Unit 3

Ecosystems

Let's understand

- What an ecosystem is
- How to utilise the existing resources
- The structure and functions of an ecosystem
- What producers, consumers and decomposers are
- How energy flows in the ecosystem
- How the various cycles—water, carbon, oxygen, nitrogen, phosphorus, sulphur, energy—operate in nature
- What ecological succession is
- What food chains, food webs and ecological pyramids are
- The various types of ecosystems
- The characteristic features, structure and functions of various ecosystems
- Why degradation of ecosystems takes place

3.1 Concept of an Ecosystem

An 'ecosystem' is a region with a specific and recognisable landscape form, such as a forest, grassland, desert, wetland or coastal area. The nature of the ecosystem depends on its geographical features such as hills, mountains, plains, rivers, lakes, coastal areas or islands and is also controlled by climatic conditions—the amount of sunlight, temperature and rainfall in the region. The geographical, climatic and soil characteristics form its non-living or **abiotic components.** These features create conditions that support a community of plants and animals that evolution has produced to live in these specific conditions. The living part of the ecosystem is referred to as the **biotic component.**

Ecosystems are divided into terrestrial or land-based ecosystems and aquatic or water-based ecosystems. These form the two main habitat conditions for the earth's living organisms.

All the living organisms in an area live in communities of plants and animals. They interact with the abiotic environment and with each other at different points in time for a large number of reasons. Life can exist only in a small portion of the earth's land, water and atmosphere. At a global level, the thin skin of the earth on the land, sea and air forms the biosphere.

At a sub-global level, this is divided into *biogeographical realms*. For example, Eurasia is called the Palearctic realm; South and Southeast Asia (of which India forms a major part) is the Oriental realm; North America is the Nearctic realm; South America forms the Neotropical realm; Africa the Ethiopian realm; and Australia the Australian realm.

At a national or state level are *biogeographic regions*. India has several distinctive geographical regions—the Himalayas, the Gangetic plains, the highlands of Central India, the Western and Eastern ghats, the semi-arid desert in the West, the Deccan plateau, the coastal belts and the Andaman and Nicobar Islands. These geographically distinctive areas contain plants and animals that have adapted themselves to live in each of these regions. At an even more local level, each area has several structurally and functionally identifiable *ecosystems*, such as different types of forests, grasslands, river catchments, mangrove swamps in deltas, seashores or islands to give just a few examples. Here, too, each of these forms a habitat for specific plants and animals.

Definition: The living community of plants and animals in any area together with the non-living components of the environment—soil, air and water—constitute the ecosystem.

3.1.1 Understanding Ecosystems

Natural ecosystems include forests, grasslands, deserts and aquatic ecosystems such as ponds, rivers, lakes and the sea. Human-modified ecosystems include agricultural land and urban or industrial land use patterns.

Each ecosystem has a set of common features that can be observed in the field:

- What does the ecosystem look like?
  One should be able to describe specific features of the different ecosystems in one's own surroundings. Field observations must be made in both urban and natural surroundings.
- What is its structure?
  Is it a forest, a grassland, a water body, an agricultural area, a grazing area, an urban area or an industrial area?

  What you should look for are its different characteristics. A forest has various layers from the ground to the canopy. A pond has different types of vegetation from the periphery to its centre. The vegetation on a mountain changes from its base to its summit.
- What is the composition of its plant and animal species?
  List the well-known plants and animals you can see. Then, document their abundance and numbers in nature—very common, common, uncommon, rare. For example, wild mammals will not be seen in large numbers, cattle would be common. Some birds are common; find out which are the most common species. Insect species are very common and most abundant. In fact, there are so many that they cannot be easily counted.
- How does the ecosystem work?
  The ecosystem functions through several biogeochemical cycles and energy-transfer mechanisms. Observe and document the components of the ecosystem, which consist of its non-living or abiotic features such as air, water, climate and soil and its biotic components, the various plants and animals. Both these aspects of the ecosystem interact with each other through several functional aspects to form nature's ecosystems. Plants, herbivores and carnivores can be seen to form food chains. All these chains are joined together to form

a 'web of life' on which man depends. Each of these food chains uses energy that comes from the sun and powers the ecosystem.

3.1.2 Resource Utilisation

Most traditional societies used their environmental resources fairly sustainably. Though inequality in resource utilisation has existed in every society, the number of individuals that used a large proportion of resources was extremely limited. In recent times, the proportion of rich people in affluent societies has grown rapidly. Inequality has thus become a serious challenge. Whereas in the past many resources such as timber and fuelwood from the forest were extracted sustainably, this pattern has drastically changed during the last century. The economically powerful sections began to use greater amounts of forest products, while those people who lived in the forest became increasingly poor. Similarly, the building of large irrigation projects has led to wealth in those areas that had canals, while those who remained dependent on a constant supply of water from the river itself have found it difficult to survive.

The key to this issue is the need for an equitable distribution of all types of natural resources. A more even sharing of resources within the community can reduce these pressures on the natural ecosystems.

3.2 Structure and Functions of an Ecosystem

Since each ecosystem has a non-living and a living part that are linked to each other, one needs to look around and observe this closely.

The non-living components of an ecosystem are the amount of water, inorganic substances and organic compounds, and climatic conditions, which depend on geographical conditions and location. The living organisms in an ecosystem are inseparable from their habitat.

The living component of plant life ranges from extremely small bacteria, which live in the air, water and soil, algae which live in fresh and saltwater, to the terrestrial plants which range from grasses and herbs that grow after the monsoon every year, to the giant long-lived trees of the forest. The plants convert energy from sunlight into organic matter for their growth, thus functioning as **producers** in the ecosystem. The living components of the animal world range from microscopic animals, to small insects and larger animals such as fish, amphibians, reptiles, birds and mammals. Humans are just one of the 1.8 million species of plants and animals that inhabit the earth.

Structural aspects: This refers to all the elements that make up an ecosystem—the individuals and communities of plants and animals as well as the non-living natural resources present in the ecosystem.

(i) Inorganic compounds—C, N, CO_2, H_2O
(ii) Organic compounds—proteins, carbohydrates, lipids, which link the abiotic to biotic aspects

(*Continued*)

(iii) Climatic regimes—temperature, moisture, light and topography
(iv) Producers—plants
(v) Macro-consumers—Phagotrophs, that is, large animals
(vi) Micro-consumers—Saprotrophs, that is, absorbers like fungi

Functional aspects: This refers to all the services, processes and interactions performed by the organisms in an ecosystem.

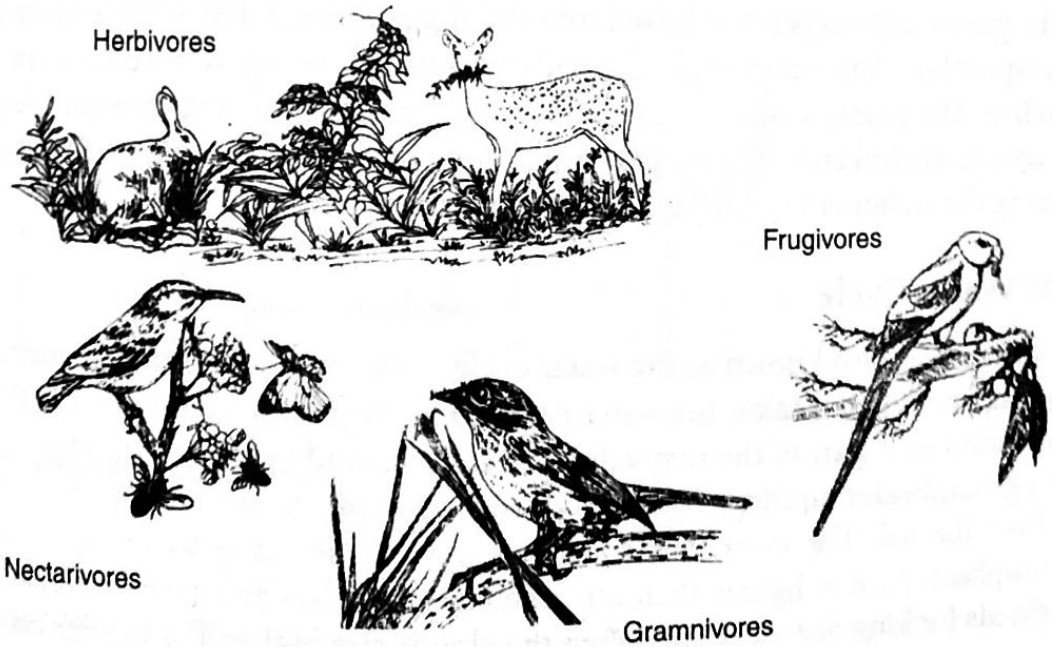
- Energy cycles
- Food chains
- Diversity—interlinks between organisms
- Nutrient cycles—biogeochemical cycles
- Evolution

3.3 Producers, Consumers and Decomposers

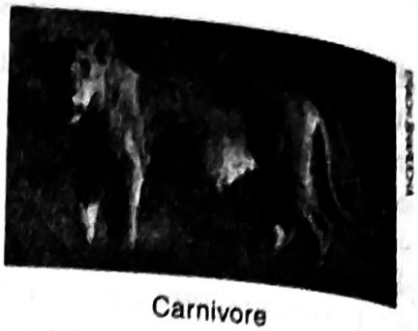
Every living organism is in some way dependent on other organisms. Plants are food for herbivorous animals, which are in turn food for carnivorous animals. Thus, there are different trophic levels in the ecosystem. Some organisms such as fungi live only on dead material and inorganic matter.

Plants are the *producers* in the ecosystem, as they manufacture their food by using energy from the sun. In the forest, these form communities of plant life. In the sea, these range from tiny algal forms to large seaweed.

The *herbivorous animals* are *primary consumers*, as they live on the producers. In a forest, these are the insects, amphibians, reptiles, birds and mammals. The herbivorous animals include, for example, the hare, deer and elephants that live on plant life. They graze on grass or feed on the foliage from trees. In grasslands, there are herbivores such as the blackbuck that feed on grass. In the semi-arid areas, there are animals such as the *chinkara* or Indian gazelle that also feed on grass. In the sea, there are small fish that live on algae and other plants.



At a higher trophic level, there are *carnivorous animals*, or *secondary consumers*, which live on the herbivores. In our forests, the carnivores are tigers, leopards, jackals, foxes and small wild cats. In the sea, carnivorous fish live on other fish and marine animals. The animals that live in the sea range in size from microscopic forms to giant mammals such as the whale.



Carnivore

Decomposers or *detrivores* are a group of organisms consisting of small animals such as worms, insects, bacteria and fungi, which break down dead organic material into smaller particles and finally into simpler substances that are used by plants as nutrition. Thus, decomposition is a vital function in nature, as without this, all the nutrients would be tied up in dead matter and no new life would be produced.

Detrivore

Most ecosystems are highly complex and consist of an extremely large number of individuals of a wide variety of species. In the species-rich tropical ecosystems (such as in India), only a few species are very common, while most species have relatively few individuals. Some species of plants and animals are extremely rare and may occur only at a few locations. These are said to be *endemic* to these areas.

When human activities alter the balance of these ecosystems, such perturbations often lead to the disappearance of some uncommon species. When this happens to an endemic species that is not widely distributed, it becomes extinct forever.

3.4 Energy Flow in the Ecosystem

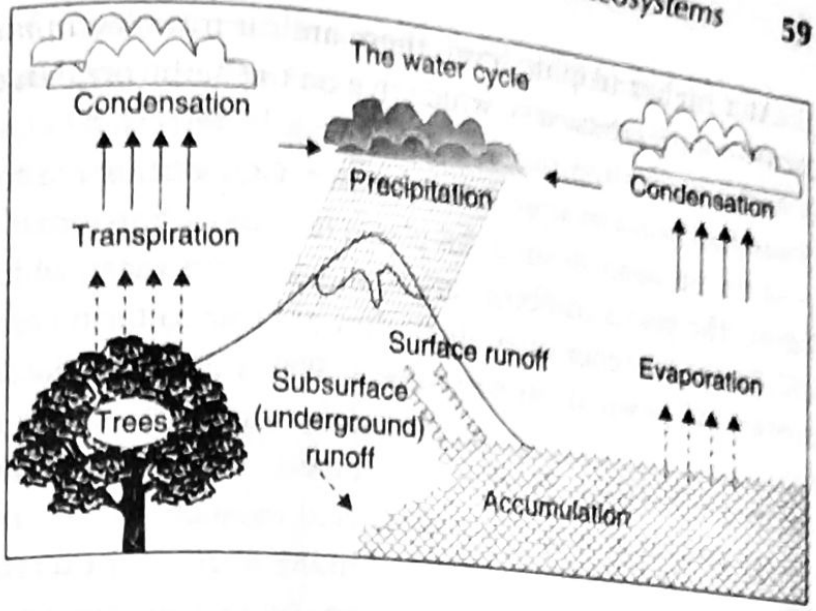
Every ecosystem has several interrelated mechanisms that affect human life. These are the water cycle, carbon cycle, oxygen cycle, nitrogen cycle and energy cycle. While every ecosystem is controlled by these cycles, each ecosystem's abiotic and biotic features are distinct from each other.

All the functions of the ecosystem are in some way related to the growth and regeneration of its plant and animal species. These interlinked processes can be depicted as various cycles; all these processes depend on energy from sunlight. During photosynthesis, carbon dioxide is absorbed by plants and oxygen is released into the atmosphere. Animals depend on this oxygen for their respiration. The water cycle depends on rainfall, which is necessary for plants and animals to live. The energy cycle recycles nutrients into the soil on which plant life grows. Our own lives are closely linked to the proper functioning of these cycles of life. If human activities go on altering them, humanity cannot survive on earth.

3.4.1 The Water Cycle

The hydrologic cycle, also known as the water cycle, collects, purifies and circulates the earth's finite water supply. When it rains, the water runs along the ground and flows into rivers or falls directly into the sea. A part of the rainwater that falls on land percolates into the ground, thus recharging groundwater aquifers. Water is drawn up from the ground by plants along with nutrients from the soil. The water then transpires from the leaves as water vapour and returns to the atmosphere. As it is lighter than air, water vapour rises and forms clouds. The winds blow the clouds for long distances and when the clouds rise higher, the vapour condenses and

changes into droplets, which fall on the land as rain. Part of this rain gets locked in glaciers. Thus, the processes of evaporation from water bodies, transpiration from plant leaves, condensation of water vapour, precipitation and percolation form an endless cycle that replenishes streams, lakes and wetlands. Furthermore, the above mentioned natural processes of the water cycle also remove impurities in water.



While this is an endless cycle on which life depends, human activities are making drastic changes in the water cycle and its processes through over-extraction of surface water and ground water, construction of large dams, deforestation and pollution.

3.4.2 The Carbon Cycle

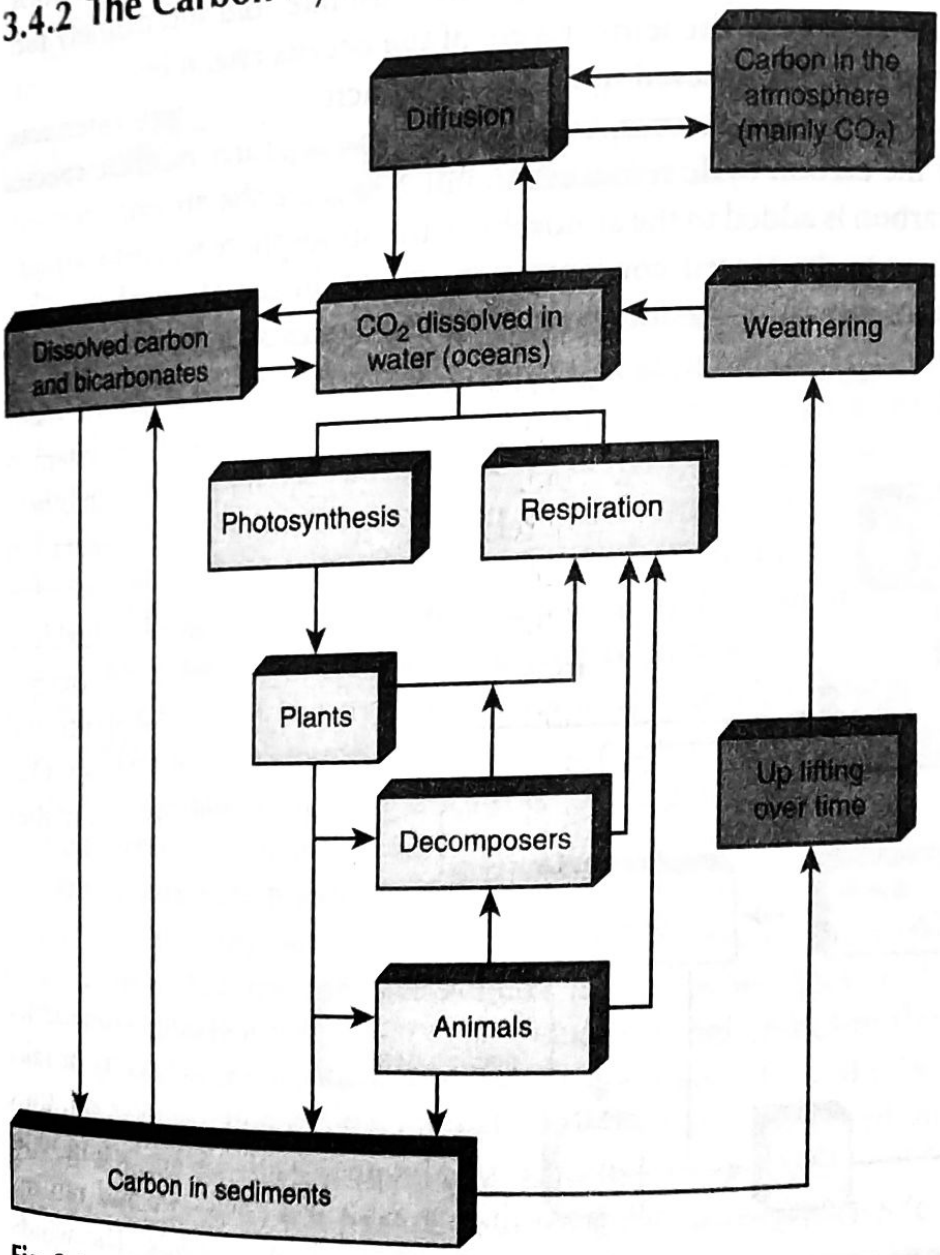


Fig. 3.1 The carbon cycle

The carbon found in organic compounds is included in both the abiotic and biotic parts of the ecosystem. Carbon is a building block of both plant and animal tissues. The carbon cycle is based on carbon dioxide gas (CO_2). In terrestrial ecosystems, CO_2 is removed from the atmosphere and in aquatic ecosystems, CO_2 is removed from water.

In the presence of sunlight, plants take up carbon dioxide from the atmosphere through their leaves. The plants combine carbon dioxide with water, which is absorbed by their roots from the soil. In the presence of sunlight they are able to form carbohydrates that contain carbon. This process is known as photosynthesis. Plants use this complex mechanism for their growth and development. In this process, plants release oxygen into the atmosphere on which animals depend for their respiration. Furthermore, herbivores feed on plant material, which is used by them for energy and for growth. Both plants and animals release carbon dioxide during respiration. They also return fixed carbon to the soil in the waste they excrete. When plants and animals die, they return their carbon to the soil, thus completing the carbon cycle. Plants play a very important role in regulating and monitoring the percentage of oxygen and carbon dioxide in the earth's atmosphere.

Equally, oceans play a crucial role in the carbon cycle. Some CO_2 is removed by marine species during photosynthesis, some stays dissolved in sea water (making it a major carbon-storage sink), and finally some of the CO_2 reacts with sea water to form carbonate and bicarbonate ions. Cold sea water can hold more carbon than warm sea water, just like cold soft drinks hold their fizz longer than warm soft-drinks. As the temperature of the oceans rise, it becomes less able to absorb CO_2 and thus more CO_2 is released into the atmosphere.

The carbon cycle ensures that CO_2 is at acceptable levels. This in turn moderates the temperature for life to exist. If the carbon cycle removes too much carbon, the atmosphere will become cool and if too much carbon is added to the atmosphere, the atmosphere will get warmer.

Current climate models show an increased concentration of CO_2 in the atmosphere. The resulting climate change phenomenon is at the forefront of the environmental problems faced by the world today.

3.4.3 The Oxygen Cycle

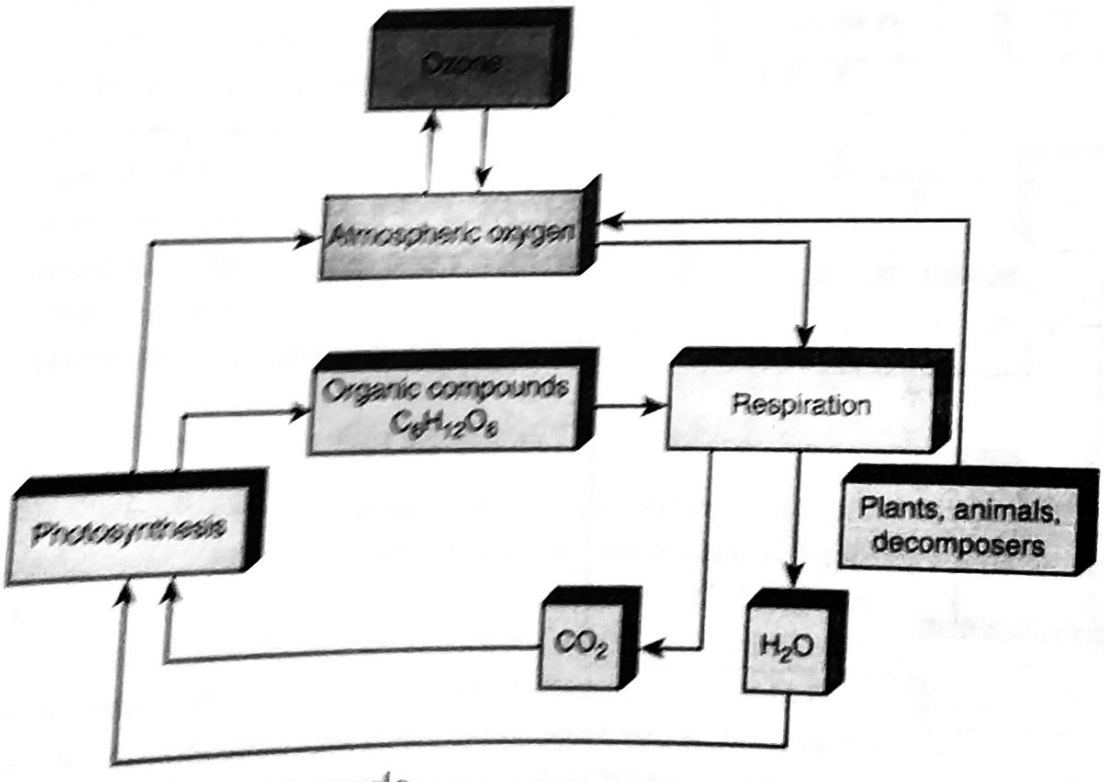


Fig. 3.2 The oxygen cycle

Oxygen is absorbed by plants and animals from the air during respiration. The plants return oxygen to the atmosphere during photosynthesis. This links the oxygen cycle to the carbon cycle. Deforestation is likely to gradually reduce the oxygen levels in the atmosphere. Thus, plant life plays an important role in our lives, the enormity of which we frequently fail to appreciate.

3.4.4 The Nitrogen Cycle

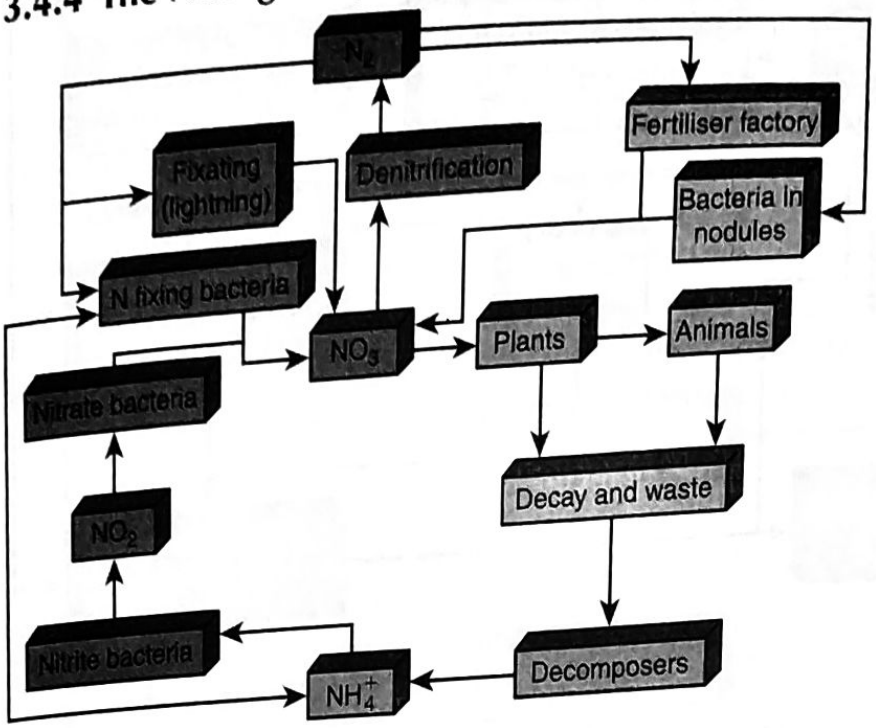


Fig. 3.3 The nitrogen cycle

Nitrogen (N_2) in the atmosphere cannot be directly used as a nutrient by plants or animals. It must be converted into its compound form of ammonia (NH_4), nitrates or nitrites. This occurs through four steps of fixation, nitrification, ammonification and denitrification. Nitrogen fixing bacteria feed off the root nodules of certain plant species such as beans, peas and alfalfa while they fix nitrogen. This nitrogen is then converted into ammonia to be used by those plants. Any unused ammonia undergoes nitrification. In the ammonification step, specialised bacteria and fungi feed and convert dead material (from animals) into compounds such as ammonia and water-soluble salts containing ammonium ions. These compounds are absorbed by plants for growth. In this manner, nutrients are recycled back from animals to plants. Finally, the denitrifcation step completes the nitrogen cycle as nitrogen leaves the soil and is released into the atmosphere as nitrogen or nitrous oxide gas.

It is important to realise that nitrogen-fixing bacteria and fungi in the soil give this important element to plants, which absorb it as nitrates. These nitrates are a part of the plant's metabolism, which help in forming new plant proteins. This is used by the animals that feed on the plants. The nitrogen is then transferred to the carnivores when they feed on the herbivores. So, our own lives are closely interlinked to soil animals, fungi and even the bacteria in the soil. When we think of food webs, we usually think of large mammals and other large forms of life. But we need to understand that it is the unseen small animals, plants and microscopic forms of life that are of great value for the functioning of the ecosystem.

The global nitrogen cycle has been altered due to nitrogen-rich fertilisers used in agriculture, pollution emitted by vehicles and industries and from sewage treatment facilities such as septic tanks which release large amounts of nitrogen into the ground.

3.4.5 The Phosphorus Cycle

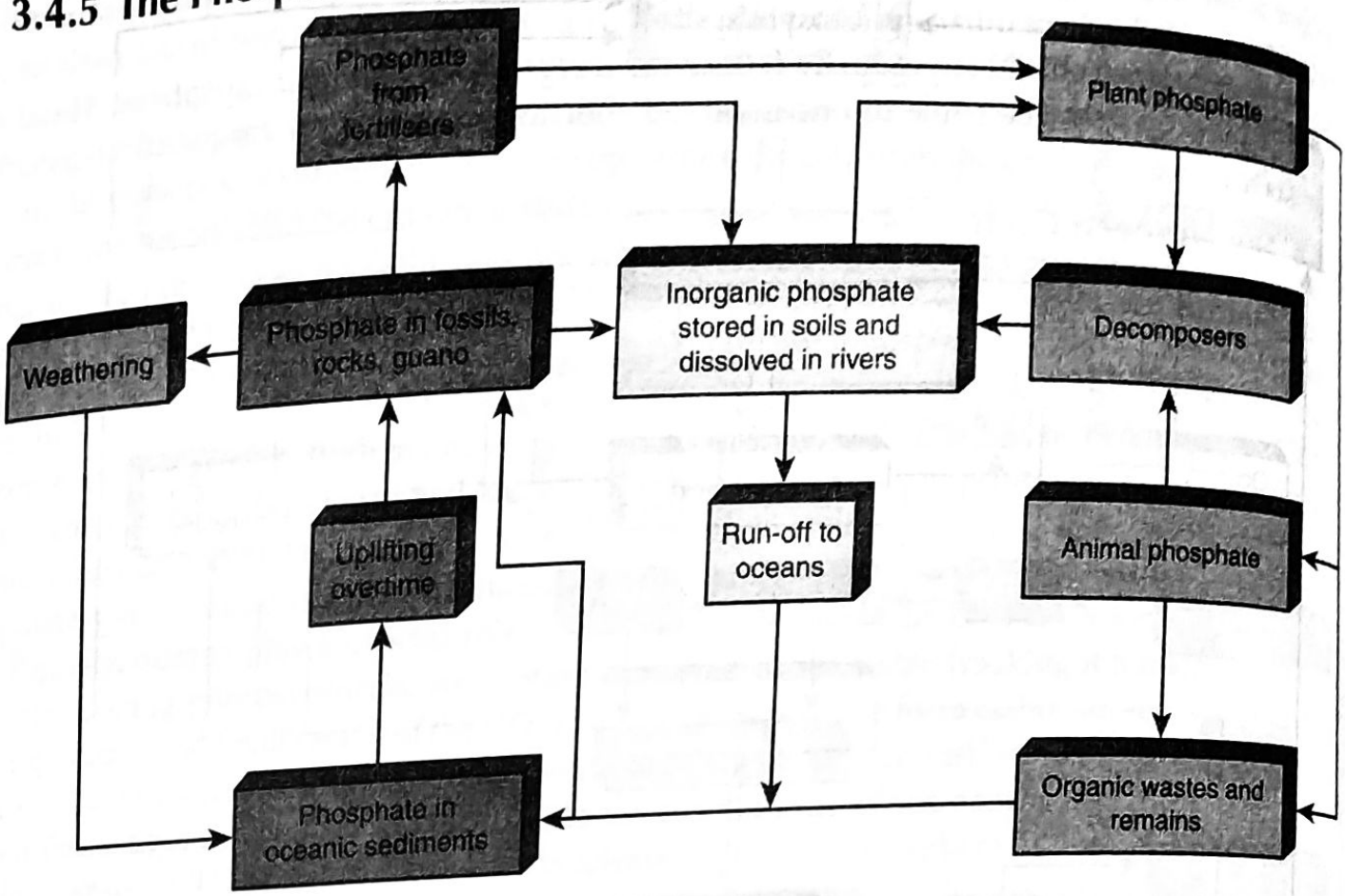


Fig. 3.4 The phosphorus cycle

Very little phosphorus enters the earth's atmosphere; it is usually found as part of a phosphate ion in terrestrial rocks or as deposits in ocean bottom sediments. Over time, weathering of rocks brings phosphates into the soil which is then absorbed by plants. Thus, the phosphorus cycle is completed in both land and water. However, most soil contains very little phosphate. It is therefore mined from the earth and added to soil as a fertiliser. Once utilised by plants, it enters the food chain—animals may consume these plants. After death, plant and animal decay allows phosphate to return to the soil. Run-off from rain carries phosphorus back to the ocean or deposits it on rocks, thus completing the phosphorus cycle. Human activities such as phosphate rock mining for commercial fertilisers and detergents have a significant impact in altering the phosphate cycle. Run-off of excess phosphate from the soil pollutes aquatic ecosystems by overloading them with nutrients, which in turn minimises the amount of oxygen available and causes toxic algal blooms.

3.4.6 The Sulphur Cycle

Sulphur enters the earth's atmosphere in the form of hydrogen sulphide (H_2S) and sulphur dioxide (SO_2). H_2S and SO_2 are both emitted from active volcanoes. Additionally, H_2S is released from organic matter that decomposes anaerobically (without oxygen) found in swamps and tidal flats. Other sources of sulphur are sulphate salts that can be found buried under ocean sediments and in underground rocks and minerals. Humans influence the sulphur cycle by burning coal and oil, both containg sulphur, refining sulphur containing petrol and finally through the release of sulphur dioxide by smelting for the extraction of copper, lead and zinc.

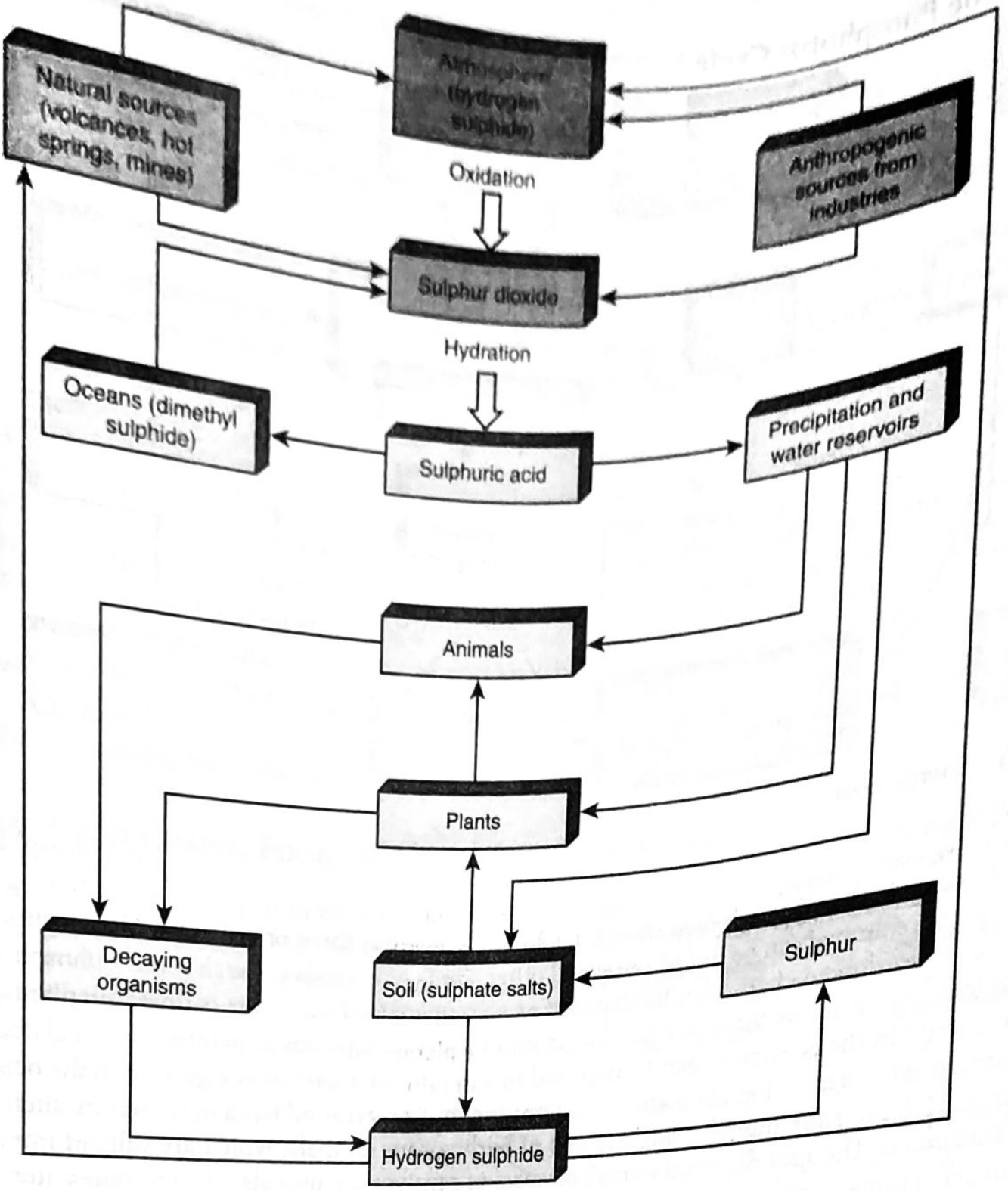


Fig. 3.5 The sulphur cycle

3.4.7 The Energy Flow

The energy cycle is based on the flow of energy through the ecosystem. The energy from sunlight is converted by plants into growing new plant material, which includes the leaves, flowers, fruit, branches, trunks and roots of plants. Since plants can grow by converting the sun's energy directly into their tissues, they are known as producers in the ecosystem. The plants are used by herbivores as food, which gives them energy. A large part of this energy is used up for the metabolic functions of these animals such as breathing, digesting food, supporting the growth of tissues, maintaining blood flow and body temperature. Energy is also used for activities such as looking for food, finding shelter, breeding and rearing young ones. The carnivores, in turn, depend on the herbivores on which they feed. Thus, different plant and animal species are

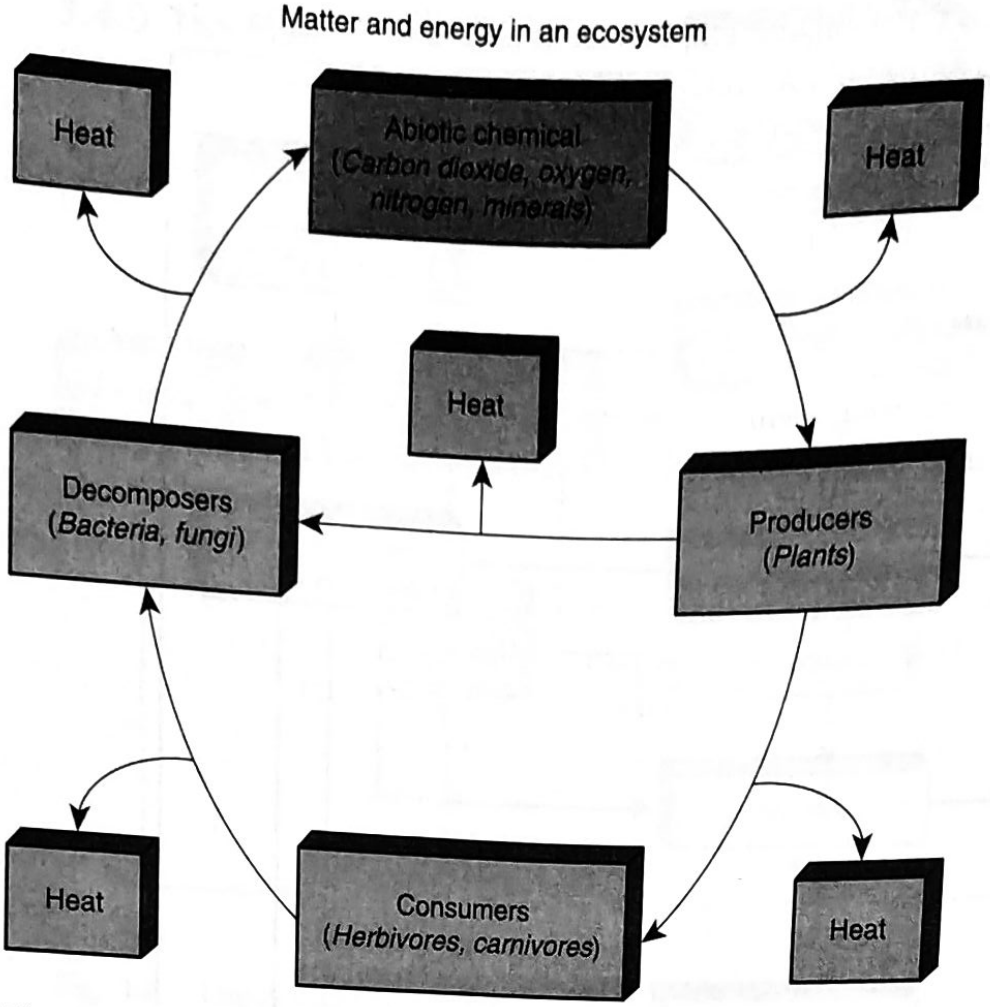


Fig. 3.6 Energy flow

linked to one another through *food chains*. Each food chain has three or four links. However, as each plant or animal can be linked to several other plants or animals through many different links, these interlinked chains can be depicted as a complex *food web*. This is thus called the 'web of life' since it shows that there are thousands of interrelationships in nature.

The energy in the ecosystem can be depicted in the form of a *food* or *energy pyramid*. The food pyramid has a large base of plants called producers. The pyramid has a narrower middle section that depicts the number and biomass of herbivorous animals, which are called *first-order consumers*. The apex depicts the small biomass of carnivorous animals called *second-order consumers*. Humans are one of the animals at the apex of the pyramid. Thus, to support mankind, there must be a large base of herbivorous animals and an even greater quantity of plant material.

When plants and animals die, this material is returned to the soil after being broken down into simpler substances by decomposers, such as insects, worms, bacteria and fungi, so that plants can absorb the nutrients through their roots. Animals excrete waste products after digesting food, which goes back to the soil. This links the energy cycle to the nitrogen cycle.

3.4.8 Integration of Cycles in Nature

These cycles are a part of global life processes. These biogeochemical cycles have specific features in each of the ecosystems. These cycles are linked to those of adjacent ecosystems, although

their characteristics are specific to the plant and animal communities in the region. This is, in turn, related to the geographical features of the area, the climate and the chemical composition of the soil. Together, the cycles are responsible for maintaining life on earth. If humans disturb these cycles beyond the limits that nature can sustain, they will eventually break down and lead to a degraded earth on which we will not be able to survive.

3.5 Ecological Succession

Ecological succession is a process through which ecosystems tend to change over a period of time. Succession can be related to seasonal environmental changes, which create changes in the community of plants and animals living in the ecosystem. Other successional events may take much longer periods of time, extending to several decades. If a forest is cleared, it is initially colonised by a certain group of species of plants and animals, which gradually change through an orderly process of community development. One can predict that a cleared or open area will gradually be converted into a grassland, a shrubland and finally a woodland and a forest, if permitted to do so without human interference. There is a tendency for succession to produce a more or less stable state at the end of the successional stages. The most frequent example of successional changes occur in a pond ecosystem, where it fluctuates from a dry terrestrial habitat to the early colonisation stage by small aquatic species after the monsoon, which gradually passes through to a mature aquatic ecosystem, and then reverts back to its dry stage in summer when its aquatic life remains dormant.

3.6 Food Chains, Food Webs and Ecological Pyramids

The transfer of energy from the source in plants through a series of organisms, by eating and being eaten, constitutes the food chain. At each transfer, a large proportion of energy is lost in the form of heat. These food chains are not isolated sequences, but are interconnected. This interlocking pattern is known as the food web. Each step of the food web is called a *trophic level*. These trophic levels together form the ecological pyramid.

3.6.1 The Food Chains

The most obvious aspect of nature is that energy must pass from one living organism to another. When herbivorous animals feed on plants, energy is transferred from the plants to the animals. In an ecosystem, some of the animals feed on other living organisms, while some feed on dead organic matter; the latter form the detritus of the food chain. At each link in the chain, a large part of the energy from the food is lost through daily activities. Each chain usually has only four to five such links. However, a single species may be linked to a large number of species.

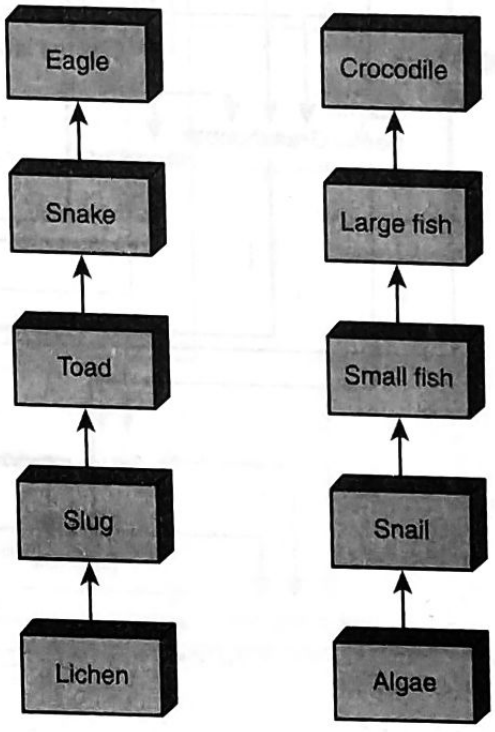


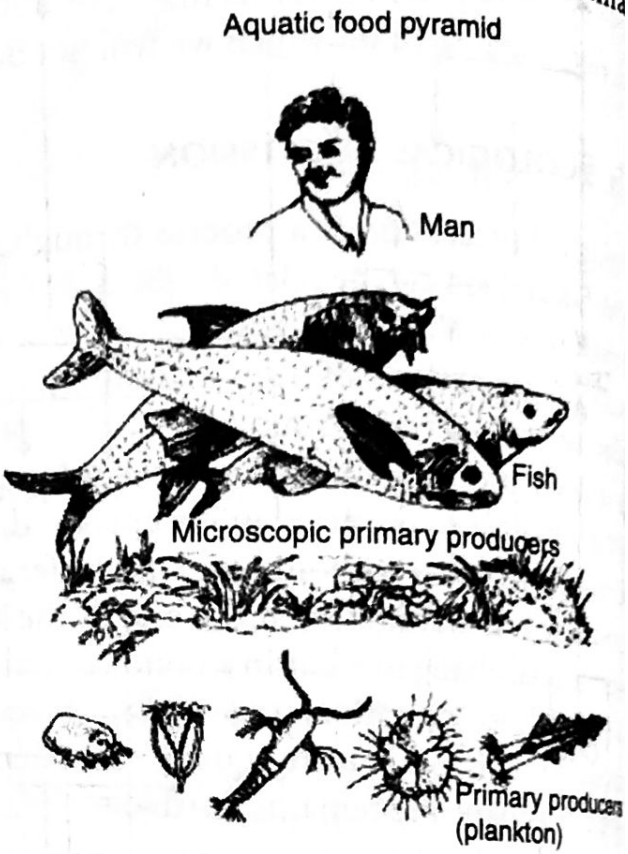
Fig. 3.7 Simple food chains

3.6.2 The Food Webs

In an ecosystem, there are a very large number of interlinked chains; together, these form food web. If the links in the chains that make up the web of life are disrupted due to human activities that lead to the loss or extinction of species, the web breaks down.

3.6.3 The Ecological Pyramids

In an ecosystem, green plants (the producers) utilise energy directly from sunlight and convert it into matter. A large number of these organisms form the most basic or first trophic level of the food pyramid. The herbivores that eat plants are at the second trophic level and are called primary consumers. The predators that feed on them form the third trophic level and are known as secondary consumers. Only a few animals form the third trophic level consisting of the carnivores at the apex of the food pyramid. This is how energy is used by living creatures and flows through the ecosystem from its base to the apex.



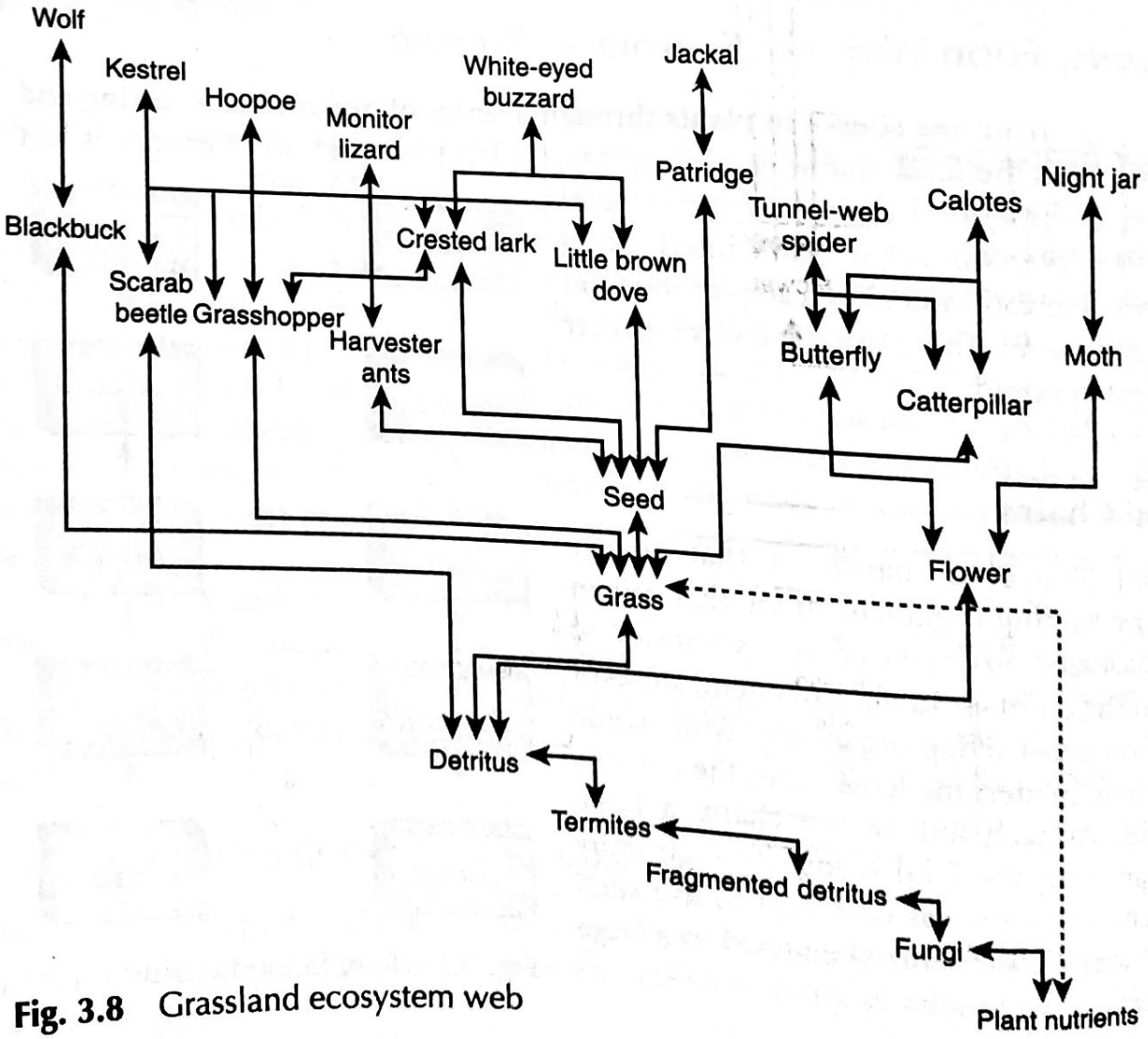


Fig. 3.8 Grassland ecosystem web

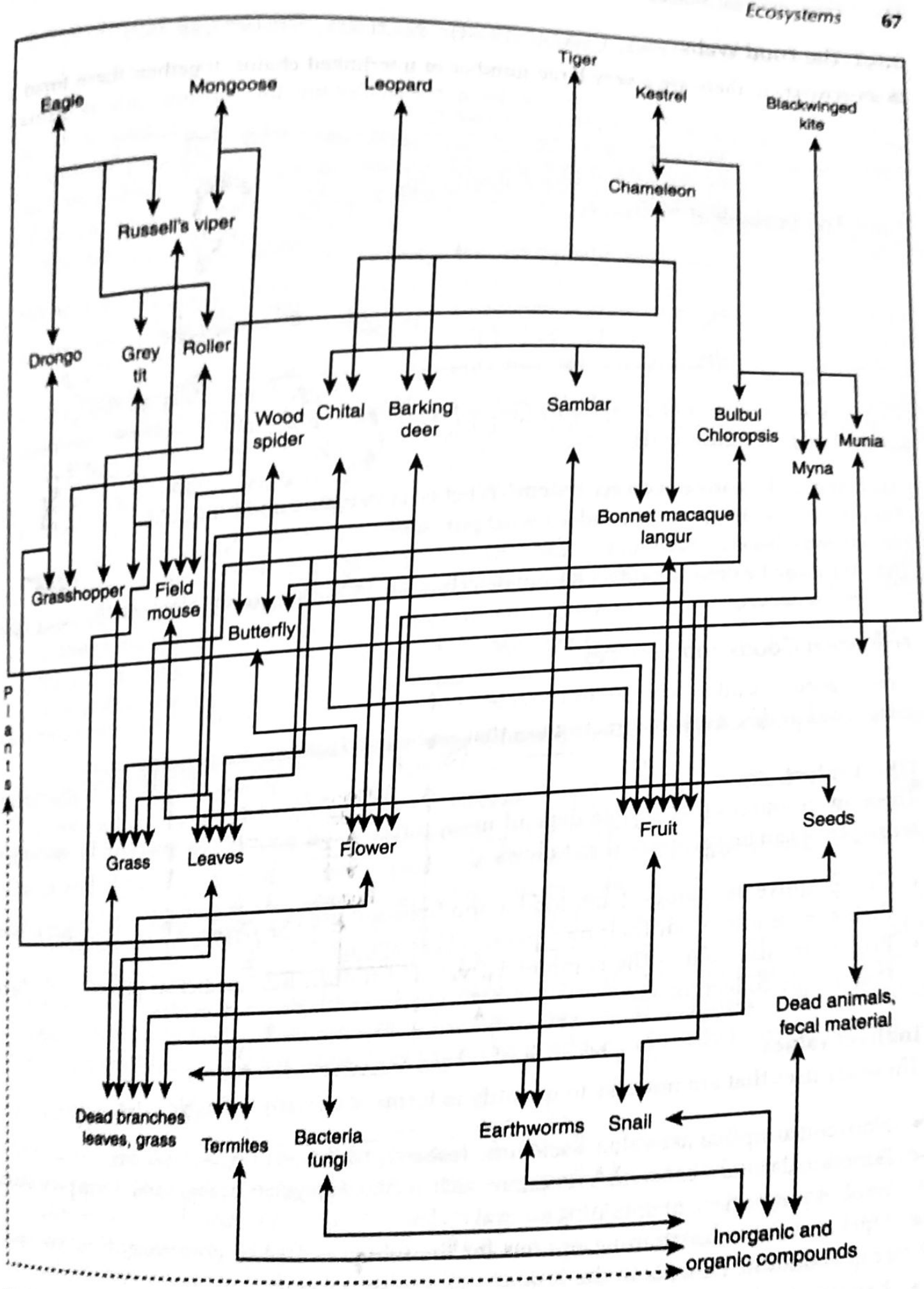


Fig. 3.9 Forest ecosystem web

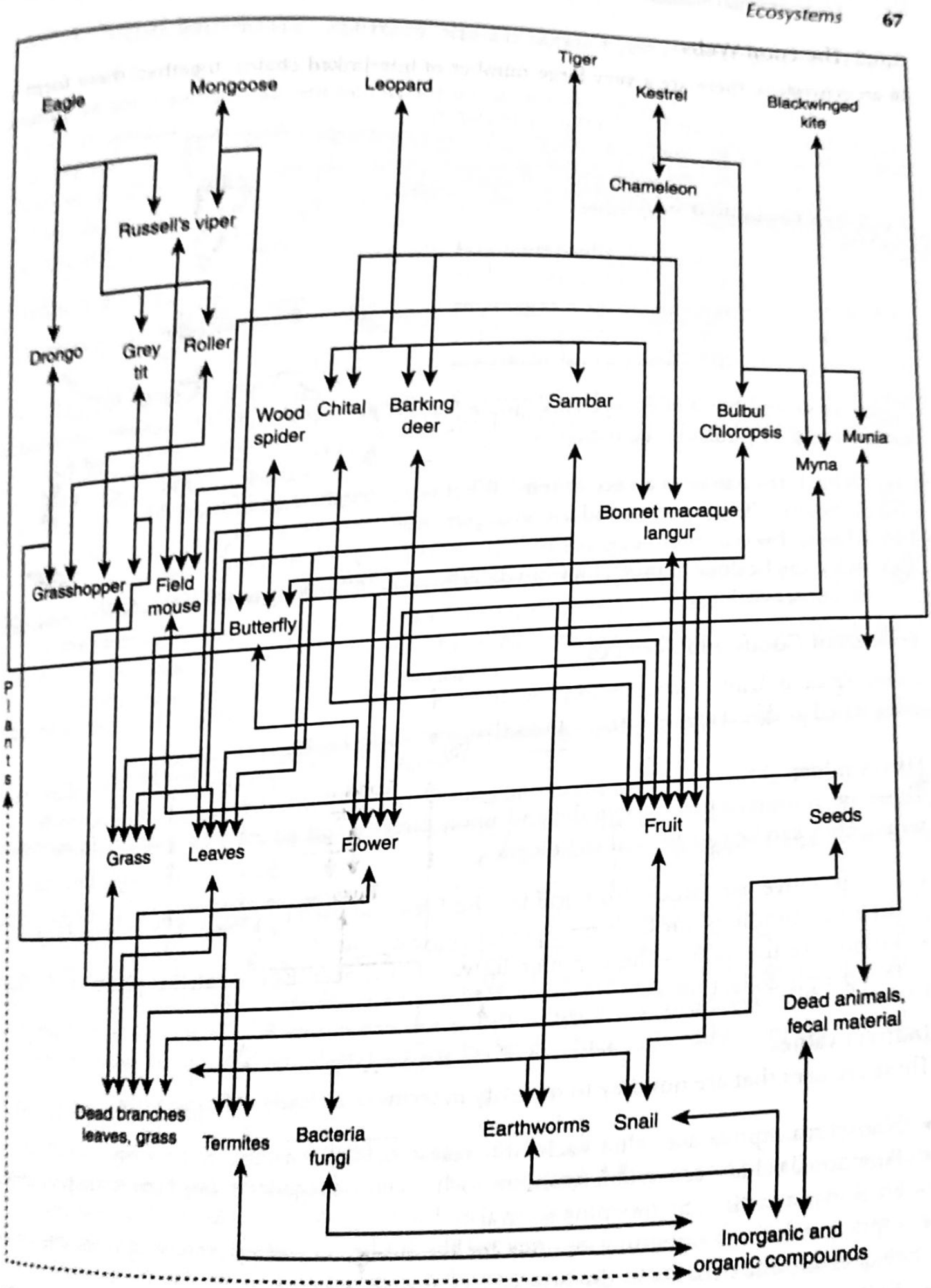


Fig. 3.9 Forest ecosystem web

3.7 Introduction, Types, Characteristic Features, Structure and Functions

Table 3.1 Types of ecosystems

Terrestrial ecosystems	Aquatic ecosystems
Forest	Pond
Grassland	Lake
Semi-arid areas	Wetland
Deserts	River
Mountains	Delta
Islands	Marine

There are several types of ecosystems (Table 3.1). For each of these ecosystems, we need to understand four fundamental issues:

(i) What is the nature of an ecosystem? What is its structure and function?
(ii) Who uses the ecosystem and for what purpose?
(iii) How is this ecosystem degraded?
(iv) What can be done to protect it from deteriorating in the long term? How can the ecosystem be conserved?

Ecosystem Goods and Services

As discussed in Unit 1, ecosystems provide a range of goods and services. These can be broadly categorised as direct and indirect values that we benefit from.

Direct values

These are resources that people depend upon directly and are easy to quantify in economic terms. They can be categorised as follows:

- Consumptive use value—fruit, fodder and firewood used by people who collect them from their surroundings, for their own personal use and not for sale.
- Productive use value—the commercial value of timber, fish, medicinal plants, and others that people collect for sale.

Indirect values

These are uses that are not easy to quantify in terms of a clearly definable price.

- Non-consumptive use value—scientific research, bird-watching, ecotourism.
- Functional value—ecosystem functions such as climate regulation, flood and storm protection, erosion prevention, maintaining natural cycles.
- Option value—maintaining options for the future, so that by preserving them one could reap economic benefits in the future.
- Existence value—the ethical and emotional aspects of the existence of wildlife and nature.

3.7.1 Forest Ecosystems

Forests are formed by a community of plants, which is predominantly structurally defined by its trees, shrubs, climbers and ground cover. Natural vegetation looks and is vastly different from a group of planted trees in orderly rows. The most 'natural' undisturbed forests are located mainly in national parks and wildlife sanctuaries. The landscapes that make up various types of forests look very different from each other. Their distinctive appearance is one of the fascinating aspects of nature. Each forest type forms a habitat for a specific community of animals that are adapted to live in it.

What is a Forest Ecosystem?

A forest ecosystem has two parts:

- *The non-living or abiotic aspects of the forest*: The type of forest depends on the abiotic conditions at the site. Forests on mountains and hills differ from those along river valleys. The vegetation is specific to the amount of rainfall and local temperature, which vary according to latitude, altitude and soil type.
- *The living or biotic aspects of the forest:* The plants and animals form communities that are specific to each forest type. For instance, coniferous trees occur in the Himalayas; mangrove trees in river deltas; thorn trees in arid areas. The snow leopard lives in the Himalayas, while the leopard and tiger live in the forests in the rest of India. Wild sheep and goats live high up in the Himalayas and many of the birds of the Himalayan forests are different from those in the rest of India. The evergreen forests of the Western Ghats and Northeast India have the richest diversity of plant and animal species.

The biotic component includes both large (macrophytes) and microscopic plants and animals.

Plants include the trees, shrubs, climbers, grasses and herbs in the forest. These include species that flower (angiosperms) and are non-flowering (gymnosperms) such as ferns, bryophytes, fungi and algae. The *animals* include species of mammals, birds, reptiles, amphibians, fish, insects and other invertebrates and a variety of microscopic animals.

As the plant and animal species are closely dependent on each other, together they form different types of forest communities. Humans are a part of these forest ecosystems and the local people depend directly on the forest for several natural resources that act as their life-support systems. People who do not live in the forest buy forest products such as wood and paper extracted from the forest. Thus, they use forest produce indirectly from the market.

Forest Types in India

The forest type depends on abiotic factors such as the climate and soil characteristics of a region. Forests in India can be broadly divided into coniferous forests and broad-leaved forests.

They can also be classified according to the nature of their tree species—evergreen, deciduous, xerophytes or thorn trees, mangroves and so on. They can also be classified according to the most abundant species of trees, such as sal or teak forests. In many cases, a forest is named after the first three or four most abundant tree species.

3.7.1 Forest Ecosystems

Forests are formed by a community of plants, which is predominantly structurally defined by its trees, shrubs, climbers and ground cover. Natural vegetation looks and is vastly different from a group of planted trees in orderly rows. The most 'natural' undisturbed forests are located mainly in national parks and wildlife sanctuaries. The landscapes that make up various types of forests look very different from each other. Their distinctive appearance is one of the fascinating aspects of nature. Each forest type forms a habitat for a specific community of animals that are adapted to live in it.

What is a Forest Ecosystem?

A forest ecosystem has two parts:

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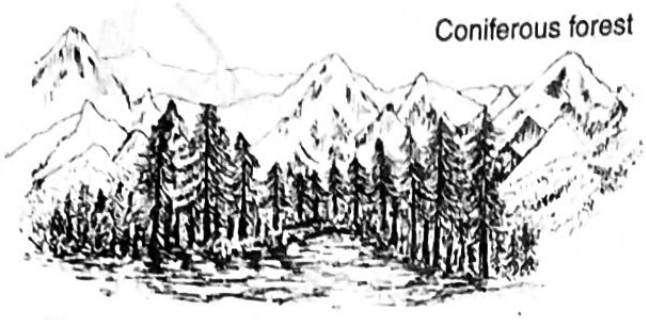

Coniferous forest

Coniferous forests grow in the Himal mountain region, where the temperatures are These forests have tall stately trees with nee like leaves and downward-sloping branches, that the snow can slip off the branches. Th have cones instead of seeds and are call gymnosperms.

Broad-leaved forests are of several types, such as evergreen forests, deciduous forests, thorn forests, and mangrove forests. Broad-leaved trees usually have large leaves of various shapes and are found in the middle to lower latitudes.

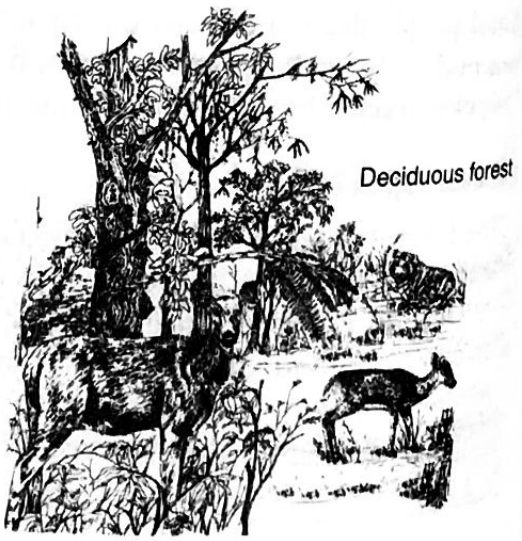
Broadleaved forest

Evergreen forests grow in the high rainfall areas of the Western Ghats, Northeastern India and the Andaman and Nicobar Islands. These forests grow in areas where the monsoon lasts for several months. Some places even get two monsoons, such as in Southern India. Evergreen plants shed a few of their leaves throughout the year. There is no dry leafless phase as in the case of deciduous forests. So an evergreen forest looks green throughout the year. The trees overlap with each other to form a continuous canopy. Thus, very little light penetrates down to the forest floor. Only a few shade-loving plants can grow in the ground layer in areas where some light filters down from the closed canopy. The forest is rich in orchids and ferns. The barks of the trees are covered in moss. The forest abounds in animal life and is very rich in insect life.

Evergreen forest

Deciduous forests are found in regions with a moderate amount of seasonal rainfall that lasts for only a few months. Most of the forests in which teak trees grow are of this type. The deciduous trees shed their leaves during the winter and hot summer months. In March or April they regain their fresh leaves just before the monsoon, when they grow vigorously in response to the rains. Thus, there are periods of leaf-fall and canopy regrowth. The forest frequently has thick undergrowth as light can penetrate easily onto the forest floor.

Deciduous forest



Thorn forests are found in the semi-arid regions of India. The trees, which are sparsely distributed, are surrounded by open grassy areas. Thorny plants, called xerophytic species, are able to conserve water. Some of these trees have small leaves, while other species have thick, waxy leaves to reduce water loss during

transpiration. Thorn-forest trees have long or fibrous roots to enable them to reach water at great depths. Many of these plants have thorns, which reduce water loss and protect them from herbivores.

Mangrove forests grow along the coast, especially in the river deltas. These plants are uniquely adapted to be able to grow in a mix of saline and freshwater. They grow luxuriantly in muddy areas covered with silt that the rivers have brought down. They have breathing roots that emerge from the mudbanks.

Forest utilisation

Natural forests provide local people with a variety of products, if the forest is used carefully. The forest products collected by people include food like fruit, roots, herbs and medicinal plants. People depend on fuelwood to cook food, collect fodder for domestic animals and cut building material for housing, medicinal plants that have been known for generations to treat several ailments, and use a variety of NTFPs such as fibre, cane and gum to make household articles.

Table 3.2 Forest communities

Forest type	Plants (examples)	Common animals (examples)	Rare animals (examples)
Himalayan coniferous	Pine, deodar	Wild goats and sheep, Himalayan black bear	Snow leopard, *hangul*, Himalayan brown bear, musk deer, Himalayan wolf
Himalayan broad-leaved	Maple, oak		
Evergreen North-east, Western ghats, Andaman and Nicobar	Jamun, ficus, Dipterocarpus	Tiger, leopard, *sambar*, Malabar whistling thrush, Malabar pied hornbill, tree frogs	Pigmy hog, rhinocerous, lion-tailed macaque
Deciduous-dry	Teak, *ain*, terminalia	Tiger, *chital*, barking deer, babblers, flycatchers, hornbills	
Deciduous-moist	Sal		
Thorn and scrub, semi-arid forests	*Ber*, babul, neem lizard	Blackbuck, *chinkara*, four-horned antelope, partridge, monitor lizard	Bustard, florican
Mangrove delta forests	Avicenia	Crocodiles, shorebirds such as sandpipers, plovers, fish, crustaceans	Water monitor lizard

Woods from different species of trees are put to a variety of uses. For instance, softwood is used for the yoke of a bullock cart while hardwood is used for its axle.

These forest products are of great economic value as they are collected, sold and marketed. Forest dwellers and agricultural people use these goods directly, while other people get them indirectly from the market. Traditional types of agriculture need forest material like branches and leaves, which are burnt to form wood-ash which acts as a fertiliser for crops such as rice.

Forest services include the control of the flow of water in streams and rivers. Forest cover reduces the surface run-off of rainwater and allows groundwater to be stored. Forests also prevent the erosion of soil. Once soil is lost by erosion, it can take thousands of years to re-form. Forests also regulate the local temperature. It is cooler and more moist under the shade of the trees in the forest. Most importantly, forests absorb carbon dioxide and release oxygen that we require to breathe.

The wild relatives of crop plants and fruit trees have special characteristics which are used to develop new crops and newer varieties of fruit. These newer varieties give greater yields or are more resistant to diseases. New industrial products are being produced from the wild plants of the forest. Many of our new medicines come from wild plants.

Direct uses of forest products

- Fruits: Mango, *jamun*, *amla*
- Roots: Dioscoria
- Medicine: Gloriosa, foxglove
- Fuelwood: Many species of trees and shrubs
- Small timber for building huts and houses
- Wood for farm implements
- Bamboo and cane for baskets
- Grass for grazing and stall feeding livestock

Indirect uses of forest products

- Building material for construction and furniture for the urban sector
- Medicinal products collected and processed into drugs
- Gums and resins processed into a variety of products
- Raw material for industrial products and chemicals
- Paper from bamboo and softwoods

What are the Threats to the Forest Ecosystem?

As forests grow very slowly, we cannot use more resources than they can produce during a growing season. If timber is felled beyond a certain limit, the forest cannot regenerate. The gaps in the forest change the habitat quality for animals, and the more sensitive species cannot survive under these changed conditions. Over-utilising forest resources for fuelwood or timber and conversion to monoculture plantations for timber or other products impoverishes the local people as the economic benefit usually accrues to people who live elsewhere. The entire resource base on which local people have traditionally survived for generations, gets rapidly destroyed. Eventually, the forest is completely degraded, impacting other forest functions. For

example, the loss of forest cover leads to irreversible changes such as soil erosion, large run-off of surface water during monsoons leading to flash-floods and a shortage of water once the monsoon is over. Other threats such as illegal extraction of wood from many forests result in similar problems of forest degradation.

Developmental activities such as rapid population growth, together with urbanisation, industrialisation and the increasing use of consumer goods, lead to the over-utilisation of forest produce. The forests are rapidly shrinking as the need for agricultural land increases. It is estimated that India's forest cover has decreased from about 33% to 11% in the last century. The increasing use of wood for timber, wood-pulp for paper and the extensive use of fuelwood result in continual forest loss. Forests are also lost by mining and building dams. As the forest resources are exploited, the forest canopy is opened up, the ecosystem is degraded, and its wildlife is seriously threatened. As the forest is fragmented into small patches, wild plant and animal species become extinct. And these can never be brought back.

CASE STUDY 1

Threats to Kudremukh National Park in Karnataka

Kudremukh, a tropical wet evergreen-type forest of the Western ghats, extends to over 600 square kilometres and provides a habitat for the three big carnivores – tiger, leopard and wild dog – amongst several other species such as the lion-tailed macaque and wild boar. Mining continues to be a threat to this national park, even though the Supreme Court placed an order in 2005 to shut down all such operations and to restore all degraded land in the forest area. However, the mining lobby and state government agencies have still not restored the degraded forest land. Furthermore, illegal storage and maintenance of mining equipment in Kudremukh indicates the unwillingness of the state government to stop mining operations.

What if the Forests Disappear?

When forests are cut, tribal people who depend directly on them for food and fuelwood and other products find it very difficult to survive. Agricultural people do not get enough fuelwood and small timber for making houses and farm implements. Urban people depend on food from agricultural areas, which in turn depend on neighbouring forest ecosystems, and they have to pay higher prices for food as the human population increases.

The insects that live and breed in the forest such as bees, butterflies and moths decrease in number once forests are degraded. As their numbers decrease, they are unable to effectively pollinate agricultural crops and fruit trees. This leads to a decline in agricultural yield.

The rain that falls on deforested land flows directly into nearby rivers. Thus, water is not retained underground and people do not get a sufficient supply of water throughout the year. The exposed soil is rapidly washed away during the rains once the protective forest cover is removed, seriously affecting agriculture in such areas. In deforested areas, the water in streams is brown in colour as the soil is washed away, while the water in forested streams is crystal clear.

In addition, wild animals lose their habitat, leading to the extinction of many precious species. The residual forests must be protected from being destroyed any further if all the diverse species of plants and animals are to be protected for future generations.

CASE STUDY 2

Maharashtra floods 2005

Many parts of Maharashtra, including Mumbai, were impacted by severe flooding on 26 July 2005. The floods were caused by heavy torrential rain; Mumbai was lashed with 994 mm (39.1 inches) of rain which lasted 24 hours and continued erratically the next day. At least 5000 people died and thousands of people were left stranded on the road with their homes inundated. The entire city came to a standstill. Amongst other causes such as clogged and insufficient drainage systems, the large-scale destruction of mangroves and wetlands along the coastline was a major contributor to the magnitude of damage in terms of lives and property. These mangroves and wetlands would otherwise have provided for a natural barrier against flooding and reduced the strength of the waves.

How can Forest Ecosystems be Conserved?

We can conserve forests only if we use the resources carefully. This can be done by leading sustainable lifestyles. Some examples include using non-wood products in homes, re-using paper and using alternative sources of energy instead of fuelwood. Further, there is a need to grow more trees to replace those that are cut down from forests every year for timber. Afforestation needs to be done continuously, from which fuelwood and timber can be judiciously used.

The natural forests with all their diverse species must be protected as national parks and wildlife sanctuaries where plants and animals can be preserved.

3.7.2 Grassland Ecosystems

These include a wide range of landscapes in which the vegetation is predominantly grass and small annual plants specifically adapted to India's climatic conditions.

What is a Grassland Ecosystem?

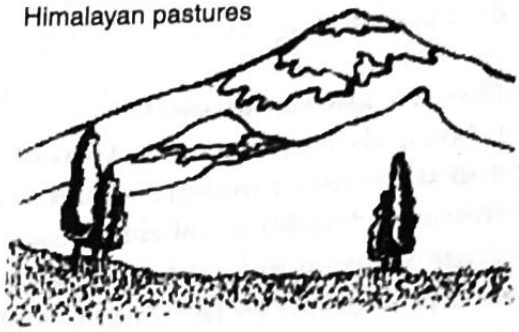
Grasslands cover areas where rainfall is usually low and/or soil depth and quality is poor. The low rainfall prevents the growth of a large number of trees and shrubs, but is sufficient to support the growth of grass cover during the monsoon. Many grasses and other small herbs become dry and the exposed portion of the plant above the ground dies in summer. In the next monsoon, the grass cover grows back from the root-stock and the seeds of the previous year. This change gives grasslands a highly seasonal appearance, with periods of increased growth being followed by a dormant phase.

A variety of grasses, herbs and several species of insects, birds and mammals have evolved so that they are adapted to these wide-open grass-covered areas. These animals can live in conditions where food is plentiful after the rains, so they can store this as fat for use during the dry period when there is very little to eat. Humans began to use these grasslands as pastures to feed livestock when animals were domesticated and thus became pastoralists in ancient times.

Types of grasslands in India: Grasslands form a variety of ecosystems located in different climatic conditions, ranging from near-desert conditions to patches of shola grasslands that occur on hill-slopes alongside the extremely moist evergreen forests in South India. In the Himalayas, there are the high cold pastures. There are tracts of tall elephant grass in the low-lying *terai* belt south of the Himalayan foothills. There are also semi-arid grasslands in Western India, parts of Central India and in the Deccan plateau.

The *Himalayan pasture belt* extends up to the snowline; the grasslands at a lower level form patches along with coniferous or broad-leaved forests. Himalayan wildlife requires both forest and grassland ecosystems as vital parts of their habitat. The animals migrate up into the high-altitude grasslands in the summer and move down into the forest in the winter when the snow covers the grasslands. These Himalayan pastures have a large variety of grasses and herbs. The Himalayan hill-slopes are covered with thousands of colourful flowering plants as well as a large number of medicinal plants.

Himalayan pastures



Terai grassland

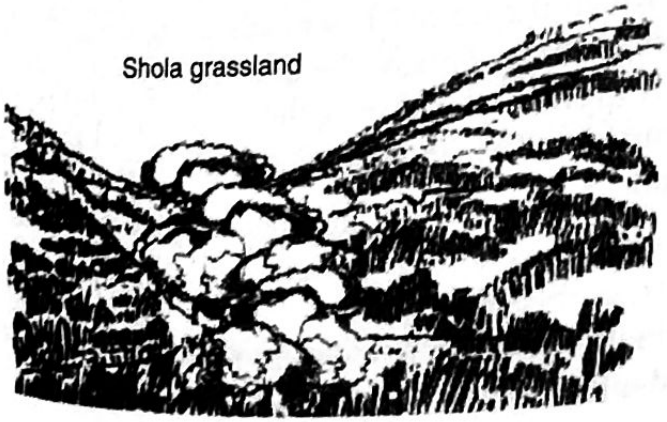
The *terai* consists of patches of tall grasslands interspersed with sal forest ecosystems. The patches of tall elephant grass, which grow to a height of about five metres, are located in the low-lying waterlogged areas. The sal forest patches cover the elevated regions and the Himalayan foothills. The *terai* also includes marshes in low-lying depressions. This ecosystem extends in a belt south of the Himalayan foothills.

The *semi-arid plains of Western India, Central India and the Deccan* are covered by grassland tracts with patches of thorn forest. Several mammals such as the wolf, blackbuck, *chinkara* and birds such as bustards and floricans are adapted to these arid conditions. The scrublands of the Deccan plateau are covered with seasonal grasses and herbs on which its fauna is dependent. It teems with insect life on which the insectivorous birds feed.

Semiarid grassland

The *shola grasslands* consist of patches on hill-slopes that occur alongside the *shola* forests on the Western ghats, the Nilgiri and Anamalai ranges. These form patchworks of grassland on the slopes and forest habitats along the streams and low-lying areas.

Shola grassland



Grasslands are not restricted to low-rainfall areas. Certain grassland types form when clearings are made in different forest types. Some are located on the higher, steep hill-slopes with patches of forest that occur along the streams and in depressions. The grasslands are related to repeated fires that do not permit the forest to grow.

Grasses are the main producers of biomass in these regions. Each grassland ecosystem has a wide variety of species of grasses and herbs. Some grass and herb species are more sensitive to excessive grazing and are suppressed if the area is over-grazed. Others are destroyed by repeated fires and cannot regenerate. Thus over-used or frequently burnt grasslands are degraded and are poor in plant species diversity.

How are grasslands used?

Grasslands are the grazing areas of many rural communities. Farmers who keep cattle or goats and shepherds who keep sheep, are highly dependent on grasslands to supply food for their livestock. Fodder is collected and stored to feed cattle when there is no grass left for them to graze in summer. Further, grasslands maintain biodiversity, serve as a storehouse for carbon and provide for recreational use and wildlife viewing. Grass is also used to thatch houses and farm-sheds. The thorny bushes and branches of the few trees that are seen in grasslands are used as the main source of fuelwood.

What are the threats to grassland ecosystems?

In many areas, grasslands have been used for centuries by pastoral communities. Over-utilisation and changes in use of the 'common grazing lands' of rural communities has led to their degradation. Grasslands have a limited ability to support domestic animals and wildlife. When animals over-graze, the grasses are converted into flat stubs with very little green matter. Degraded grasslands have fewer grass species as the nutritious species are entirely used up by the large number of domestic animals and are thus unable to regenerate. Therefore, increasing the number of domestic animals reduces the 'naturalness' of the grassland ecosystem, leading to its deterioration. The grassland cover in the country, in terms of permanent pastures, is only 3.7% of the total land (Food and Agriculture Organisation, 2002).

Other than over-grazing, another major threat to natural grasslands is their conversion into irrigated farmlands. In the Deccan, grasslands have been converted to irrigated farms and are now mainly used to grow sugarcane, which is a water-intensive crop. After continuous irrigation, such land becomes saline and useless in a few years. More recently, many of these residual grassland tracts have been converted into industrial areas. This provides short-term economic gains but results in long-term economic and ecological loss. Other human activities such as fires also affect grasslands adversely. When fires are lit in the grasslands in summer, the burnt grass gets a fresh flush of small green shoots which the domestic animals graze on. If this is done too frequently, the grasslands begin to deteriorate. Finally, the grasslands become bare; the soil is solidly compacted by trampling, or is washed away during the monsoon by rain and whipped into dust storms during the hot dry summer. The land is degraded, as there is no grass to hold the soil in place. It becomes a wasteland.

Why are our grassland species vanishing?

Most people think that it is only our forests and its wildlife that is disappearing. However, other natural ecosystems, such as grasslands, are disappearing even more rapidly.

Many of the grassland species have disappeared from several parts of India in which they were found 50 or 60 years ago. The cheetah is extinct in India; the wolf is now highly threatened; the blackbuck and *chinkara* are being poached for their meat; birds such as the beautiful great Indian bustard are vanishing. Unless grassland species are protected, they will vanish from their shrinking habitat, as natural and undisturbed grasslands are left in very few locations. If these animals and birds are killed or their habitat is reduced further, their extinction will rapidly follow.

What if our grasslands disappear?

If our grasslands are destroyed, we will lose a highly-specialised ecosystem to which plants and animals adapted themselves over millions of years. In addition, the local people will not be able to support their livestock herds.

The extinction of species is a great loss to humankind. The genes of wild grasses are extremely useful for developing new crop varieties. New medicines could well be discovered from wild grassland plants. It is possible that genes from wild herbivores like wild sheep, goat and antelope may be used for developing new strains of domestic animals. All these possibilities will be lost along with the grasslands.

How can grassland ecosystems be conserved?

Grasslands should not be over-grazed and some areas should be closed for grazing. It is better to collect grass for stall-feeding cattle. A part of the grassland in an area must be closed every year, so that a rotational grazing pattern is established. Fires must be prevented and rapidly controlled. In hilly areas, soil and water management in each micro-catchment will help the grassland to return to a natural, highly-productive ecosystem.

To protect the most natural undisturbed grassland ecosystems, sanctuaries and national parks must be created. Their management should focus on preserving all their unique species of plants and animals. Thus, they should not be converted into plantations of trees. The open grassland is the habitat of its specialised fauna. Planting trees in these areas reduces the natural features of this ecosystem, resulting in the destruction of this unique habitat for wildlife.

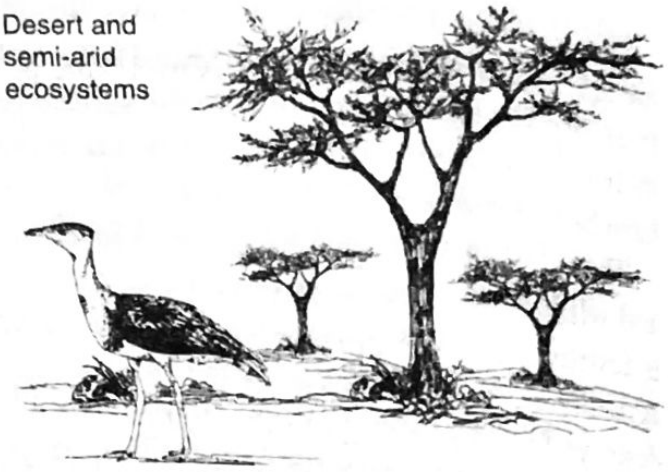
What should we do?

- There is a pressing need to preserve the few natural grassland areas that still survive by creating national parks and wildlife sanctuaries in the different types of grasslands.
- Animals such as the wolf, blackbuck, *chinkara* and birds such as the bustard and florican have now become rare. They must be carefully protected in the few national parks and wildlife sanctuaries that have natural grassland habitats as well as outside these PAs.
- We need to create awareness among people that grasslands are of great value. If we are all concerned about our disappearing grasslands and their wonderful wildlife, the Government will be motivated to protect them.
- Keeping grasslands alive should be made a national priority.

3.7.3 Desert Ecosystems

Desert and semi-arid lands are extremely specialised and sensitive ecosystems that are easily destroyed by human activities. The plants and animals that inhabit these dry areas can live only in this ecosystem.

What is a Desert or Semi-Arid Ecosystem?


Desert and semi-arid ecosystems

Deserts and semi-arid areas are mainly located in Western India and the Deccan plateau. The climate in these vast tracts is extremely dry. Cold deserts such as in Ladakh, located in the high plateaus of the Himalayas, also exist. The most typical desert landscape seen in Rajasthan is in the Thar desert. This has sand dunes; it also has areas covered with sparse grasses and a few shrubs, which grow if it rains. In most areas of the Thar, rainfall is scanty and sporadic. In some areas, it may rain only once every few years. In the adjoining semi-arid tract, the vegetation consists of a few shrubs and thorny trees such as *kher* and *babul*.

The Great and Little Rann of Kutch are extraordinarily specialised arid ecosystems. In summer, they are similar to a desert landscape. However, as these are low-lying areas near the sea, they are converted to salt marshes during the monsoons. During this period, they attract an enormous number of aquatic birds such as ducks, geese, cranes and storks. The Great Rann is famous, as it is the only known breeding colony of the greater and lesser flamingos in our country. The Little Rann of Kutch is the only home of the wild ass in India.

Desert and semi-arid regions have a number of highly-specialised insects and reptiles. The rare animals include the Indian wolf, desert cat, desert fox and birds such as the great Indian bustard and florican. Some of the more common birds include the partridge, quail and sand-grouse.

How are desert and semi-arid ecosystems used?

Areas of scanty vegetation with semi-arid scrubland have been used for camel, cattle and goat grazing in Rajasthan and Gujarat, and for sheep grazing in the Deccan plateau.

Areas that have a little moisture, for example along the watercourses, have been used for growing crops such as *jowar* (sorghum) and *bajra* (millet). The natural grasses and local varieties of crops have adapted to growing at very low moisture levels. These can be used for genetic engineering and developing semi-arid land crops for the future.

What are the threats to desert ecosystems?

Several types of development strategies as well as human population growth have begun to affect the natural ecosystem of the desert and semi-arid lands. The conversion of these lands through extensive irrigation systems has changed several of the natural characteristics of this region. Canal water evaporates rapidly bringing the salts to the surface. The region becomes highly unproductive as it becomes saline. The over-extraction of groundwater from tube wells lowers the water table, creating an even drier environment. Thus, human activities are destroying the authenticity of this unique ecosystem. The special species that evolved here over millions of years may soon become extinct.

How can desert ecosystems be conserved?

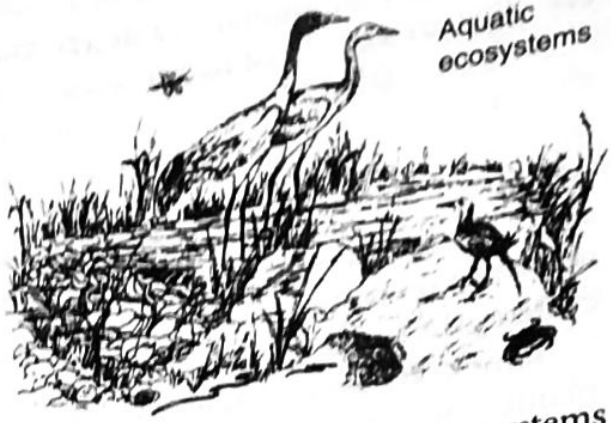
Desert ecosystems are extremely sensitive. Their ecological balance that forms a habitat for their plants and animals is easily disturbed. Desert people have traditionally protected their

meagre water resources. The Bishnoi tribe in Rajasthan is known to have protected their *khejdi* trees and the blackbuck antelope for several generations. The tradition began when the ruler of their region ordered his army to cut down trees for his own use. Several Bishnois were said to have been killed while trying to protect their trees.

There is a pressing need to protect residual patches of this ecosystem within national parks and wildlife sanctuaries in desert and semi-arid areas. The Indira Gandhi canal in Rajasthan is destroying this important natural arid ecosystem, as it will convert the region into intensive agriculture. In Kutch, areas of the little Rann, which is the only home of the wild ass, will be destroyed by the spread of salt works.

Development projects alter the desert and arid landscape. There is a sharp reduction in the habitat available for its noteworthy species, bringing them to the verge of extinction. We need a sustainable form of development that takes the special needs of the desert into account.

3.7.4 Aquatic Ecosystems


Aquatic ecosystems

The aquatic ecosystems comprise the marine environments of the sea and freshwater systems in lakes, rivers, ponds and wetlands.

What is an Aquatic Ecosystem?

In aquatic ecosystems, plants and animals live in water. These species are adapted to live in different types of aquatic habitats. The special abiotic features are its physical aspects such as the quality of the water, which includes its clarity, salinity, oxygen content and rate of flow. Aquatic ecosystems may be classified as being *stagnant* ecosystems or *running water* ecosystems. The mud, gravel or rocks that form the bed of the aquatic ecosystem alter its characteristics and influence its plant and animal species composition. Aquatic ecosystems are also classified into *freshwater, brackish* and *marine* ecosystems, which are based on the salinity levels.

The freshwater ecosystems that have running water are streams and rivers. Ponds, tanks and lakes are ecosystems where water does not flow. *Wetlands* are special ecosystems in which the water level fluctuates dramatically in different seasons. They have expanses of shallow water with aquatic vegetation, which forms an ideal habitat for fish, crustaceans and water birds.

Marine ecosystems are highly saline, while brackish areas have less saline water such as in river deltas. *Coral reefs* are very rich in species and are found in only a few shallow tropical seas. The richest coral reefs in India are around the Andaman and Nicobar islands and in the Gulf of Kutch.

Table 3.3 Types of aquatic ecosystems

Fresh water ecosystems		Marine ecosystems	
Flowing water (examples)	Still water (examples)	Brackish water (examples)	Saline water (examples)
Streams, rivers	Ponds, deltas, wetlands, lakes	Coastal	Deep ocean, shallows, coral reefs

Brackish water ecosystems in river deltas are covered by mangrove forests and are among the world's most productive ecosystems in terms of biomass production. The largest mangrove swamps are in the Sunderbans in the delta of the Ganges river.

Pond ecosystems

The pond is the simplest aquatic ecosystem. There are differences between a temporary pond that has water only in the monsoon season and a larger tank or lake that is an aquatic ecosystem throughout the year. Most ponds become dry after the rains are over and are covered by terrestrial plants for the rest of the year.

When a pond begins to fill during the rains, its life forms, such as algae and microscopic animals, aquatic insects, snails and worms, emerge from the floor of the pond where they remained dormant during the dry phase. Gradually, more complex animals such as crabs, frogs and fish return to the pond. The vegetation consists of floating weeds and rooted vegetation on the periphery, whose roots are in the muddy floor under the water and whose foliage emerges from the surface of the water.

As the pond fills in the monsoon season, a large number of food chains are formed. The algae are eaten by microscopic animals, which are in turn eaten by small fish, on which the larger carnivorous fish depend. These are in turn eaten by birds such as kingfishers, herons and birds of prey. Aquatic insects, worms and snails feed on the waste material excreted by animals and the dead or decaying plant and animal matter. They act on the detritus, which is broken down into nutrients which aquatic plants can absorb, thus completing the nutrient cycle in the pond.

Temporary ponds begin to dry up after the rains and the surrounding grasses and terrestrial plants spread into the moist mud that is exposed. Animals like frogs, snails and worms remain dormant in the mud, awaiting the next monsoon.

Lake ecosystems

A lake ecosystem functions like a giant permanent pond. A large amount of its plant material is algae, which derives energy from the sun. This is transferred to microscopic animals which feed on the algae. Herbivorous fish depend on algae and aquatic weeds. Small animals such as snails are eaten by small carnivorous fish, which in turn are preyed upon by larger carnivorous fish. Some specialised fish, such as catfish, feed on the detritus on the muddy bed of the lake; they are called 'bottom feeders' or 'bottom dwellers'.

Energy cycles through the lake ecosystem from the sunlight that penetrates the water surface to the plants. From the plants, the energy is transferred to herbivorous animals and carnivores. Animals excrete waste products, which settle at the bottom of the lake and are broken down by small animals that live in the mud in the lake bed. This acts as the nutrient material used by aquatic plants for their growth. During this process, plants use carbon from CO_2 for their growth and release oxygen. This oxygen is then used by aquatic animals, which filter water through their respiratory system.

Stream and river ecosystems

Streams and rivers are flowing water ecosystems in which all living forms are specially adapted to different rates of flow. Some plants and animals, such as snails and other burrowing animals, can withstand the rapid flow of hill-streams. Other species, like water beetles and skaters,

can live only in slower moving water. Some species of fish, like the Mahseer, move upstream from rivers to hill-streams for breeding. They need crystal clear water to be able to breed.

As deforestation occurs in the hills, the water in the streams that once flowed throughout the year becomes seasonal. This leads to flash-floods during the rains and water shortage when the streams dry up after the monsoon.

The community of flora and fauna of streams and rivers depends on the clarity, flow and oxygen content as well as the nature of their beds. The stream or river can have a sandy, rocky or muddy bed, each type having its own species of plants and animals.

Marine ecosystems

The Indian Ocean, Arabian Sea and Bay of Bengal constitute the marine ecosystems around peninsular India. In the coastal areas, the sea is shallow while further away it is deep. Both are different ecosystems. The producers in this ecosystem vary from microscopic algae to large seaweeds. There are millions of zooplankton and a large variety of invertebrates which fish, turtles and marine mammals feed on.

Olive ridley turtle

The shallow areas near Kutch and around the Andaman and Nicobar islands are some of the most incredible coral reefs in the world. Coral reefs are second only to tropical evergreen forests in their richness of species. Fish, crustaceans, starfish, jellyfish and polyps that deposit coral are just a few of the thousands of species that form this incredible world under the shallow seas.

The deforestation of the adjacent mangroves leads to silt being carried out to sea where it is deposited on the coral, which gets bleached and then dies. There are many types of coastal ecosystems, which are highly dependent on the tide.

The marine ecosystem is used by coastal fisherfolk for fishing, which is their livelihood. In the past, fishing was done at a sustainable level and the marine ecosystem continued to maintain its abundant supply of fish over many generations. Now, with the growth of intensive fishing using giant nets and mechanised boats, the fish catch in the Indian Ocean has dropped significantly.

Seashore ecosystems

Beaches can be sandy, rocky, shell-covered or muddy. On each of these different types, several specific species have evolved to occupy a separate niche. There are different crustaceans, such as crabs, that make holes in the sand. Various shore birds feed on their prey by probing into the sand or mud on the seashore. Several different species of fish are caught by fishermen. In many areas, the fish catch has decreased over the last two decades.

How are Aquatic Ecosystems Used?

Humans use aquatic ecosystems for clean freshwater on which our lives depend. We need clean water to drink and for other domestic uses. Water is usually impounded by large dams to ensure supply throughout the year. Agriculture and industry are highly dependent on these large quantities of water. Further, dams are built across rivers to generate electricity. A large

proportion of this energy is used by urban people, by agriculturists in irrigated farmlands and in enormous quantities for industry.

Fisherfolk use the aquatic ecosystems to earn a livelihood. People catch fish and crabs; they also collect edible plants. These are used locally as food or sold in the market. Over-fishing leads to a serious decline in catch and a long-term loss of income for the fisherfolk.

Marshes and wetlands are of great economic importance for people who live on their fish, crustaceans, reeds, grasses and other produce.

What are the Threats to Aquatic Ecosystems?

Water pollution occurs from sewage and poorly-managed solid waste in urban areas when it enters the aquatic ecosystem of lakes and rivers. Sewage leads to a process called *eutrophication*, which destroys life in the water as the oxygen content is severely reduced. Fish and crustaceans cannot breathe and are killed; a foul odour is produced; gradually, the natural flora and fauna of the aquatic ecosystem are destroyed. In rural areas, the excessive use of fertilisers causes an increase in nutrients, which leads to eutrophication. Pesticides used in adjacent fields pollute the water and kill off its aquatic animals. Chemical pollution from industry kills a large number of life forms in adjacent aquatic ecosystems. Contamination by heavy metals and other toxic chemicals affects the health of people who live near these areas as they depend on this water.

Other than water quality, the quantity of water in freshwater ecosystems also poses a significant threat. Dams built across rivers greatly alter the flow of natural river ecosystems, causing some rivers to slowly run dry as they no longer join a sea. Further, changing the nature of an aquatic ecosystem from a flowing water one to a static one destroys the natural biological diversity, causing habitat loss to the species that require running water. In some semi-arid areas that are artificially irrigated, the high level of evaporation leads to severe salinisation as salts are brought up into the surface layers of the soil. Land is therefore eventually rendered unproductive. The social implications of large dams cannot be undermined—all over the world, thousands of people have been displaced and lost their livelihoods because of the construction of large dams.

CASE STUDY 3

Threats to wetlands in Assam

Almost 40% of all wetlands in Assam are under threat. A survey conducted by the Assam Remote Sensing Application Centre (ARSAC), Guwahati, and the Space Research Centre, Ahmedabad, has revealed that 1367 out of 3513 wetlands in Assam are under severe threat due to the invasion of aquatic weeds and several developmental activities. The wetlands of Assam form the greatest potential source of income for the state in terms of fisheries and tourism. Though the wetlands have the capacity to produce 5,000 t/ha/yr of fish, around 20,000 t of fish have to be imported to meet local demands. This is primarily due to poor wetland management.

How can Aquatic Ecosystems be Conserved?

For the sustainable use of an aquatic ecosystem, water pollution must be prevented in the first place, as cleaning up or treating polluted water is a reactive approach.

Healthy rivers must be protected against damming, other options for meeting water and energy needs must be explored. Proper planning and assessment must be carried out to protect dam-affected people to ensure a more equitable distribution of benefits from dams.

Aquatic ecosystems, especially wetlands, need protection by including them in sanctuaries or national parks in the same way in which we protect our natural forests. These sanctuaries in aquatic ecosystems protect a variety of forms of life as well as rare fish which are now highly endangered, such as the Mahseer. Wetland sanctuaries and national parks are of the greatest importance, as they are among the most threatened of our ecosystems.

3.8 Degradation of Ecosystems

Ecosystems are the basis of life itself! The natural ecosystems in the wilderness provide a variety of products and are regions in which a number of vital ecological processes are present; without these processes, human civilisation would not be able to exist.

However, ecosystems are frequently disrupted by human actions, leading to the extinction of species of plants and animals that can live only in the different natural ecosystems. Some species, if eliminated, seriously affect the ecosystem. These are called 'keystone' species. Extinction occurs due to changes in land use. Forests are deforested for timber, wetlands are drained to create agricultural land and semi-arid grasslands used as pastures are converted to irrigated fields. The pollution from industries and the waste from urban settings can also lead to the poisoning and extinction of several species.

The reason for the depletion of natural resources is two-fold—our rapidly exploding population that needs increasing resources to sustain itself, and the growth of affluent societies that consume and waste a very large proportion of resources and energy. The increasing extraction of resources is at the cost of our natural ecosystems, leading to a derailing of their important functions. We all use a variety of resources in our daily lives. If traced back to their source, we find that the resources were originally obtained from nature and natural ecosystems. Our insensitivity to using resources carefully has produced societies that nature can no longer sustain. If we think before wasting resources such as water, reuse and recycle paper, use less non-biodegradable material, then all this can cumulatively help conserve our natural resources.

Summary

- Ecosystems represent the living community of plants and animals in any area along with the non-living components of the environment such as soil, air and water.
- The structural aspects of ecosystems include *producers* (plants which manufacture food), *consumers* (plants, animals and invertebrates that live on producers) and *decomposers* (worms, insects, bacteria and fungi which break down organic material into smaller particles).
- Every ecosystem has several interrelated mechanisms that cycle through the biosphere: the water cycle, carbon cycle, nitrogen cycle, phosphorus cycle, sulphur cycle and the energy cycle. Human activities play a significant role in altering these cycles.

- Carnivores feed on herbivores which in turn feed on plants. At every stage of this food chain, energy is transferred and lost from one living organism to another.
- All the interlinked food chains together form a food web. Loss or extinction of species implies that a food web has broken down.
- Terrestrial ecosystems in their natural state are found in different types of forests, grasslands, semi-arid areas, deserts and sea-coasts. Over thousands of years, these ecosystems have been modified for human use and converted into intensively irrigated agricultural ecosystems and urban industrial centres.
- Aquatic ecosystems comprise the marine environments of the seas and freshwater systems in lakes, rivers, ponds and wetlands.
- Land use changes, habitat loss, disruption of environmental cycles and population pressure are some of the driving forces of ecosystem degradation.
- Ecosystems provide a range of goods and services essential to human life. Therefore, it is crucial that we protect and conserve our natural ecosystems and its resources.

Questions

1. Define an ecosystem.
2. Describe at least five ecosystem goods and services that humans benefit from.
3. Name all the cycles that constitute the proper functioning of an ecosystem.
4. Describe the water cycle.
5. Describe any two forest ecosystems in India. What are the current threats to forest ecosystems and how can they be conserved?
6. Name the types of grasslands in India and two animal species found in these grasslands.
7. Describe any two aquatic ecosystems in terms of their structure and function.
8. What are the main threats to aquatic ecosystems, and how can we protect them?