

RAIN FORESTS: FLORISTICS

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Summary

The tropical rain forest is well-known for its megadiversity and some important ecological services, especially on climate regulation. This forest type occurs in all four major tropical zones (America, Africa, Indo-Malaya and Australia) and covers about seven percent of the Earth's forest area. Floristic composition varies largely within and among the main phytogeographic regions. However, some distinctive characteristics can be emphasized on family distribution such as the dominance of Dipterocarpaceae in

western Malaysia and species richness of Lecythidaceae in America. In general, tropical forests show higher species richness when disturbance is at an intermediate intensity or frequency. On the other hand, monodominant forests can occur when small but frequent disturbances take place or after long periods without any relevant disturbance. Early studies associated low species diversity with low soil nutrient availability, but there is still controversy in this respect. However, chemical fertility and soil moisture are among the factors which have been considered important determinants of species richness in tropical forests. Although tropical forest provides important services to natural systems and humankind, it still suffers severe deforestation in most tropical countries.

1. Introduction

Forests cover ~ 42 million km² of the Earth's land surface, which only about 7 percent are within tropical regions. However, tropical forests, and especially the tropical rain forests, are extremely important for regulation of global weather and, therefore, of human existence as highlighted by the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity. Estimates are that more than 50% of all the Earth species live in tropical rain forests. Thus, they are a natural reservoir of **genetic diversity** that offers a myriad of useful forest products. Despite their obvious importance, every year thousands of hectares are destroyed worldwide. Most of the world's remaining tropical rain forests are located in developing nations and financial return on timber and farming is crucial for human survival in many such nations.

Tropical rain forests across the world are very diverse, but share several basic characteristics. They are limited between the Tropic of Capricorn and Tropic of Cancer and, because of the high solar energy in this region, tropical rain forests are usually warm year round with temperatures about 22-34° C. However, forests at higher elevations can be significantly cooler. Temperature may fluctuate slightly during the year, which in equatorial forests is almost imperceptible. As tropical rain forests lie in the intertropical convergence zone, they are subjected to heavy rainfalls: at least 2,000 mm of rain, and in some areas more than 10,290 mm per year. In equatorial regions, some forests do not show precise "wet" or "dry" seasons, although many forests do have seasonal rains. Even dry periods are usually not long enough to completely dry out leaf litter. The usually constant cloud cover is enough to keep the air moist and prevent plant desiccation.

A **primary or mature tropical forest** often has several layers and three tree strata. The top layer or upper storey (overstory) is formed by emergent trees that consist of scattered tall trees that have most of their foliage fully above a closed canopy layer formed by the crowns of other trees. The middle storey, or canopy, is the stratum where most of the flowering and fruiting of the trees take place. A third layer (lower storey or understory) is formed by smaller trees whose crowns do not meet. Immediately underneath this stratum one finds the shrubby layer, formed by woody and herbaceous shrubs, and the ground layer (or forest floor), which is the darkest layer where scattered herbaceous plants and **seedlings** of tree species are found.

2. Global Distribution and Main Features of Tropical Rain Forests

The global distribution of tropical rain forests can be broken up into four biogeographic realms: the Neotropics (northern South America and Central America), the Afrotropics (equatorial Africa), the Indo-Malayan (parts of the Indian subcontinent and Southeast Asia, and tropical islands of the Pacific Ocean), and the Australasian (eastern Indonesia, New Guinea, northern and eastern Australia). Formerly the Australasian rain forest has been considered an extension of the Indo-Malayan, and for the purpose of comparison done in this present chapter we will treat both together.

2.1. The Neotropical Rain Forest

There are three major blocks of rain forest in **Neotropical** realms: the largest one is located in the Amazon River Basin in South America, a second one along the Brazilian coastline, the so-called Atlantic Forest, and a third block covers the Andes on the Pacific coast extending through to Central America. The Neotropical rain forest is consistently more species rich than the African, Indo-Malayan and Australian rain forest.

The rain forest in the Amazon Basin is known as the Amazon Forest. It occupies seven million square kilometers which represent over half of the Earth's remaining rain forests. As the largest area of tropical rain forest, the Amazon Forest has unparalleled biodiversity. It is located within nine nations: Brazil (with major total area, 60%), Colombia, Peru, Venezuela, Ecuador, Bolivia, Guyana, Suriname, and French Guiana. Due to its vast extent area, several different vegetation types might be distinguished, which are often related to the flooding pulses of the main rivers at the Amazon basin. The Amazon River is the largest river in terms of discharge and the second longest river in the world after the Nile. Unfortunately, currently the Amazon Forest suffers the highest rate of deforestation associated with land use change especially for agriculture expansion (pasture and soybean), commercial logging and settlements. Deforestation is likely to be the main factor implying in biodiversity loss. There are also concerns about the releases of the carbon contained within the vegetation, which contributes to global warming.

The Amazon Forest has an extensive border with the *cerrado* (savanna woodland) and *caatinga* (dry deciduous forest) vegetation types in Brazil, which separates it from the Atlantic Forest. The Atlantic Forest originally extends along much of the Brazilian coast, forming a narrow strip between the ocean and the Brazilian drylands (*cerrado*, *caatinga*). While the Amazon Forest lies at more or less the same latitude and altitude, the Atlantic Forest spreads dramatically from the coast up into the mountains, and throughout several latitudinal zones, which confers great variation in temperature and precipitation rates. Thus, under the "Atlantic Forest" label many forest types can be found (e.g. evergreen forest, semi-deciduous forest, montane forest). The mangrove forests found in estuaries, bays and lagoons, and the xeromorphic coastal sandy plain vegetation, locally called *restingas*, are ecosystems associated to the Atlantic Forest. However, less than 10 percent of the Atlantic Forest remains intact.

The third block of tropical rain forest is found in western Andes, in very humid regions

of Ecuador and Colombia, until the latitudinal limit of 19° North, in Vera Cruz, south of Mexico. Large areas of deforestation are found in the lower foothills of the Andes, especially in Peruvian and Ecuadorian lands. However, from Panama northwards these humid forests present discontinuities due to the existence of seasonal forests at the Pacific coast. Central America and Caribbean islands suffered the highest percentage of loss of forest of any tropical region over the last century, with the forest remnants being highly fragmented and persisting only in areas which are inaccessible or are legally protected as conservation units (parks and reserves).

2.2. The African Rain Forest

In the African continent there are two important tropical rain forests: the Congo Rain forest and the Madagascar Rain forest. At Central Africa, more specifically at the Congo river basin, is located the Congo Rain forest. It is the second-largest dense tropical rain forest, surpassed only by the Amazon Forest, comprising ca. 2 million km² that represents 70% of the African forest cover. The Congo River is the second largest in volume, and its river basin expands over six nations: Cameroon, Central African Republic, Republic of Congo, Democratic Republic of Congo, Equatorial Guinea and Gabon.

Because of its large size, Congo Rain forest serves as a vast carbon sink of global importance. The forest also regulates regional and local weather patterns, and ensures the cycling of water critical for a large area of Africa. It provides a critically important resource which supports livelihood and well-being of tens of millions of people both in Africa and beyond. This forest type is still well-preserved, accounting for less than 6% of the total loss of humid forest cover in the world. However, deforestation is a severe problem in parts of the continent.

Another important rain forest is located in the Madagascar that lies off the coast of southeastern Africa. It has long been famous for its unique and diverse species of wildlife, especially lemurs, which are small primates found nowhere else on the planet. Madagascar is home to some of the richest moist forests on Earth. Well over half of Madagascar's species are found in these forests which lie on the east coast of the island. However, eastern forests of Madagascar have been threatened by deforestation owing to slash-and-burn agriculture, logging and mining.

2.3. The Indo-Malayan and Australian Rain Forest

The Asian region holds 60% of the world's population, and centuries of tremendous population pressure has significantly reduced forest surface. Actually, major threats to Asian Rain forests are the paper industry, intensive exploitation for timber and expansion of palm oil plantations.

The scattered fragments of tropical rain forest in Asia are located in the Indo-Malayan Peninsula. The Indo-Malayan Peninsula is the world's largest archipelago located between mainland Southeastern Asia (Indochina) and Australia, lying between the Indian and Pacific Oceans. It comprises around 20,000 islands, with about 6,000 of

those inhabited. The biggest islands are New Guinea, Borneo and Sumatra. Some of the Malay islands are administratively shared by more than one nation. The Republic of Indonesia comprises the majority of those islands (17,508).

Southeast Asia's tropical rain forests are some of the oldest on Earth, and some present-day forests may have existed over 100 million years ago. Geologically, the archipelago (chain or cluster of islands) is one of the most active volcanic regions in the world. Tectonic uplifts in the region have also produced some impressive mountains, as the Mount Kinabalu (4,101 m) in northern Borneo. During the **ice ages**, when sea level lowered, some islands were connected to the Asian mainland. Therefore, today these islands have in common with the continent a great quantity of species of flora and fauna. Geographers believe that New Guinea Island may once have been part of the Australian continent, although New Guinea's flora has more affinities with Asia, and its fauna with Australia. Today, Australia has small areas of tropical rain forest in the extreme northeastern part of the continent near the coast.

3. Floristic Patterns

Regarding the species composition of the tropical flora, three patterns are recognized for the families of angiosperms:

- Large families generally have **pantropical** distribution.
- Few families are entirely restricted to any of the three major blocks of tropical rain forest.
- Families that are entirely restricted to any of the three blocks have few genera and species.



Figure 1. Bromeliaceae are generally herbaceous plants, with leaves often lanceolate, and spirally arranged, forming a water reservoir tank among leaf sheaths. The Atlantic rainforest in Brazilian southeast is one of the main centers of diversity and shows a high

degree of endemism. The family has a remarkable importance in the vegetation physiognomy, contributing to structural complexity of the environment which is directly reflected on richness and diversity of associate fauna and flora.

These patterns appear to be related to major biogeographic events during Earth's geological history. Families of Angiosperms that could have been differentiated in the tropics - after the separation of continental masses corresponding to South America, Africa, India and Australia, about 100 million years ago - generally have few genera and species, probably because there was not enough time for greater diversification. Such families are also restricted to certain realms due to geographical barriers that prevent dispersion. Examples of small families that have exclusivity for certain flora are Cyrillaceae (endemic to the Americas), Sarcolaenaceae (endemic to Madagascar) and Peridiscaceae (endemic to Amazon Basin). Vochysiaceae is also a small family represented by only 6 genera and predominantly distributed in the Americas, with only one African species. However, there are large families, such as Bromeliaceae (Figure 1), composed by 56 genera and about 3,000 species, which is exclusively American, except for one species *Pitcairnia feliciana* (A. Chev.) Harms & Mildbr. that occurs in the Gulf of Guinea, West Africa.

Other families went through some evolutionary stability in the continent, suffering only diversification into the lower taxonomic categories. Currently, some of them may be considered as large families because they have many genera and species, which may be a unique feature of the taxon, or the result of the diversification that followed the **continental drift**. Some of the largest families of angiosperms more common in tropical forests are listed in Table 1. Among these, Araceae, Annonaceae, Euphorbiaceae, Moraceae, Myrtaceae and Rubiaceae are examples of families well represented throughout the tropical region. Other families, even with pantropical distribution, have variation in their abundances. Fabaceae (mainly Caesalpinoideae) and Passifloraceae are more important in America and in Africa than in Asia. Lecythidaceae is much larger in the New than in the Old World, especially in Amazon and Orinoco Basin, both in South America, where there are 105 species of 11 genera. This same pattern is shared by Chrysobalanaceae.

Dicots		
Acanthaceae	Euphorbiaceae	Nyctaginaceae
Anacardiaceae	Fabaceae	Passifloraceae
Annonaceae	Gesneriaceae	Piperaceae
Apocynaceae	Lauraceae	Rubiaceae
Araliaceae	Lecythidaceae	Rutaceae
Asteraceae	Malpighiaceae	Salicaceae
Bignoniaceae	Malvaceae	Sapindaceae
Boraginaceae	Melastomataceae	Sapotaceae
Celastraceae	Meliaceae	Solanaceae
Chrysobalanaceae	Moraceae	Tiliaceae
Combretaceae	Myrsinaceae	Urticaceae
Convolvulaceae	Myrtaceae	Verbenaceae
	Monocots	

Araceae	Cyperaceae	Liliaceae
Arecaceae	Dioscoriaceae	Orchidaceae

Table 1. Largest Angiosperms families in tropical rain forests.

Dipterocarpaceae, which is a large and dominant family of the flora of Southeast Asia is absent in Australia, while in Africa it is represented only by two genera (*Monotes* and *Marquesia*) and by the monotypic genera *Pakaraimaea* (from Guayana) and *Pseudomonotes* (from Colombia) in the Neotropics.

The Gymnosperms, unimportant group in tropical forests, are represented mainly by the families Araucariaceae and Podocarpaceae. Nowadays, the Araucariaceae is constituted by the genera *Araucaria* Juss. (Figure 2) that is confined to the southern hemisphere, with species in New Caledonia, New Guinea, Malaysia, Philippines, South America, and Northeast Queensland, Australia. On the other hand, the Podocarpaceae family is represented by 17 genera and about 125 species that are mainly distributed in the subtropical mountains of the Southern Hemisphere. However, most members of this family are represented by the genus *Podocarpus* (widely distributed), but the genus *Sundacarpus*, with only one species, *Sundacarpus amarus* (Blume) C.N. Page, is native of Indonesian islands (Sulawesi, Timor, Sumbawa, Java, Sumatra, and Sabah province on the island of Borneo), Philippines (Mindanao and Luzon), New Guinea and parts of Australia (including northeastern coastal Queensland) and Malaysia.



Figure 2. In the tropics, Gymnosperms are less representative, but in the mountainous areas of southern Atlantic Brazil and extends into northeastern Argentina, we can find the endangered Brazilian Araucaria (*Araucaria angustifolia*). Forest with *Araucaria angustifolia* are easily set apart from other portions of the Brazilian Atlantic forest. However apparent homogeneity, Araucaria forests represent an extraordinary mosaic

combining species from a relict coniferous forest (including several Andean genera) with Atlantic forest species. In this mosaic, several endemic species are found.

Tropical rain forest largely varies as regards to **phytophysiognomies** due to differences of altitude (lowland, lower montane, upper montane and cloud montane), annual precipitation, soil types and the degree of continentality. Following these changes, the flora also varies to a greater or lesser degree between forest formations, and the differences in species and genera are the most striking.

For example, in the lowland Atlantic coastal forest of northeastern Brazil between south Bahia state and neighboring northern Espírito Santo state, corresponding to an area of ca 72,000 km², the family Lauraceae is not very conspicuous (there are just over 50 species throughout the region). On the other hand, in only 1 ha of upper montane forest (ca 800 m high) in Santa Lucia Biological Station, in southern Espírito Santo state, 46 tree species of Lauraceae can be found, indicating its preference to montane environments.

In addition, although the forest in the Amazon basin is a continuous block, the abundance of elements of given botanical families of woody plant species varies from area to area. For instance, Fabaceae and Moraceae are the most important families in the Ecuadorian Amazon, while Moraceae and Myristicaceae are predominant in the Bolivian Amazon, and Lecythidaceae and Moraceae are well represented in Central Amazon forest. On the other hand, comparisons between the elements of the woody flora of the Amazon Forest and the Atlantic Forest reveal that many individual species co-occur in both floristic domains. This can be explained, at least in part, by the migration of these species across the **dendritic drainage** of **gallery forests** that establishes connection between these two blocks of rain forests.

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Marcelo T. Nascimento is an Associate Professor and Curator of the Herbarium at the Universidade Estadual do Norte Fluminense Darcy Ribeiro (UENF), Rio de Janeiro. For the last 15 years, his research has focused on plant communities, including phytosociological studies, herbivory, and plant population dynamics.