SECTION C

The functioning of the rain forest

Function refers to the processes or flows that occur between the components (structure) of the system. With an average 45 kg of biomass per square metre, the rain forest provides an abundant supply of food in numerous ecological niches. Each layer of the rain forest can be considered as an ecosystem (often in relative isolation); the same may be true even of individual tree species. One recent attempt fully to document all biota in a few hectares of rain forest in Thailand was abandoned when it became apparent that it would have required 20 per cent of all taxonomists in the world to complete the task! In Amazonia, there are over 1800 known species of butterfly, over 1900 species of bird, and the River Amazon contains over 2000 species of fish (compared with 250 for the Mississippi).

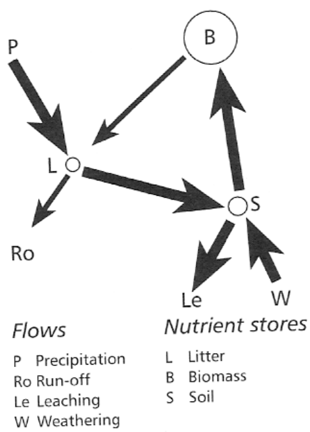


Figure 7.3 A generalised tropical forest nutrient cycle: flows and stores are shown proportionally

The quantification of relatively large organisms is demanding enough, but insects are even more difficult to collect and identify. In Thailand's forests, over 350 insects can be collected in a square metre (this includes all vertical levels) and a fair proportion of them would be new to science. In addition to their intrinsic value, fauna plays a vital role in plant reproduction, species dispersal and the recycling of organic matter. It is the intense micro-organism activity that allows the rapid transmission of nutrients through the litter and soil, and it is this that sustains such rapid vegetation growth.

The functioning of an ecosystem is generally investigated through the **nutrient cycle**, **trophic levels** and **food webs**.

The nutrient cycle

In the humid Tropics, vegetation functions relatively independently of soil-creating activity. In this respect, the nutrient cycle is unusual (**7.3**).

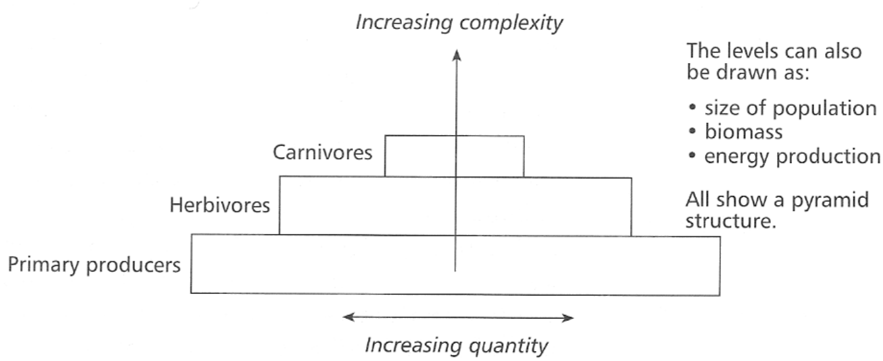
- The biomass is the main nutrient store (approximately 70 per cent by dry weight), with fairly insignificant amounts in the litter and soil. This reflects both the large scale of the vegetation and the extremely rapid rates of decomposition at the surface. Nutrients remain trapped in the biomass until either trees die or the forest is cleared and burnt.
- Nutrient flows are large due to the temperatures and precipitation, maintaining high rates of growth, decay and transport.
- Precipitation is shown as providing a large nutrient supply to the litter. Nutrients are added as the water passes through decomposing vegetation lodged in the canopies (much of the dead organic matter does not reach the forest floor).
- The soil acts as a routeway rather than as a store. Nutrients released from the litter or from weathering are either taken up by plants or are lost through leaching rather than accumulating in the soil.
- The litter store is small, as organic matter has either decomposed before reaching the litter or is rapidly broken down or consumed on the forest floor. Typically, the surface has only a thin layer of fall-out and there is no significant organic horizon.

- The usual roles of litter and soil are redundant, as the vegetation is specialised to re-circulate nutrients rapidly. With weak seasonality, the decomposition of organic matter is constant, providing a continuous flow of nutrients for the vegetation. Equally, regular rainfall reduces the need for the soil to store water. This highly efficient recycling allows rain forest to develop on variable surfaces, including abandoned roads or concrete!
- Fall-out is well distributed, as in the absence of seasons trees have independent cycles. Leaf fall is determined by pest and wind damage rather than by climate.

Trophic levels

The relationship between organisms in an ecosystem can be thought of as a sequence of energy transfers or flows. This can be represented as a hierarchy, divided into levels by status (**7.4**).

Figure 7.4 The classic trophic levels



- The base of the hierarchy forms the origin of the energy that supports all higher levels. These organisms, almost totally flora, are termed **primary producers**, as they combine carbon dioxide, water and sunlight through **photosynthesis** to produce carbohydrates, including cellulose. The level of photosynthesis is generally measured by **net primary productivity** (NPP), which quantifies the total energy fixed by plants minus the energy used for respiration and tissue repair. This is measured in terms of dry weight of biomass as kg m^{-2} yr^{-1} and the high NPP of rain forests (2.2 kg m^{-2} yr^{-1}) supports large higher trophic levels.
- A wide range of organisms, including insects, bacteria and fungi, consume the tissue produced by photosynthesis. In rain forests, grazing animals (herbivores) do not play a major role, as much of the biomass is well above the forest floor. Tree-climbing animals do consume leaves, but these are generally omnivorous, eating a range of foods, including meat. Insects, by far the largest group of organisms, are the main consumers of the living and dead biomass.
- The wide range of organisms provides food for the upper trophic level of carnivores. This is a large and diverse population, which reflects the large food supplies, and it includes the large cats (tigers and jaguars) as

well as crocodiles, alligators and fish such as the piranha.

- The quantity of energy stored in each trophic level decreases with increasing status. This is due to the loss of energy (heat) during conversion, when it is digested (broken down) and reassembled.
- The upper level of carnivores is the most vulnerable to change and dominates the list of endangered species (jaguars, tigers, alligators, sloths and monkeys) in the rain forest. Changes in the lower trophic levels cause a progressive loss of food supply to the levels above as well as a loss of habitat.

Food webs (chains)

Trophic levels do not fully explain the functioning of the ecosystem. They were recognised in the investigation of temperate ecosystems, where herbivores provide the main link between primary producers and carnivores. In rain forests, there are few true herbivores and insects form the most important group of organisms consuming biomass. Insects are generally regarded as decomposers or recyclers (**7.5**). In rain forests, their role is extremely complex, being consumers of both living and dead material, as well as food for a very wide range of fauna and even some carnivorous flora. Food webs and chains only provide a crude map of energy flows in a rain forest. A combination of the immense number of species, the range of food consumed by species, the numerous micro-habitats and micro-ecosystems, as well as the interaction between riverine and terrestrial systems, makes the construction of a full web an impossible task. In such a dynamic and competitive environment, it is difficult even to separate consumers from the consumed. What is clear is that insects play a key role, and that it is these that form the major links between the organisms in the trophic hierarchy.

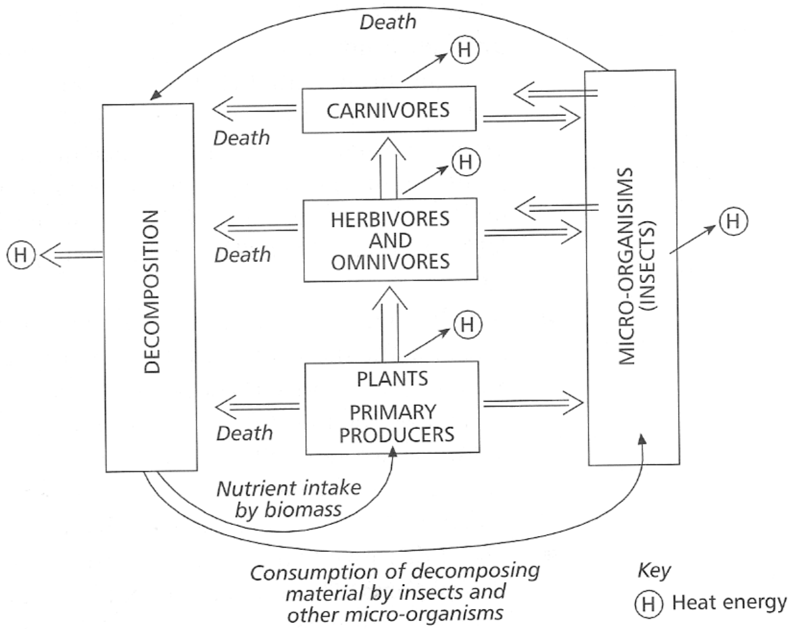


Figure 7.5 The role of insects in the tropical forest nutrient cycle .

Tropical rain forests are exotic, fascinating and even threatening environments. As a topic of considerable debate and a global issue, our scientific knowledge remains unexpectedly sparse. Rain forests appear to be structured and orderly, but in practice they consist of chaotic and extremely complex systems. They also represent a major global biomass, yet they grow on relatively infertile soils, and they appear robust when in fact they are fairly fragile. Part of the problem of understanding rain forests is that ecological models do not easily fit. Concepts such as nutrient cycling, trophic levels and food webs do not really fit the more dynamic rain forest system. Even concepts such as **primary succession** are difficult to apply, as the development through **seres** to a **climatic climax vegetation** in equilibrium seems inappropriate. The structure of the rain forest implies that change is always occurring and that an equilibrium is never reached. There is no dominant tree species, and trees are not replaced by the same species. Specific trees also provide a micro-habitat for specific communities of organisms, suggesting that fauna as well as flora is in a constant state of upheaval and change. Rain forest research is still largely at a data collection stage and the task of examining these as a system remains a mammoth one for the future.

Review

7 Attempt to explain why biomass forms the largest of the nutrient stores in the rain forest system.

8 Why is the main nutrient flow into the litter store shown as precipitation rather than fall-out (**7.2**)?

9 How can the concept of **carrying capacity** be related to trophic levels?

10 Identify how a reduction in vegetation affects the number of carnivores when they do not eat biomass.

11 What are the main problems in applying the concepts of **nutrient cycling**, **trophic levels** and **food webs** to rain forest ecosystems?

12 Suggest reasons why scientific knowledge of the tropical rain forest is relatively incomplete. What are the implications of this incomplete knowledge for human use of the environment?

13 What can be done to increase our knowledge of the tropical rain forest environment?

Enquiry

Identify and investigate ways in which the tropical rain forest may justifiably be called a hostile environment.