Ecosystems and their Structure

4

STRUCTURE

4.1

So far we have been looking primarily at the living part of the natural world, but we know that when earth was born, it did not have any life on it. Changes in the non-living components and their composition have perhaps played a key role in the evolution of life on earth. This implies that the environment and changes in the environment, impact species and their evolution on the planet. Even today the non-living environment affects lifeforms of the earth and these together with the interactions taking place between the living and the non-living world, give rise to a variety of Ecosystems.

4.2

On completion of this unit, you should be able to:

- Elaborate upon the structure of an ecosystem
- State the significance of the biotic and abiotic components of the ecosystem and the influence they exert on each other
- Describe the major ecosystem types found in India
- Understand that the various ecosystem types of the world are connected to each other
- Define an ecotone and state its ecological significance

4.3 COMPONENTS AND STRUCTURE OF AN ECOSYSTEM

Have you ever wondered, what is present in a pond, or besides the tall grand trees, what more exists in a forest? Can you explain why the type of soil, its moisture content etc. could determine what grows on the piece of land, or how population of sambars and deers in a forest affect its soil quality? Can you recall the definition of 'ecosystem'?

An ecosystem is a community of organisms involved in a dynamic network of biological, chemical and physical interactions between themselves and with the nonliving components. Study of such interaction and connections can help us explain the links mentioned in the previous paragraph. Further, such interactions are crucial for sustaining the system and allowing it to respond to changing conditions.

These days terms like forest ecosystem, grassland ecosystem, pond ecosystem very often make the headlines of the newspapers. These are some of the ecosystems found on the earth.

An ecosystem is also defined as a functional and structural unit of Ecology. This implies that each ecosystem has a definite structure and components, and that each component part of the system has a definite role to play in the functioning of the ecosystem.

Unlike ecological communities which comprise of living elements only, ecosystems have two 'parts': The living (**biotic**) components like plants and animals; and the nonliving (**abiotic**) components like water, air, nutrients and solar energy. These two parts of the ecosystem do not stand in isolation, rather they continuously interact with one another. In fact they are so closely linked to each other that experts, by looking at the type and condition of the abiotic environment of an ecosystem can identify the kind of life that one is likely to find in an ecosystem, and vice versa.

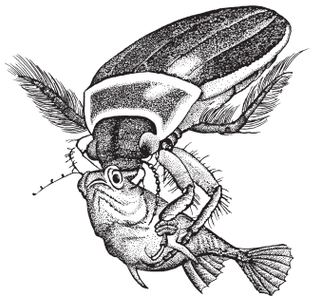
Before we understand what these interactions are like, let us analyze the two components in detail.

Living components

Living organisms (biotic components) in an ecosystem can be classified as either producers or consumers, depending on how they get their food.

Producers (**autotrophs**, i.e. selffeeders) can make the organic nutrients they need, using simple inorganic compounds in their environment: for instance, the green plants on land and the small algae in aquatic ecosystems produce their food by the process of photosynthesis.

Consumers (**heterotrophs**, i.e. otherfeeders) are those organisms, which directly or indirectly depend on food provided by producers. Consumers, depending on their food habits, can be further classified into four types.



- **Herbivores**,e.g. deer, rabbits, cattle, etc., are plant eaters and they feed directly on producers. In a food chain, they are referred to as the primary consumers.
- **Carnivores** are meat eaters and they feed on herbivores (primary consumers). They are thus known as secondary consumers. They are animal eaters, e.g. lions, tigers.
- **Omnivores** eat both plants and animals, e.g. pigs, rats, cockroaches and humans.
- **Decomposers** digest the complex organic molecules in dead organic matter (detritus) into simpler inorganic compounds. They absorb the soluble nutrients as their food. Some examples are bacteria, fungi, and mites.

What is important to note is that each ecosystem will have certain representative organisms playing each of the above mentioned roles.

Nonliving components

Nonliving (or abiotic) components of an ecosystem include all the physical and chemical factors that influence living organisms, like air, water, soil, rocks etc. Thus, it is an assemblage of organic and inorganic substances present in an ecosystem. The various climatic factors that affect the ecosystem functioning are also a part of this. The non-living components are essential for the living world. Without sunlight, water, air and minerals, life cannot exist.

OUR PLANET WITHOUT DECOMPOSERS

Decomposers (primarily bacteria, fungi; nematodes like tapeworms; mites and certain insects) are organisms that feed by degrading organic matter. They are essential components of all nutrient cycles and food chains. Decomposers break down organic waste and recycle the nutrients present in it. If decomposers are removed from the biosphere, the earth will become a vast dump of dead organisms. Life will probably stop, as the nutrients for life would be tied up in the dead organisms.

Can you state the significance/describe what functions would other 'consumer types' play in an ecosystem?

Some examples of non-living components of an ecosystem include:

Physical factors	Chemical Factors
Sunlight	Percentage of water and air in soil.
Temperature	Salinity of Water
Precipitation	Oxygen dissolved in water
Nature of soil	Nutrients present in soil
Fire	
Water currents	

4.3.1

1. What is an ecosystem? How is it different from an ecological community?
2. Name a few biotic and abitoic components of an ecosystem.
3. Define the terms autotrophs and heterotrophs.

4.4 BIOGEOGRAPHIC REGIONS OF INDIA

Because of the influence which abiotic factors exert on organisms, different ecosystems develop differently. The major factors that determine the growth and type of ecosystem include temperature, rainfall, soil type and the location (the latitude and altitude). These factors, their interactions with each other and with the local biotic community have resulted in a variety of ecosystems.

India, the seventh largest landmass in the world, possesses a variety of ecosystems. These include mountains, plateaus, rivers, wetlands, lakes, mangroves, forests and coastal ecosystems. This section looks at the ecological profile of India.

The Himalayan Region

Sparse vegetation and rare fauna that includes snow leopards, wild pigs and tigers, characterize the transHimalayan region. The Himalaya, the highest mountain range in the world, is one of the richest areas of India in terms of habitat and species diversity. Both altitudinal as well as longitudinal variations are seen in the Himalayan belt. Three distinct subzones, each with its characteristic species diversity, are recognized—Himalayan foothills from the eastern frontiers of Kashmir to Assam; Western Himalaya, which are the higher altitude region from Kashmir to Kumaun (in Uttaranchal); and the Eastern Himalaya (in the north-east part of the country).

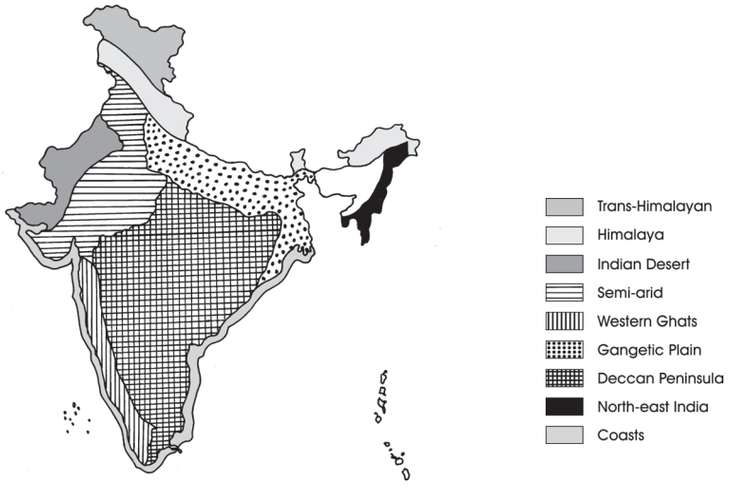
The Gangetic plains with their rich alluvial soil make excellent crop fields. It is in this area that the floodplains are found, which makes this region important for flood control too.

The Desert

The desert regions of the northwest have large expanses of grasslands in patches. For kilometers together, one may not find any signs of vegetation in the desert. Water, or the lack of it, is the single-most significant feature in the desert. In this region, both plants and animals face the problem of maintaining the water balance of their bodies under extreme diurnal temperature variation. They show many adaptations to cope with this. For details on some such adaptations, refer the box on 'Adapting to the Desert' in Unit 2.

The North-East

In contrast to the northwest, the northeastern region has lush green rain forests. The forests consist of very dense and lofty trees with multitudes of species occurring in a given area. The unique plant species include mosses, ferns, epiphytes, orchids, lianas and vines. The rich plant diversity of these



THE INDIAN BIODIVERSITY

Group	Number of species in India (SI)	Number of species in the world (SW)	SI/SW (%)
Mammals	350	4,629	7.6
Birds	1228	9,702	12.6
Reptiles	428	6,550	6.2
Amphibians	197	4,522	4.4
Fishes	2546	21,730	11.7
Flowering Plants	15,000	250,000	6.0

forests is home to an equally rich diversity of animals, including elephants, barking deer, hoolock gibbon, golden langur, macaque species and other primates.

The Western Ghats

While the Western Ghats with an evergreen forest cover make biodiversityrich zones, the Nilgiris, an offshoot of Western Ghats, have extensive grassy areas interspersed with densely forested evergreen vegetation known as *Sholas*. They provide shelter to elephants, gaur and other large animals. Many of the trees and also some of the animals found in these high *Shola*s are also found in the high altitude forests of the northeastern region.

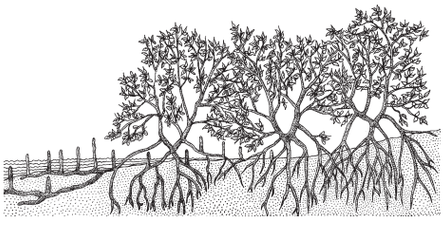
Islands and Wetlands

India also has two major groups of islands—Lakshwadeep islands in the Arabian Sea, and AndamanNicobar islands in the Bay of Bengal. These islands receive both the southwest and the northeast monsoons. Being tropical in climate, these islands are home to tropical rainforests.

India, with its varied terrain and climate, supports a rich diversity of inland and coastal wetlands. A total of 21 **wetlands** have been declared as National Wetlands. An important wetland of the country is the Keoladeo National Park in Bharatpur, Rajasthan, which is a human-made wetland. Among the various migratory species of birds that visit this Park almost every winter, is the endangered Siberian Crane (*Grus leucogeranus*). Another important wetland is Chilika (1,100 sq km), the largest brackish water lake in India, situated in Puri and Ganjam district of Orissa.

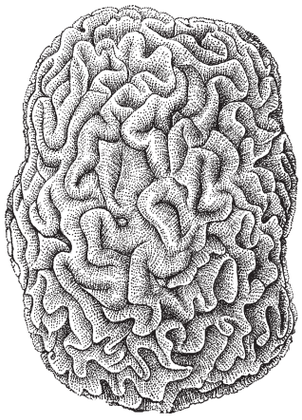
The Marine Wealth

India has the world's seventh largest coastline measuring over 7,500 km. The Indian coastline is broadly divided into the Western coast and the Eastern coast. The Western coast borders the Arabian Sea and the Eastern coast is along the Bay of Bengal. The Western coast is divided into three parts: the Saurashtra coasts along the northern part; the middle portion called the Konkan



coast; and the southern part known as the Malabar Coast. The Eastern coast extends from Kanyakumari to the delta of the Ganga in the Bay of Bengal. The southern half of the coast is called the Coromandel coast.

Oceans have great diversity of lifeforms as they provide a gradient of habitats in terms of varied light and pressure zones. With their rich cache of fish, minerals and potential energy, the marine ecosystems make an invaluable resource. It is due to the geographical location of the land masses within the Indian Ocean that the Indian subcontinent experiences a unique pattern of winds and rains. This phenomenon is known as '**monsoon**'. Oceans are also the reservoir of food and the resource for aquacultural practices.



THE CORALS

Corals come in many shapes—the stag-horn coral, brush coral, pillar coral, finger coral, brain coral, flower coral, tree coral, cluster coral and others. In the brain coral, the skeleton is round and has furrows that look like those of our brain.

Coral reef is like a joint venture between the two basic life forms—an animal and a plant. The animal is the coral polyp, belonging to the same group as a jellyfish or sea anemone. The minute polyp lives all its life with one end attached to an underwater limestone cover. The other end consists of a mouth surrounded by tentacles that captures and swallows food, mainly plankton, from the water. The coral polyp continuously secretes limestone which it crystallizes from the calcium carbonate found in the sea water. With this limestone, it builds around and under itself, a protective covering called the corallite. When each polyp has built its corallite, it sends out filaments from which sprouts another polyp. This one also begins limestone construction of its own. Thousands of polyps creating such limestone cases, in small densely packed formations, lead over time to creation and growth of coral reefs.

4.5 ECOTONES: THE TRANSITIONAL ZONES

All ecosystems are linked. While it is convenient to divide the living world into different ecosystems for purposes of study, in nature, there are seldom distinct boundaries between them. They are never totally isolated from one another. Any disturbance or change in any one of these, sooner or later, influences the other.

A transitional region between ecosystems is known as an **ecotone**; for example, the region between a forest and grassland. This region shares many of the species and characteristics of the adjacent ecosystems, and also has

WETLANDS AND THEIR SIGNIFICANCE

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land or where the land is covered by shallow water. Wetlands are areas of great ecological and economic significance.

In their natural condition, wetlands supply numerous ecological, economic, and cultural benefits to local communities, including water quality protection, flood control, erosion control, fish and wildlife habitat, aquatic productivity, and unique opportunities for education and recreation.

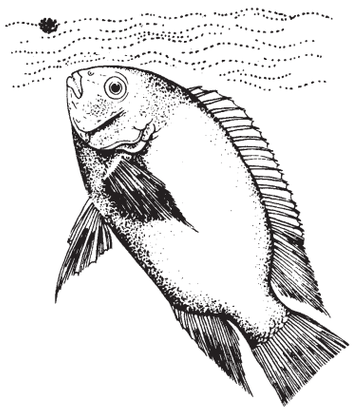
One of the most important functions of wetlands is the ability to maintain good surface water quality in rivers, streams, and reservoirs and to improve degraded surface waters. Wetlands do this several ways: a) by removing and retaining nutrients. b) by processing chemical and organic wastes. c) by reducing sediment loads. Wetlands are particularly good water filters. Due to their landscape position between uplands and deep water, wetlands intercept surface water runoff before it reaches open water and filter out nutrients, wastes, and sediments from flood waters. This function is particularly important in urban and agricultural areas.

In some places, wetlands contribute to the recharge of groundwater sources of drinking water. During periods of heavy runoff, such as major storms or snow-melt in the spring, wetlands adjacent to streams and in depressions collect excess water. When the water table drops, the water held in the wetlands infiltrates slowly back through the soil into the aquifer to replenish groundwater. Also by temporarily storing and slowly releasing flood waters, wetlands help protect adjacent and downstream property owners from flood damage.

Wetlands provide critical habitat for several species—many amphibians, fishes, variety of plants including grasses.

species unique to itself. The ecotone region provides conditions of both the types of neighbouring ecosystems and thus supports a greater variety of Lifeforms. It also has species living exclusively in the ecotone region. An ecotone is thus a biologically rich area with very high species diversity. In some cases, the number of species and the population density of some of the species is greater in the ecotone than in the adjacent ecosystems. This tendency for an increased diversity and density is called the **edge effect**

A common example of ecotones is estuaries—the transitional area between rivers and the oceans. The variety of species found in an estuary is much higher than in the river or in the shallow sea-water. But high levels of pollution in river water as well as in marine systems are destroying these unique habitats. Today these unique microenvironments are being threatened by human activities.



DISTURBANCES IN ESTUARIES

Some fish species not only migrate between the waters of the various oceans and seas, but also require migrating between freshwaters and the marine waters. Such fishes, which spend part of their life-cycle in salt-water and a part in freshwater, are called **diadromous** fishes, e.g. the eel fish, the salmon, and the trout. These include the **anadromous** species, which migrate from the sea to freshwater for spawning (process of laying eggs), and the **catadromous** species, which spawn in the ocean or at sea, and migrate towards freshwater as juveniles.

The ecotone regions in many coastal areas are today highly disturbed due to constant disturbance from the mainland in the form of pollution—pesticidal pollution, discharge of effluents, silt, and etc. Such disturbances in the estuarine and coastal areas make migration of diadromous fishes to their spawning areas difficult, and adversely affects their populations by acting as the major bottlenecks in the life-cycle of these species.

4.6 RECAPITULATION

- Ecosystems are the structural and functional unit of ecology.
- All ecosystems comprise of living (biotic) and non-living (abitoic) elements, with constant interactions between the two. The two elements influence each other.
- The type of living and non-living components and the interactions between them produce different types of ecosystems.
- India has a great variety of the ecosystems, with a variety of Lifeforms characterizing each one of them.

- All ecosystems of the world are connected to each other. The connecting zone between two ecosystem types is referred to as 'Ecotone'.
- Ecosystems have multiple functions—ecological, economic, recreational, etc.
- Ecosystems are both the source as well as the sink for all human activities

4.7 CONCLUSION: THE BALANCING ACT

Natural ecosystems possess self-regulating mechanisms that maintain their balance. The tendency of ecosystems to resist change and remain in a state of equilibrium is called Homeostasis (*homeo*=same and *stasis*=standing). Such a mechanism requires 'feedback' processes and many such process exist in the natural world.

A common way of thinking is that if ecosystems are selfmaintaining, then why not throw all wastes into nature and let nature take care of it? But it has been realized and experienced that whether it is an ecosystem, a community or even an organism, every system has its tolerance limits. Stresses beyond the tolerance limits of these systems can be fatal for the biosphere and hence for us.

Do you know that there are also human-made ecosystems? Can you relate an agricultural field to a natural ecosystem? Do you think there are likely to be some differences between the two? What are these?

Ecosystems provide a number of goods such as food, timber, medicines, genetic resources, etc. Ecosystems also serve a number of functions—ecological, economic, recreational/aesthetic, as well as educational. Major ecological functions of ecosystems include: meeting the habitat (shelter), food, water, air as well as breeding demands of not just humans but also of the various other organisms; providing ecological services—clean air, water, waste absorption—to the organisms living in it; regulating climate, flood control, coastline stabilization, carbon appropriation, waste treatment, biodiversity conservation, soil generation, disease regulation, and the provision of aesthetic and cultural benefits.

Thus, an ecosystem provides both products as well as services (the ecological functions) to humans. Each ecosystem has a unique set of environmental services provided and goods that it provides (for example, grasslands are usually the fodder source for browsers and grazers, while wetlands recharge aquifers), what is important for us is to understand that these ecosystem services can be provided to us only when the integrity and overall wellbeing of the ecosystem is maintained. For example, the moment we start looking at forests as timber and start cutting down trees for their economic value, we would be deprived of several other functions of the forests, like their recharging of the water table, appropriation of carbon-di-oxide, prevention of top soil loss.

It is further important to understand that ecosystems are both the source as well as the sink of human activities. This means that human beings derive resources—from food, fibre, timber to the various raw material for the industries, from ecosystems; and that all the products and byproducts of human activities—from domestic to industrial, finally go back to the ecosystems, which could be the rivers, the oceans or even the forests.

4.8

1. Describe in detail the structure of an ecosystem.
2. Give an example of how a living component in an ecosystem can affect a non-living one.
3. What would happen if there are no decomposers in an ecosystem?
4. What is an ecotone? What is its significance?

4.9

Kaleidoscope

It is important to look at the various components of ecosystems not as individual units but understand them in the entirety. It is so, because most often the various services and functions that an ecosystem plays, are fulfilled not by the individual components of the ecosystem, but by the interactions among these. Such interactions are very often not very visible, and thus communicating the importance of such interlinkages and their role in providing us various ecological services is challenging. You may use the following activity to help your students understand this:

Group size: No restriction

Duration: 30-45 minutes

Requirements: Transparency and transparency markers

Objectives: Help students to

- Appreciate the variety of functions that ecosystems serve; and
- Understand that different stakeholders/groups have different relationships/associations/dependence on natural systems

Procedurer:

a) Make groups of 4-5 and give each group a set of transparency sheets and markers. Ask each group to draw a large rectangle on one transparency. Within this, ask them to draw how a forest would look to them from a distance. (For example they may draw trees or vertical lines or tree canopy as seen from the top, etc.)

b) Now ask them to list the various groups, which are associated with forests in one or the other way—scientists, ecologists, forest guards, women from the neighbouring village, industrialists, government officials, other species, urban dwellers, farmers, pharmaceutical companies.

c) Ask the students to draw how each one of these groups would look at the forest. For example, industry's interest in forest could be symbolized as money; the local community as some food items they derive from the forest or fuelwood; for other species, symbols of homes, food, water, shelter, medicine, etc. may be drawn. Each of these 'views' should be on a separate transparent sheet. Tell them they need to represent each of these symbolically.

d) Ask the students to place these sets of transparent sheets on the one which has their view of the forests. How does the forest look now?

Discussion

Teacher should now generate a discussion in the classroom. This can be done by asking students a number of questions, such as what does the change in the final 'view' of the forest indicate? Tell them that each one of us looks at natural systems with a very different perspective that depends mainly on our perception and our association with that system. It is important to understand that human requirements from ecosystems are complex and varied. Apart from this, there are thousands or perhaps millions of other species that of course need and use the forest as an ecosystem in a very different manner.

Further, through examples, illustrate to the students that services and functions performed by ecosystems are also divergent, complex and intricate. For example, a wetland not only gives us the food, but also help clean our drinking water sources, prevent floods, recharge our ground water, etc. While different components of an ecosystem may provide us different product or service, but for ensuring that these services and products remain available, it is important to maintain the sustainability of each of its components.

4.9.1 KALEIDOSCOPE: THE FEEDBACK

(credit points: 5)

1. What kind of symbols/visual depictions did the various groups come up with?
2. What do these symbols communicate about the relationship of the various stakeholder groups with ecosystems?
3. Did the students otherwise think about such interpretations of an ecosystem?
4. Send some sheets as example of what students did.
5. Is your school near a forest? Do you think that students in the opposite situation would have come up with different examples and uses? What would be some of the significant differences? Why?