SECTION B

The structure of the rain forest

Rain forests contain a bewildering variety of flora and fauna but do share some important characteristics, and there is a common set of concerns.

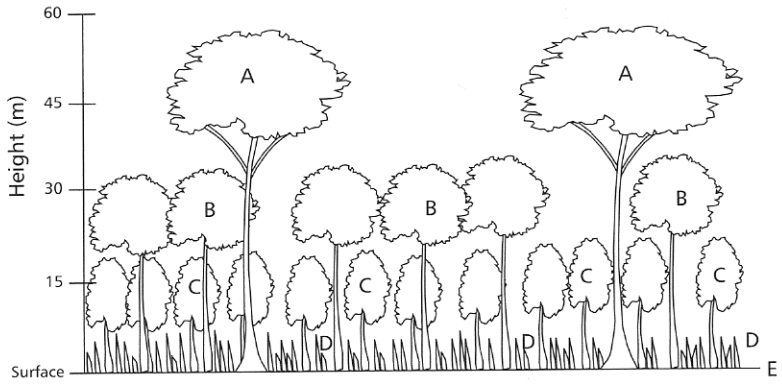

Figure 7.2 The vertical structure of the tropical rain forest

Structure

Structure is the spatial organisation and arrangement of the forest and, in particular, the vertical and horizontal patterns of flora and fauna. Rain forests are characterised by a distinctive **vertical organisation** of flora, referred to as canopies (**7.2**).

- The **emergent canopy** is discontinuous and consists of mature trees with straight **boles** (trunks). Trees can reach 50 m and typically have umbrella-shaped crowns and buttress roots, to help maintain stability. The canopy often contains a highly specialised saprophytic plant community, which uses host trees to gain access to sunlight. The saprophytes are also specialised in both retaining water and withstanding ultra-violet radiation, as the upper canopy dries out rapidly between rain events.
- The **middle canopy** consists of a continuous belt of large mature trees of between 20 and 30 m in height. These have mop-shaped crowns and the branches intermingle and are linked by lianas, providing mutual support. This zone is rich in foliage and fruit. It is the ecological niche for numerous insect, bird and animal species that will rarely, if ever, venture to the forest floor. The emergent canopy offers protection to the middle canopy from wind gusts and intense rain and drying. The protection is generally at least 90 per cent effective.
- The **lower canopy** consists of densely packed conical shaped trees. This layer is protected from intense sunlight and intense rain by the upper and middle canopies. Humidity is generally high. Rich in food, this canopy provides a major niche for fauna.
- The **shrub canopy** reaches approximately 5 m from the ground. It is discontinuous, with plants such as palms, banana and ferns, that are specialised in having large chlorophyll-rich leaves that can exploit the heavily filtered sunlight. Rain reaches this layer as a mist or gentle

drip. Saplings, from the seeds of the adjacent trees, have a short life span due to the lack of sunlight, unless the upper canopies are punctured.

- **Ground cover** is generally limited and discontinuous due to shading by the canopies. The forest floor is often dark and has a more limited fauna than the tree canopies, with insects and decomposers dominating.
- The **root mat** forms a dense and tangled floor to the forest. The close spacing of the tree trunks means that root systems overlap, forming a ribbed surface. This efficiently protects the underlying regolith and soil, as well as serving as a filter to trap nutrients as soon as they are released by the decomposition of leaves, branches and trunks that litter the floor. Rain forest trees have a very high above-ground to below-ground ratio of tissue (at least 4 : 1), so that most of the energy is invested in productive tissue.

The **horizontal distribution** of species in tropical rain forests has three main features.

The **diversity** is the number of species found within a specific area. The total number of tree species remains an estimate, although the Amazon Basin contains over 2500 species of tall trees; over 1000 species are found in Pará State alone. A sample area of one hectare may contain up to 80 species (compared with a value of 35 for temperate deciduous forest). But diversity increases as the sample area increases. In a 1.5 ha area more than 120 species can be found, and in 2 ha over 175. No one dominant species tends to develop, so the forest continually varies. The high diversity is thought to reflect both high rates of mutation and the role of past climate. There is one theory that during the Quaternary period, the tropical rain forests fragmented into small areas separated by tropical savanna. Small enclaves of forest evolved separately and developed different characteristics. Under rising temperatures at the end of the Quaternary, the pockets re-merged, creating the present diverse pattern. In contrast, **mosaic theory** focuses on the consistent pattern of saplings not being related to the species that they are growing under. Thus, when canopy trees die, they are seldom replaced by the same species, which makes for dynamic change over time and space.

The **spatial patterns** of particular tree species tend not to show concentrations. Rather, on average, individual specimens are over 2 km apart. This is particularly hard to explain in a system in which high humidity and the dense packing of trees limit dispersal of seed by wind. Explanations focus on the role of pests. The combination of temperature, water and a large biomass provides a rich ecological niche for bacteria, viruses, insects, herbivores and omnivores, making the humid Tropics a very hostile environment. Specialisation by pests to tolerate specific tree defences has resulted in tree-specific pest populations. As concentrations of a tree species develop over time, the food supply for the specific pest increases, leading to a dramatic increase in the pest population. This

multiplication of population eventually exceeds the carrying capacity and so the destruction of the entire tree concentration begins.

Rain forest vegetation shows a wide range of adaptation strategies that allow survival in a highly competitive and hostile environment:

- **Growth rates** In an environment with strong competition for light, rapid vertical growth allows saplings to exploit access to sunlight provided by any gap in the canopy. Vines and lianas use existing trees to reach sunlight. Lacking large trunks, some – such as the fig vine – eventually strangle and kill the host tree, forming a vertical chimney of interlocking stems. Figs illustrate the complexity of adaptation, as the plant is established from a wind-blown seed and grows as a small bush at the junction of an upper branch and the trunk. It then produces aerial roots, with some coiling around the trunk and some descending vertically to root in the soil. This source of water and nutrients allows the bush to grow upwards, and eventually to shade and kill the host tree. One species of palm tree even has a symbiotic relationship with leaf-cutting ants, so that in 'exchange' for residence in the trunk, the ants clear a forest patch, allowing the palm access to light.
- **Height** Although not the tallest trees in the world (the sequoia of North American coniferous forests reaches 110 m), rain forest species reach over 60 m, with an average of 45–55 m. Trunks tend to have relatively small **girths** (diameters), although taller species tend to have buttress roots to increase stability. The dense packing and the growth of vines between trees increase stability; energy is not wasted in growing deep root systems.
- **Root systems** Feeding roots (**tendrils**) are concentrated near the surface. They are highly efficient at absorbing nutrients and water, with 80 per cent of roots in the top 25 cm of the soil. Specialised fungi (**mycorrhiza**) play an important role in accelerating the decomposition of organic matter and its absorption by roots. Few roots penetrate into the deep regolith, as there are few nutrients, and a copious supply of water to the upper soil reduces the need for tap roots to exploit groundwater.
- **Leaves** Leaves are vulnerable to the impact of rain, wind and pests. The weight of water in a tropical downpour poses a threat to branches and leaves, and adaptations include large ribs, a V-shape to channel water off rapidly, a waxy cuticle to reduce surface tension and extended leaf points to increase drip-flow. To reduce attack by pests, plants have developed extraordinary defences, ranging from alkaloid poisons to thick cuticles and thorns.
- **Reproduction** Wind dispersal of seeds is only efficient for upper canopy plants above the high humidity and shelter of the lower layers. Many plants produce fruits that are consumed by animals and then 'deposited' at a distance, giving fauna an important role in the maintenance of the forest systems. Plants growing adjacent to rivers, or in areas prone to flooding, use water as means of transmission.

Review

4 Briefly define the terms **biome, forest structure** and **ecosystem**.

5 Explain what is meant by 'competition' between plant species.

6 Why do more canopy layers develop in tropical rain forests than in other forest ecosystems?