation of the monsoon forest type, which is very important economically, because of the timber value of the dominant species. Teak forests are also quite prevalent in the central part of India, whereas, towards the peninsular and North-eastern part of the country, the representation of the species is much less (Figures 13 and 14). The *Albizia-Xylia-Pterocarpus* association is more common in the south

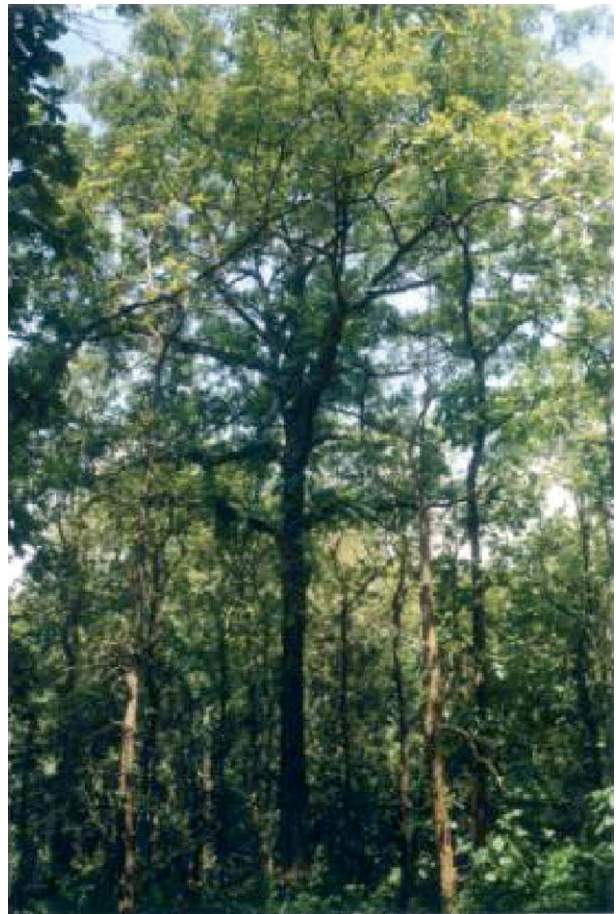


Figure 13 Moist deciduous forests of India.

and *Shorea-Schima* trees are quite prevalent in the northeastern parts of the country. In the Andaman Islands, it is the *Pterocarpus-Terminalia-Canarium* association that is characteristic of the monsoon forests. In Sri Lanka, dry-zone evergreen forests are widespread and these are also found in the eastern part of the Deccan peninsula (India), in fragments. In southeastern Indochina, species of *Chloroxylon*, *Drypetes*, *Feronia*, and *Manilkara*, dominate the

monsoon forests with associated scrub composed of species of *Bauhinia*, *Cassia*, and *Dichrostachys*. *Acacia* thorn scrub is also common there, in heavily disturbed areas. The monsoon forests of Sri Lanka are also characterized by a high degree of endemism and is the major habitat of the Asian elephant.



Figure 14 Buttressed trees in monsoon forests.

However, more than 75% of the forest type of the island is in a highly degraded state, and a network of protected areas has been established to preserve the forest formation and its biodiversity.

Biodiversity, Endemism, and Conservation

South and Southeast Asian countries are very rich in biodiversity and endemism. They are also the centers of origin of many cultivated plants and domesticated animals. Forests of the region contain gigantic trees like dipterocarps and terminalias on the one hand and rich and diverse shrub and herbaceous ground flora on the other. Reputed timber trees such as teak, rosewood, and sal, medicinal and other nontimber forest produce plants of arborescent or herbaceous habit, while plants yielding paper and handicraft raw material including bamboos and canes, horticultural plants like orchids and ferns, epiphytic species of both flowering and nonflowering plant groups, creepers, herbaceous and woody climbers form part of the forest type in the region. The Asian elephant, lion, tiger, panther, mountain goat, monkeys, birds, insects, reptiles, and thousands of other terrestrial and arboreal fauna represent the rich and diverse faunal heritage of the monsoon forests of the region. In South and Southeast Asia, India, Indochina, and Malesia are the main biodiversity-rich regions, and specific floristic and faunistic accounts are also available for almost all the countries in the region.

There are no separate estimates available on the biodiversity of the different ecosystems (monsoon forests, rainforests, and savannahs) in the region. **Table 2** gives details of total numbers of plant and animal species in different countries of South and Southeast Asia and also which are threatened with extinction or genetic impoverishment. It may be

Table 2 Total and endangered plant and animal species in different countries of South and Southeast Asia

Country	Plants		Animals	
	Total	Endangered ^a	Total	Endangered ^a
Bangladesh				
Cambodia	770	0	1334	41
India	15 000	3120	4735	172
Indonesia	11 217	184	6359	416
Laos	347	1	2487	57
Malaysia	12 082	371	3215	76
Myanmar	2211	6	2935	75
Philippines	8481	320	2531	135
Sri Lanka	7456		3658	
Thailand	3497	355	3705	79
Vietnam	1130	297	3155	85
Total	62 191	4654	34 114	1136

^aEndangered implies threatened with extinction or genetic erosion and impoverishment.

Table 3 Details of protected areas in different countries of South and Southeast Asia

Country	Total area (km ²)	Protected area (km ²)	Annual deforestation percentage
Bangladesh	13 570	688	
Cambodia	181 000	32 671	1
India	3 268 090	49 434	
Indonesia	1 919 445	345 118	0.7
Laos	236 725	27 563	1
Malaysia	332 965	15 274	1.2
Myanmar	678 030	1735	0.3
Philippines	300 000	14 540	1.5
Sri Lanka	64 740	8193	
Thailand	514 000	70 711	2.5
Vietnam	329 565	9951	1.2

noted here that all the animal and plant groups are not covered in such estimates; angiosperms among plants, and amphibians, birds, fishes, mammals, and reptiles, among animals are the groups on which more exhaustive data are available for most countries in the region. Moreover, such estimates do not reflect the actual species content of the monsoon forests *per se*, and the data given in **Table 2** provide only an overall picture with regard to the biodiversity status of different South and Southeast Asian countries.

Due to various disturbances to the ecosystem and the habitats of species in the region, several plant and animal taxa, and especially those confined to one country, phytogeographical region or ecological niche, are now listed in one of the threatened categories such as rare, endangered, threatened, or vulnerable recognized by various national and international institutions. In **Table 2**, country-wise details on the representation of such taxa in the region are given and many more such species are likely to be added to the list, once their population status is assessed. It may be noted that monsoon forests of the region, rich in timber and nontimber plants and edible and game animals, have suffered the greatest loss in biodiversity, mainly due to the proximity and accessibility of the forest type to human habitations and suitability of the area for agriculture and plantation establishment, as well as from fire and other natural and anthropogenic causes. Also, the food and other habits of people living in the region have influenced the conservation status of the floral and faunal wealth of the region. In order to protect biodiversity, countries in South and Southeast Asia have established conservation areas like wildlife sanctuaries, national parks, biosphere reserves, World Heritage Sites, Ramsar sites, Man and Biosphere sites. Details of the extent of protected areas in relation to the total forest area of different countries in the region are given in **Table 3**. Also, the annual deforestation data given for various countries indicate the pace of loss in biodiversity. Available

data point to the fact that deforestation is occurring faster in Laos, Philippines, Thailand, and Vietnam than in Cambodia, Indonesia, and Myanmar, all of which are neighboring countries. Moreover, in the South Asian countries of Bangladesh, India, and Sri Lanka, the deforestation rate will be greater due to various factors, including increases in population and the consequent escalation in demand for land, plant, and animal resources.

The International Union for the Conservation of Nature and Natural Resources (IUCN) has prepared *The Red Data Book* on plant and animal species throughout the world, identifying those belonging to different threatened categories. This is mainly intended to promote a conservation program for such species in order to save them from total extinction. Also, the protected-area network in South and Southeast Asian countries, established in representative ecosystems, including the monsoon forests, can facilitate the preservation of dwindling populations of many such species, in addition to the overall conservation of the ecosystem.

See also: **Biodiversity:** Endangered Species of Trees. **Ecology:** Human Influences on Tropical Forest Wildlife. **Health and Protection:** Forest Fires (Prediction, Prevention, Preparedness and Suppression). **Tropical Ecosystems:** *Ficus* spp. (and other important Moraceae); Acacias; Dipterocarps; Mangroves; Teak and other Verbenaceae. **Tropical Forests:** Combretaceae; Tropical Dry Forests; Tropical Moist Forests; Tropical Montane Forests; Woody Legumes (excluding Acacias).

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Myristicaceae

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Introduction

The Myristicaceae is a pantropical family of trees found in Central and South America, Africa, Madagascar, India, and Asia. The family consists of 20 genera and at least 500 species. Floristic and ecological studies have revealed that the Myristicaceae rank among the top five to ten most common and important tree families throughout the majority of the lowland moist tropical forests of the world, where the family has significant ecological

importance. Fruit of the Myristicaceae, particularly the lipid-rich aril surrounding the seed in some species, are important as food for birds and mammals of tropical forests. Numerous species are valued by humans as sources of food, medicine, narcotics, and timber, including *Myristica fragrans*, the source of nutmeg and mace, the spices of commerce.

Throughout the geographical range of Myristicaceae, aromatic leaves, often stellate pubescence, a unique arborescent architecture (Figure 1), and sap the color of blood (Figure 2) are characteristics that strongly enhance recognition of this family in the field. Species of this family are usually dioecious. Flowers are tiny and found in panicle inflorescences, with filaments of stamens fused into a column, giving rise to either free or fused anthers (Figures 3 and 4). Fruits are one-seeded, dehiscent or indehiscent, and are notable for the typically red arillate covering around the seed.

Taxonomy and Genetics

There are about 500 species of Myristicaceae in 20 genera, restricted to individual continents (Table 1). Nutmeg trees first appeared in the earliest botanical works dealing with the East Asian region, and in 1742 Linnaeus established the genus *Myristica*, which remained a broad concept and the only genus in the family until 1856. Warburg produced the first

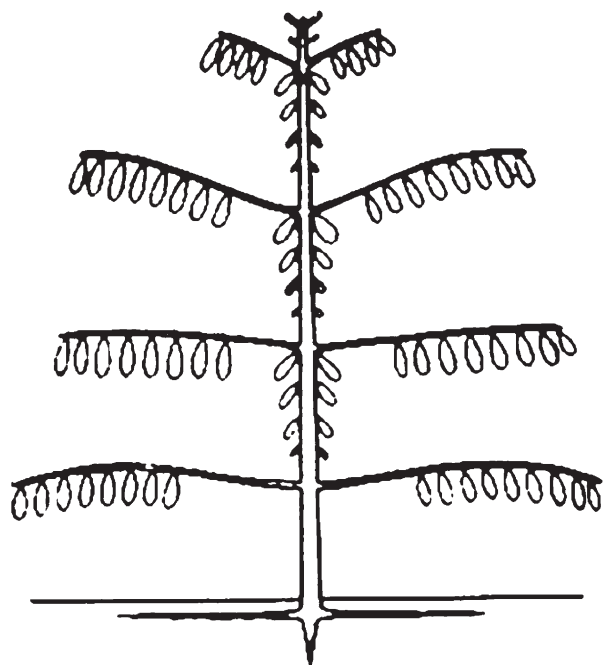


Figure 1 Massart model of tree architecture typical of the Myristicaceae. Modified with permission from Hallé F, Oldeman RAA, and Tomlinson PB (1978) *Tropical Trees and Forests: An Architectural Analysis*. Berlin: Springer-Verlag.