UNIT 1 CONCEPT OF ECOSYSTEM

Structure

1.0 INTRODUCTION

Both the biotic (living) and abiotic (non-living) components of nature form an interacting and vibrant system called 'ecosystem'. In an ecosystem, producers, consumers and decomposers represent various trophic levels and these are linked by complex food relationships. Such ecosystems involve various on-going functions such as energy flow, production, decomposition, nutrient cycling and succession. It has been widely recognized that ecosystems are the planet's life-support systems. Nature's goods and services are the ultimate foundations of life for the human species and all other living beings. As a result of human actions, however, the structure and functioning of the world's ecosystems have changed more rapidly in the second half of the twentieth century than at any other time in human history. A number of negative impacts on many ecosystems have been reported by various scientific studies. It has therefore become indispensible to adjust our pattern of development so that various ecosystems remain intact and continue to provide their services for our wellbeing. This unit aims to provide a conceptual basis for understanding ecosystem processes and their sensitivity to human induced changes.

1.1 OBJECTIVES

After reading this unit, you will be able to:

- explain the concept of ecology and ecosystem;
- describe structure and function of a typical ecosystem;
- underline some important ecosystem services; and
- discuss how humans have negatively impacted some ecosystems.

1.2 CONCEPT OF ECOLOGY AND ECOSYSTEM

Throughout their life, the living beings keep on interacting among themselves as well as with their physical surroundings like soil, air and water. Study of the interrelationships of organisms with their natural environment is known as 'ecology'. This term is derived of two Greek words: *Oikos* (means house or living place) and *logos* (means study). It was coined by Ernst Haeckel in 1869.

E.P.Odum, an American ecologist, defined ecology as 'the study of the structure and function of nature, which includes the living world'. He referred ecosystem as the basic fundamental unit of ecology. In other words, ecology is the study of relationships between (i) biotic and abiotic components and also (ii) biotic and biotic components of the ecosystem. For practical purpose, ecology involves collecting information about organisms and their environment, looking for patterns of their distribution, abundance and adaptation to environmental changes and seeking to explain these patterns.

The biosphere, the living world, is composed of smaller units like ecosystems. Ecosystem refers to a whole community of organisms and its environment as one unit. It may thus be defined as a structural and functional unit of biosphere or a segment of natural systems consisting of community of living beings and their physical environment, both interacting and exchanging materials between them with consistent flow of energy across the system. The term ecosystem was coined in 1930 by Roy Clapham to mean the combined physical and biological components of an environment but the British ecologist Arthur Tansley later refined the term in 1935 to convey its meaning as we understand it today

An ecosystem includes all living organisms and the nonliving components of environment that are found in a particular place. In simple words, it can be defined as a piece of land or water body where life continues without the need of human support or intervention. A forest, grassland, pond, lake, coral reef provide some examples of natural ecosystems. Croplands and different farming systems, on the other hand, represent human made ecosystems.

The simplest level of organization in any ecosystem is that of an organism, which refers to any plant, animal or microorganism inhabiting an ecosystem. A population includes all the members of the same organism that live in one place at one time. All the different populations that live in a particular area make up a community. The physical location of a community is called the habitat. An ecosystem is in turn is a level of organisation and has another higher level of organisation called biosphere.

In other words, an ecosystem is the basic functional unit of the biosphere. The major terrestrial ecosystems of the world with their groups of climax biotic community are called 'biomes'. The major terrestrial biomes are: tundra, taiga, deciduous forests, tropical rain forests, chapparals, savannah, grasslands and deserts. Extent of a biome is determined by climatic edaphic factors and geographic and geomorphic factors.

1.3 ECOSYSTEM STRUCTURE

An ecosystem can also be viewed as a piece of land or water-body where life continues naturally. Structurally it consists of a community of living organisms along with their abiotic environment. Ecosystem structure can be described in terms of its components, trophic organization, species composition, stratification, consideration of size scale and boundaries etc. These structural parameters will be discussed sequentially in the following sub-sections.

1.3.1 Ecosystem Components

As explained earlier, an ecosystem comprises biotic and abiotic components which keep interacting with each other to represent various ecosystem functions. Biotic components include all living beings, e.g., humans, animals, plants and microorganisms. Abiotic components include all physico-chemical entities like air, water, soil, rocks, minerals etc.

Biotic components comprises the living part of the environment, which includes the association of a number of interrelated populations belonging to different species in a common environment. The populations are that of animal community, plant community and microbial community. Biotic community is distinguished into autotrophs, heterotrophs and saprotrophs. Let us now understand these new terms.

Autotrophs (Greek: *auto* - self; *trophos* - feeder) are also called producers, convertors or transducers. These are photosynthetic plants, generally chlorophyll bearing, which synthesize high energy complex organic compounds (food) from inorganic raw materials with the help of sunlight, and the process involved is termed as photosynthesis. Certain autotrophs, for example certain bacteria, are called chemosynthetic as they synthesize their food by deriving energy from some chemical substances instead of sunlight. Autortophs form the basis of all ecosystems. In terrestrial ecosystems, they are mainly the rooted plants. In aquatic ecosystems, floating plants called phytoplankton and shallow water rooted plants called macrophytes are the dominant producers.

Heterotrophs (Greek: *heteros* - other; *trophs* - feeder) are also called consumers, which are generally animals feeding on other organisms. Consumers, also referred as phagotrophs (*phago* - to ingest or swallow) or macroconsumers, are mainly herbivores and carnivores. Herbivores are referred as the first order consumers or primary consumers, as they feed directly on plants. For example, terrestrial ecosystem consumers include cattle, deer, rabbit, grasshopper, etc. Aquatic ecosystem consumers like protozoans, crustaceans, etc. Carnivores are animals, which feed or prey upon other animals. Primary carnivores are the second order consumers comprising the animals which feed on the herbivorous animals. Familiar examples include fox, frog, predatory birds, smaller fishes, snakes, etc. Secondary carnivores are the third order consumers and include those animals, which feed on the primary carnivores, such as wolf, peacock, owl, etc. Secondary carnivores are preyed upon by some larger carnivores. Tertiary carnivores or quaternary consumers include the animals, which feed on the secondary carnivores, and include lion, tiger, etc. These are not eaten by any other animals. The larger carnivores, which cannot be preyed upon further are called the top carnivores.

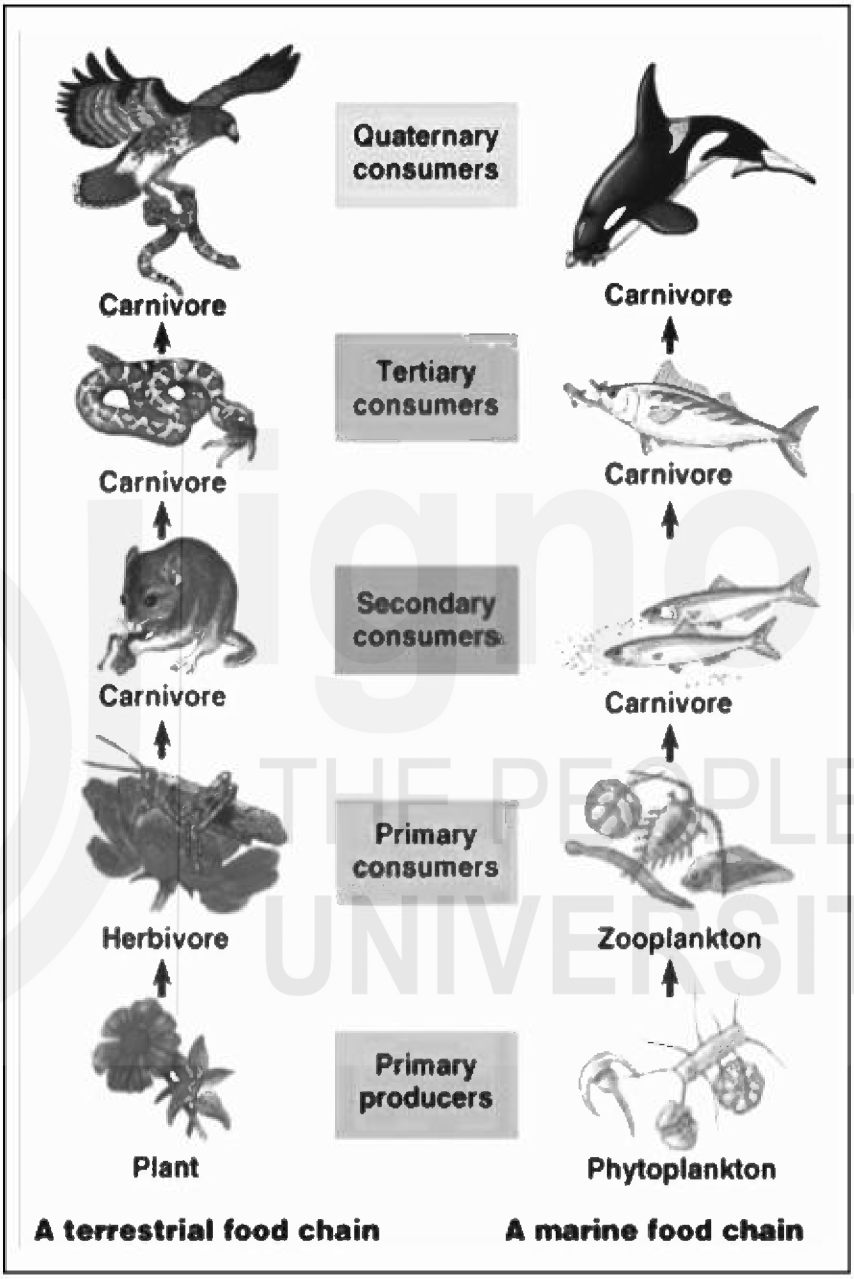

Fig.1.1: Food chains in different ecosystem

(**Source-**http://canarygeog.canaryzoo.com/Ecosystems%20Ecosystems.htm)

Saprotrophs (Greek: *sapros* - rotten; *trophos* - feeder) are also called decomposers or reducers. They break down the complex organic compounds of dead matter (of plants and animals). Decomposers do not ingest their food. Instead they secrete digestive enzymes into the dead and decaying plant and animal remains to digest the organic material. Enzymes act upon the complex organic compounds of the dead matter. Decomposers absorb a part of the decomposition products for their own nourishment while the remaining substances are added as minerals to the substratum (mineralisation). Released minerals are reused (utilised) as nutrients by the plants (producers).

Abiotic components represent the physico-chemical environment of the earth and include different physical entities like air, water, soil etc. as well as conditions such as temperature, light etc. These are also referred as factors as they influence the behavior of any individual in an ecosystem. Abiotic components are further classified under three categories: climatic, geographic or geomorphic and edaphic components or factors. Climatic factors include the climatic conditions like light, humidity, atmospheric temperature, wind, etc. Geographic or geomorphic factors include land topography, slope, aspects (direction towards the sun), altitude, latitude, etc. Edaphic factors are related to the structure and composition of soil and include inorganic substances like water, carbon, sulphur, nitrogen, phosphorus etc., as well as organic substances like proteins, lipids, carbohydrates, humic substances etc.

1.3.2 Trophic Organization

An ecosystem can be represented by its 'trophic organization'. Pattern of food relationships in ecosystem is called trophic organization. There are several trophic levels in the ecosystem which are sequentially represented by Producers, Primary Consumers, Secondary Consumers, Tertiary Consumers and Top Consumers. The trophic level, or feeding level, is a way of delineating the position of an organism in the food chain or food web. The producers (green plants) always form the first trophic level. Herbivores, which feed on producers, are at the second trophic level followed by secondary consumers, tertiary consumers and so on.

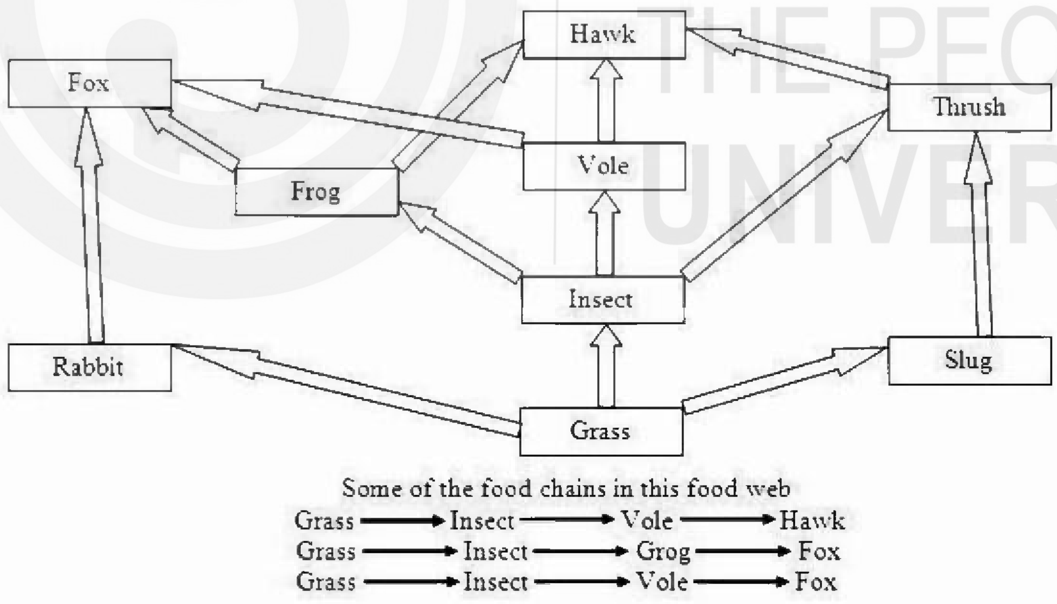

Fig 1.2: Diagrammatic representation of food web and food Chain

Trophic organization can be graphically represented by means of ecological pyramids. Graphical representation of ecological parameters like number of individuals, amount of biomass and amount of energy results in the ecological pyramid of number, pyramid of biomass and pyramid of energy respectively. Pyramids of number and biomass can be upright and inverted both. Pyramid of energy is always upright. Trophic structure of an ecosystem can also be described in terms of total amount of nutrients or the amount of living material. The amount of nutrients in the soil at any given time is referred as 'standing state' whereas the amount of living material is referred as 'standing crop'.

Food relationships in an ecosystem are also represented in form of foodchain and foodweb. The patterns of eating and being eaten forms a linear chain called food chain which can always be traced back to the producers. On the basis of nature, basically two types of food chains are recognized: grazing food chain and detritus food chain. Grazing food chain starts from the living green plants, goes to grazing herbivores and on to the carnivores. Detritus food chain start from the detritus or dead organic matter and goes through a series of saprophytic or decomposer organisms. Both types of food chains are essential for flow of energy and nutrient cycling in ecosystem. In nature various food chains are linked together and form multichannel pattern or complex network of food relationship that is called food web.

1.3.3 Species Composition and Stratification

'Species composition' and 'stratification' are two additional structural features of ecosystem. Species composition means number of species present in an ecosystem. It is also called as species richness, or species diversity. Species are the basic unit of classification, consisting of a population or series of populations of closely related and similar individuals that freely interbreed with one another in natural conditions but not with members of other species. Species can show different functional states in ecosystem. Species can perform unique functions but many times they also show redundancy. Some species are called 'Keystone species' since they perform critically important role in the ecosystem and if they are destroyed, entire ecosystem can collapse. Species diversity is generally proportionate to productivity and stability of the ecosystem.

Stratification means presence of layers (stratum) in vertical structure of an ecosystem. Plants or trees in an ecosystem constitute several height classes. Plants belonging to same height class can be viewed as one stratum. Several such strata are found in an ecosystem. Ecosystem vary in terms of degree of stratification which is often proportional to diversity, productivity and stability of the ecosystems.

1.3.4 Size, Scale and Boundaries

The size and scale of an ecosystem can vary widely. They may be very large, such as a tropical rain forest, Sahara desert, or very small, such as a test tube experiment of phytoplankton, or an aquarium tank with plants and fish. Some even define a biome as an extensive ecosystem, although generally an ecosystem is viewed as having a more defined abiotic environment than a biome, and a biome as a group of ecosystems sharing broad environmental characteristics.

The boundary of an ecosystem is not always easy to delineate. Different ecosystems are often separated by geographical barriers, like deserts, mountains, or oceans, or are isolated otherwise, like lakes or rivers. As these borders are never rigid, ecosystems tend to blend into each other. For example, the boundary of a river may seem clear, yet crocodile crawl from the river to bask in the sun, water birds get food from the river but nest in trees, and tapirs (pig like animal) may swim in the water and yet live on the land. To some extent, the whole earth can be seen as a single ecosystem, or a lake can be divided into several ecosystems, depending on the scale used.

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) What is the difference between community and ecosystem?

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2) Can the size and the boundaries of an ecosystem be defined?

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1.4 ECOSYSTEM FUNCTIONS

By now we understand that an ecosystem is a dynamic assemblage of biotic and abiotic components which interact among themselves and perform different ecosystem functions. Major functional aspects of an ecosystem include energy flow, production, decomposition and nutrient cycling.

Energy flow means transfer of energy from one trophic level to the next trophic level and it is always unidirectional, flowing from producers to top consumers. Production means production or assimilation of biomass by different component of an ecosystem. The rate of biomass production by living beings in an ecosystem is called productivity. Decomposition is breaking down of dead plant and animals and their excreta into simple compounds like carbon dioxide (CO_2), water (H_2O) and nutrients. Bacteria and fungi are the major decomposers. Nutrient cycling means movement of elements or compounds through living beings and across the ecosystem in form of characteristic pathways. Succession is the sequential change in the community structure resulting in establishment of stable or climax community. These functions have been described in detail in the following sub-sections.

1.4.1 Energy Flow

The main source of energy in almost all natural ecosystems is radiant energy coming from the sun. Primary producers or autotrophic organisms, such as plants, algae, and photosynthetic bacteria, take radiant energy and fix it into organic molecules by photosynthesis, such a creating glucose from carbon dioxide. Only a small portion of radiant energy actually is converted into biochemical form via photosynthesis. Studies suggest that ecosystems generally fix about 3 percent or even less of the radiant sunlight. In fact, for most ecosystems, this figure is probably less than 1 percent. There are also other autotrophic organisms, such as chemosynthetic bacteria living around deep-sea vents that can manufacture their own food from chemical energy. Energy then flows through the system when organisms eat each other. The trophic level, or feeding level, is a way of delineating the position of an organism in the food chain, that is, the relationship between what the organism eats and what it is eaten by.

Energy flows through an ecosystem in the form of carbon-carbon bonds. As carbon-carbon bonds are broken, energy is released, which then can be used by the organism or dissipated as heat. While the energy flows through an ecosystem, only a portion of the energy available to an organism is actually stored by the organism. Thus, the total energy in one trophic level never flows to the next level. That simply means that the lower trophic levels always contain more total energy than the higher trophic levels. Energy does not recycle, but ultimately all energy that is brought into an ecosystem is lost as heat.

Lindemann (1942) put forth the Ten Percent law for the transfer of energy from one trophic level to the next. According to this notion, during the transfer of organic food from one trophic level to the next, only about ten percent of the organic matter is stored as flesh. The remaining is lost during transfer or gets broken down in respiration. Plants utilise sun energy for primary production and can store only about 10% of the utilised energy as net production available for the herbivores. When these plants are consumed by an animal, about 10% of the energy in the food is fixed into animal flesh which is available for next trophic level (carnivores). When a carnivore consumes that animal, only about 10% of energy is fixed in its flesh for the higher level. So, at each transfer, 80 - 90% of potential energy is dissipated as heat (second law of thermodynamics) while only 10 - 20% of energy is available to the next trophic level.

Energy transformations, which occur within an ecosystem are considered in ecological energetics. The quantity of solar energy entering the earth's atmosphere is about 15.3×10^8 cals/m^2/year (1 cal = 4.184 J). But the average amount of solar energy (per unit area per unit time), actually available to autotrophs, depends upon their geographical location. Only the photosynthetically active radiation (PAR) is the energy available to autotrophs. A major portion (90 - 95%) of this energy is lost in the form of heat of evaporation and sensible heat while only around 1 to 5% is used for photosynthesis (primary production). Hence the energy transfer is not 100% efficient and there is degradation of energy from a non-random to a random form. Energy conserving efficiency is about 1.5% for grassland, 0.9% for savannah, 0.81% for mixed forest, 5% for most crops and 10 - 12% for a sugarcane field.

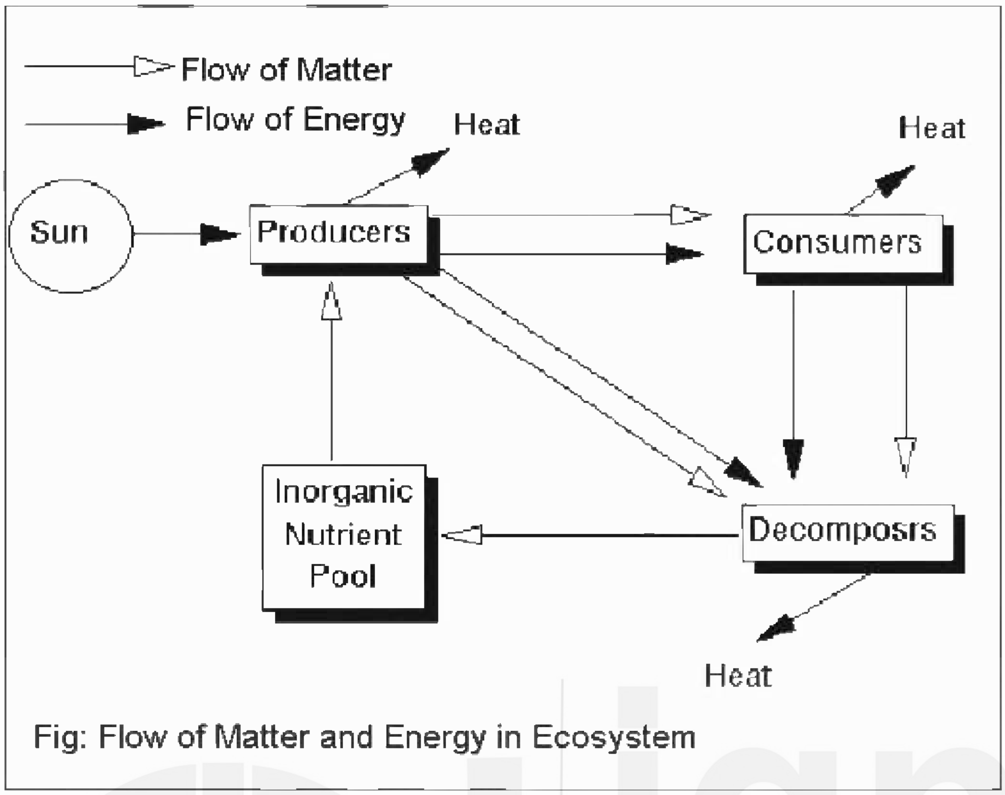

Fig. 1.3: Flow of matter and energy in an ecosystem

1.4.2 Production Processes

In an ecosystem, autotrophs, which include green plants, algae and certain bacteria, synthesize organic food by the process of photosynthesis or chemosynthesis. In the process of photosynthesis, plants take CO_2 from atmosphere, water from environment and radiant energy from the sun and produce food in the form of carbohydrate. This accumulation of organic matter by plants is called primary production. Heterotroph organisms feed on autotrophs and accumulate biomass in their body: that is termed as secondary production.

The amount of organic matter or biomass produced by an individual organism, population, community or ecosystem during a given period of time is called productivity. The total amount of solar energy converted (fixed) into chemical energy by green plants is called 'Gross Primary Production' (GPP). A certain portion of gross primary production is utilised by plants for maintenance (largely respiratory energy loss) and the remainder is called 'Net Primary Production (NPP)' which appears as new plant biomass. Primary production is of special importance in ecology, since it is the energy fixed by plants by converting solar energy into chemical energy of food material that supports life in other trophic levels. The biochemical equation that describes the process of photosynthesis is,

$$6CO_2 + 12H_2O \xrightarrow{\text{(Green-plants in Sunlight)}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Secondary production refers to the net quantity of energy transferred and stored in the bodies of heterotrophs over a period of time. Some heterotrophs (consumers and decomposers) feed on net primary production and some on other heterotrophic organisms. The rate of increase in the biomass of heterotrophs per unit time and area is called secondary productivity. Secondary productivity serves as an index of significance of the population in terms of food resources available to the heterotrophic populations, including man, in the food chain.

Herbivores and carnivores ingest the food material where a part of this is assimilated and a part is egested. A large part of assimilated food (energy) is utilised for metabolism (largely respiration), growth, reproduction, maintenance of body and other activities. Remaining part is stored in somatic and reproductive tissues and thus compared to net production.

Carbon that enters ecosystems as gross primary production (GPP) accumulates within the ecosystem, returns to the atmosphere via respiration or disturbance, or is transported laterally to other ecosystems. About half of GPP is respired by plants to provide the energy that supports their growth and maintenance. Plants lose carbon through several pathways besides respiration. The largest of these releases is typically the transfer of carbon from plants to the soil. This occurs through litter fall (the shedding of plant parts and death of plants), root exudation (the secretion of soluble organic compounds by roots into the soil), and carbon transfers to microbes that are symbiotically associated with roots (e.g., mycorrhizae and nitrogen-fixing bacteria). These carbon transfers from plants to soil eventually give rise to soil organic matter (SOM), which is typically the largest pool of ecosystem carbon.

Herbivores also remove carbon from plants. Herbivory often accounts for 5 to 10% of NPP in terrestrial ecosystems but can be less than 1% in some forests or greater than 50% in some grassland. Herbivores account for most of the carbon loss from plants in aquatic ecosystems. Plants also release carbon to the atmosphere through emission of volatile organic compounds or by combustion in fires. Volatile emissions typically account for less than 1% of NPP but give plants their distinctive smells, which govern the behavior of many herbivores and are an important component of atmospheric chemistry. Finally, carbon can be removed from vegetation by human harvest or other disturbances.

The carbon balance of ecosystems depends not only on the carbon balance of vegetation but also on the respiration of heterotrophs, organisms that eat live or dead organic matter. Heterotrophic respiration by microbes and animals converts organic matter to CO_2, which is lost from the ecosystem to the atmosphere. In some ecosystems fire transforms additional organic matter to CO_2, which moves to the atmosphere. Finally carbon leaches from ecosystems in dissolved and particulate forms and moves laterally through erosion and deposition of soil, movement of animals etc.

Biomass production by plants determines the amount of energy available to sustain all organisms, including humans. We depend on plant production directly for food and fiber and indirectly because of the critical role of vegetation in all ecosystem processes. Much of the carbon produced by plants eventually moves to the soil, where it influences the capacity of soils to retain water and nutrients and therefore to support plant production. Carbon cycling through ecosystems also directly affects Earth's climate by modifying the concentration of atmospheric CO_2. Because of the many critical roles of carbon balance in the biosphere and the Earth System, the recent rapid change in carbon cycling of plants and ecosystems is an issue of fundamental societal importance.

1.4.3 Decomposition

Decomposition is the physical and chemical breakdown of detritus or dead organic matter (i.e.,dead plant, animal, and microbial material), which results into release of carbon to the atmosphere and of nutrients in forms that can be used for plant and microbial production. If there were no decomposition, ecosystems would quickly accumulate large quantities of detritus, leading to a sequestration of nutrients in forms that are unavailable to plants and a depletion of atmospheric CO_2. Depletion of these resources in non-decomposing detritus would eventually cause many biological processes to a halt. There have been times such as the Carboniferous period when decomposition did not keep pace with primary production, leading to vast accumulations of carbon-containing coal and oil. The balance between NPP and decomposition therefore strongly influences carbon cycling at ecosystem and global scales.

If the global warming associated with anthropogenic CO_2 emissions were to cause even small changes in the balance between net primary prouction (NPP) and decomposition, the CO_2 concentration in the atmosphere would be greatly altered and therefore so would the rate of global warming. Understanding the impacts of decomposition on carbon cycling is thus critical for making projections about the future state of Earth's climate.

Decomposition results from three types of processes with different controls and consequences.

1) Leaching by water transfers soluble materials away from decomposing organic matter into the soil matrix. These soluble materials are absorbed by organisms, react with the mineral phase of the soil, or are lost from the system in solution.

2) Fragmentation by soil animals breaks large pieces of organic matter into smaller ones, which provide a food source for soil animals and create fresh surfaces for microbial colonization. Soil animals also mix the decomposing organic matter into the soil.

3) Chemical alteration of dead organic matter is primarily a consequence of the activity of bacteria and fungi, although some chemical reactions also occur spontaneously in the soil without microbial mediation.

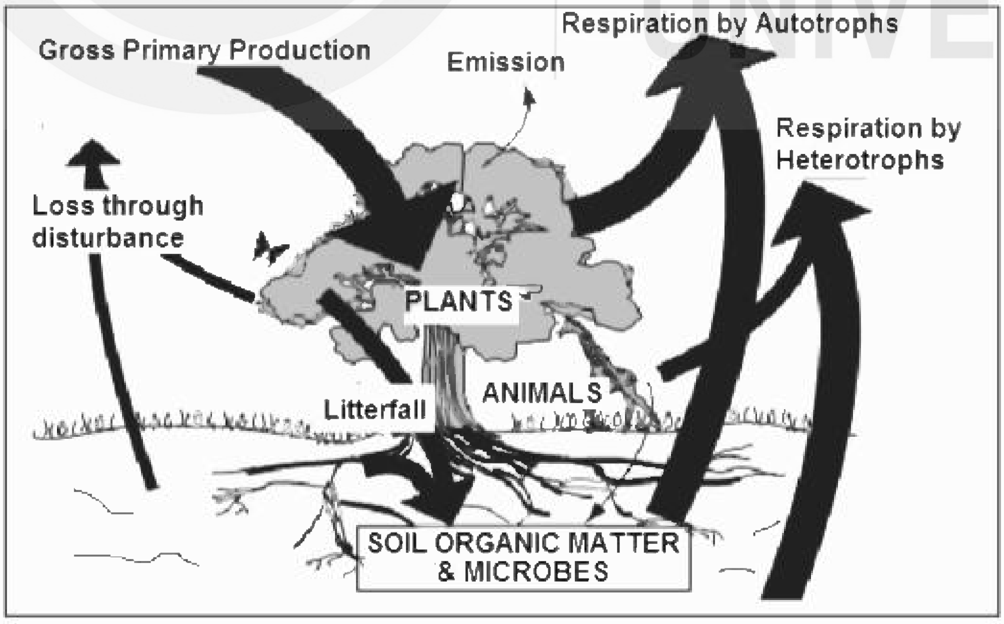

Fig. 1.4: Overview of major carbon fluxes in terrestrial ecosystem

Source: Chapin *et al;* 2002

Dead plant material (litter) and animal residues are gradually decomposed until their original identity is no longer recognizable, at which point they are considered soil organic matter (SOM). Litter consists primarily of compounds that are too large and insoluble to pass through microbial membranes. Microbes therefore secrete exoenzymes (extracellular enzymes) into their environment to initiate breakdown of litter. These exoenzymes convert macromolecules into soluble products that can be absorbed and metabolized by microbes.

The consequences of decomposition are the mineralization of organic matter to inorganic components (CO_2, mineral nutrients, and water) and the transformation of organic matter into complex organic compounds that are recalcitrant (i.e., resistant to further microbial breakdown). In other words, decomposition occurs to meet the energetic and nutritional demands of decomposer organisms, not as a community service for the carbon cycle.

1.4.4 Nutrient Cycling

Nutrient cycling involves the entry of nutrients to ecosystems, their internal transfers between plants and soils, and their loss from ecosystems. Nutrients enter ecosystems through the chemical weathering of rocks, the biological fixation of atmospheric nitrogen, and the deposition of nutrients from the atmosphere in rain, wind-blown particles, or gases. Fertilization is an additional nutrient input in managed ecosystems.

Internal cycling processes include the conversion of nutrients from organic to inorganic forms, chemical reactions that change elements from one ionic form to another, biological uptake by plants and microorganisms, and exchange of nutrients on surfaces within the soil matrix. Nutrients are lost from ecosystems by leaching, tracegas emission, wind and water erosion, fire, and the removal of materials in harvest.

Most of the nitrogen and phosphorus required for plant growth in unmanaged ecosystems is supplied by the decomposition of plant litter and soil organic matter. Inputs and outputs in these ecosystems are a small fraction of the quantity of nutrients that cycle internally, producing relatively closed systems with conservative nutrient cycles. Human activities tend to increase inputs and outputs relative to the internal transfers and make the element cycles more open. There are important differences among elements in their patterns of biogeochemical cycling.

Anthropogenic disturbances such as forest conversion, harvest, and fire increase the proportion of the nutrient pool that is available and therefore vulnerable to loss from the ecosystem. Some of these losses occur by leaching of dissolved elements to groundwater, causing a depletion of soil cations, increase in soil acidity and increases in nutrient inputs to aquatic ecosystems.

Gaseous losses of nitrogen influence the chemical and radiative properties of the atmosphere, causing air pollution and enhancing the greenhouse effect. The combustion of fossil fuels has released large quantities of nitrogen and sulfur oxides to the atmosphere and increased their inputs to ecosystems. Fertilizer use and the cultivation of nitrogen-fixing crops have further increased the fluxes of nitrogen in agricultural ecosystems. Together these human impacts have doubled the natural background rate of nitrogen inputs to the terrestrial biosphere. Changes in the cycling of nutrients therefore dramatically affect the interactions among ecosystems, as well as the carbon cycle and the climate of Earth.

1.5 ECOSYSTEM SERVICES AND HUMAN WELLBEING

It has been widely recognized that ecosystems are the planet's life-support systems. Nature's goods and services are the ultimate foundations of life for the human species and all other living beings. Human biology has a fundamental need for food, water, clean air, shelter and relative climatic constancy. All these resources are directly or indirectly derived from ecosystems or nature. Changes in the flow of these services affect health, livelihoods, income, migration and political affairs of human society which in turn have wide-ranging impacts on human well-being.

Table 1.1: Ecosystem good and services

Ecosystem Goods and Services	
Goods (Provisioning Services)	**Cultural Services**
Food, fiber and fuel	Spiritual and religious values
Genetic resources	Knowledge system
Biochemicals	Education and inspiration
Fresh-water	Recreation and aesthetic value
Regulating Services	**Supporting Services**
Invasion resistance	Primary production
Herbivory	Provision of habitat
Pollination	Nutrient cycling
Seed dispersal	Soil formation and retention
Climate regulation	Production of atmospheric oxygen
Pest regulation	Water cycling
Disease regulation	
Natural hazard protection	
Erosion regulation	
Water purification	

Source: Global Biodiversity Outlook 2 (2006)

Global Biodiversity Outlook 2, a comprehensive report published in 2006 by the Convention on Biological Diversity, proposed systematic accounting of ecosystem goods and services. Parallel to this, the Millennium Ecosystem Assessment (MEA), a project conducted by UN and completed in 2005, assessed the current status of various ecosystem services at the global scale. A total of 24 ecosystem goods and services have been described in these studies which are grouped into four sets: Goods (Provisioning services), Supporting services, Regulating services and Cultural services. These goods and services have been enlisted in the given table 1.1.

1.6 HUMAN INTERVENTION IN ECOSYSTEM

Our biosphere is home to an estimated 5-10 million species of living creatures. Man, however, is the single most dominant species that has been drastically modifying the earth for the last several thousand years, in order to fulfill his needs as well as limitless aspirations. Significant effects of human activities on environment were observed, during the past ten thousand years when man started agriculture. As a result of human actions, the structure and functioning of world's ecosystems have changed more rapidly in the second half of the twentieth century than at any other time in human history. A number of negative impacts on world ecosystem have been documented by numerous scientific studies.

It is becoming increasingly clear that population growth and economic development are leading to rapid changes in our global ecosystems. In recognition of this, the United Nations undertook the Millennium Ecosystem Assessment in order to assess the consequences of ecosystem change as related to human well-being, and establish the scientific basis for actions needed to enhance the conservation and sustainable use of those systems, so that ecosystems can continue to supply the services that underpin all aspects of human well being. This assessment exercise has involved more than 1300 experts worldwide.

As mentioned earlier, the Millennium Ecosystem Assessment examined the state of 24 services, that make a direct contribution to human well-being. The assessment concludes that 15 out of these 24 services are in decline, including provision of fresh water, marine fishery production, the number and quality of places of spiritual and religious value, the ability of the atmosphere to cleanse itself of pollutants, natural hazard regulation, pollination, and the capacity of agricultural ecosystems to provide bio-control of pests.

The findings of this assessment provide the strongest evidence so far of the impact of human actions on the natural world. They show, for example, that over the past 50 years, humans have changed natural ecosystems more rapidly and extensively than in any other comparable period in human history . This transformation of the planet has apparently contributed to substantial net gains in human well-being and economic development but not all regions and groups of people have benefited from this process. In fact, many have been harmed. Moreover, the full costs associated with these gains are only now becoming apparent.

Poverty and hunger have tended to force many rural people to do farming on marginal drought-prone lands with poor soil fertility, and others to move to urban slums. About 1 billion people are affected by land degradation such as that caused by soil erosion, water logging or salinity of irrigated land. Erosion has caused substantial reductions of crop yields in Africa. Diminished human health and well-being tends to increase the immediate dependence on ecosystem services and the resultant additional pressure can damage the ecosystems' capacity to deliver services.

Interestingly, the regions facing the greatest challenges in achieving the Millennium Development Goals, overlap largely with those facing the greatest problems related to the sustainable supply of ecosystem services. Ecosystem changes may occur on such a large scale, as to have a catastrophic effect on human health.

The concept of ecological footprint has been designed to measure the extent of human pressure on the land and seas. Ecological footprint measures the biologically productive area that people use for provision of renewable resources, occupy with infrastructure, or require for absorption of CO_2 wastes. As per Living Planet Report 2010, humanity used nature's services 50% faster than what the Earth could renew in 2007. The report also reveals humanity's Ecological Footprint has more than doubled since 1966. Moreover, with the modest UN projections for population growth, consumption and climate change, by 2030 humanity will need the capacity of two Earths, to absorb carbon dioxide waste and keep up with natural resource consumption of ever growing human population. Now it depends on the people and the nations that how they respond to such an alarming situation. Adopting sustainable development in future course of human endeavor is the only solution and way forward.

1.7 NEED FOR MANAGING ECOSYSTEMS

It has been made clear in the preceding sections that ecosystem services are indispensable to the wellbeing of people everywhere. It is also now widely recognized that adverse changes in ecosystems have a more direct influence on human well-being among poor populations than among wealthy populations. Even wealthy populations cannot be insulated fully from the degradation of ecosystem services. Social adaptations may minimize, displace or postpone the negative impacts of ecosystem disruption, but there are limits to what can be achieved.

To sum up, in order to achieve the goal of sustainable development and to enhance human well-being, ecosystem services need to be conserved by all means. For achieving this target, comprehensive reforms in governance, institutions, laws and policies are required along with personal commitment at the level of individuals to adopt an eco-friendly lifestyle. Reducing the present level of resource consumption, fighting inequalities in resource access and giving top priority for managing essential ecosystem services like provision of clean water and nutritious food are some of the pathways to achieve sustainability.

Check Your Progress 2

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) What will happen, if decomposition process in ecosystems stops?

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2) Why are ecosystems important for us?

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1.8 LET US SUM UP

- The biotic and abiotic components of nature form an interacting system called 'ecosystem'. Ecosystem is the structural and functional unit of biosphere.
- Ecosystem structure can be described in terms of its components, trophic organization, species composition, stratification, consideration of size and scale etc.
- Major functional aspects of an ecosystem include energy flow, production, decomposition and nutrient cycling.
- Goods and services, provided by ecosystems, are the ultimate foundations of life for the human species and all other living beings.
- Pattern of development in the past 50 years indicates that population growth and economic development are leading to degradation of 60% of ecosystem services.
- Human societies can achieve long term growth sustainability by restructuring their development needs, adjusting their lifestyles and managing more judiciously, and scientifically, world's ecosystems.

1.9 KEY WORDS

Food chain	:	Linear sequence of who eats whom in ecosystem.
Food web	:	Many food chains when interwoven together.
Detritus	:	Dead plants and animals fallen on ground.
Decomposition	:	Break down of complex organic molecules into simple ones.
Trophic levels	:	A way of delineating the position of an organism in the food chain.
Ecological pyramid	:	Graphical representation of ecological parameters.

1.10 REFERENCES AND SUGGESTED FURTHER READINGS

- Chap, F.S., Matson, P.A. and Mooney, H.A. 2002. Principles of Terrestrial Ecosystem Ecology. Springer-Verlag, New York.
- Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington DC.
- Odum, E.P. 1959. Fundamentals of Ecology. Saunders, Philadelphia.
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- Schmitz, O. J. 2007. Ecology and Ecosystem Conservation. Island Press, Washington, DC
- Secretariat of the Convention on Biological Diversity 2006. Global Biodiversity Outlook 2. Montreal.

Relevant Websites:

- www.http://cbd.int [Ecosystem approach]
- www.http://unep.org [Developing an ecosystem approach]
- www.http://wikipedia.org/wiki/ecosystem [What is an ecosystem?]

1.11 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Your answer must include the following points:
   - Community include assemblage of living being of an area
   - Ecosystem include living community along with abiotic environment
2) Your answer must include the following points:
   - Scale vary as per context
   - Boundaries may overlap making assessment of the size difficult

Check Your Progress 2

1) Your answer must include the following points:
   - Dead organic matter will accumulate
   - Atmospheric CO_2 concentration may fluctuate
2) Your answer must include the following points:
   - Ecosystem provides goods and services
   - Human wellbeing depends on ecosystem services