PEOPLE'S DEMOCRATIC REPUBLIC OF ALGERIA
وزارة التعـليـــم الـعالـــي والـبحث الـعلـــمي
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

جامعـة 20 اوت 1955 سكيكدة
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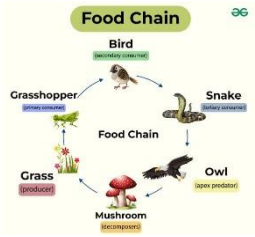
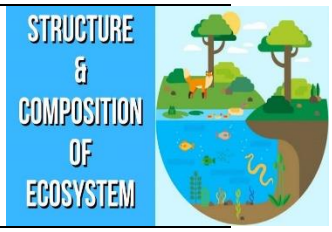
FACULTY OF SCIENCE

DEPARTMENT OF NATURAL AND LIFE SCIENCES

Course handout



Degradation and conservation of ecosystems (DCE)



Ineeded for master 2 of Applied Microbiology students.

Prepared by :
Mme. Dr. Sabrine BOUCETTA
Lecturer A (S.boucetta@univ-skikda.dz)

Academic Year 2024/2025

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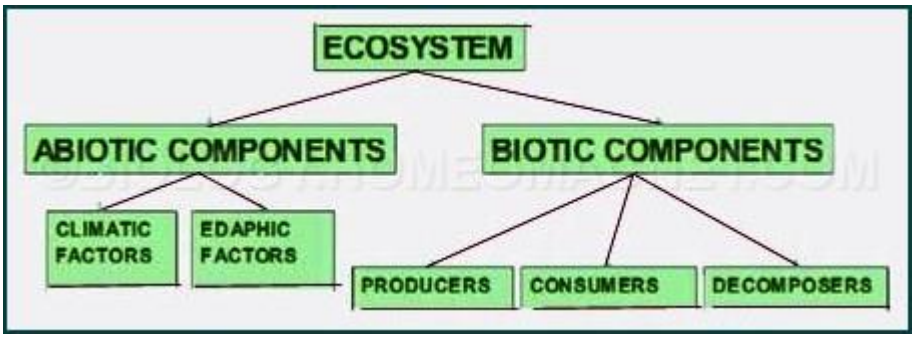
2.1 FUNDAMENTAL COMPONENTS OF THE ECOSYSTEM:

2.1.1 What is the structure of ecosystem?

The structure of ecosystem is generally a description of an environment's organisms and physical features. This includes the amount and distribution of energy in the environment. Now let you have some very easy discussion about the **structure of ecosystem** in brief:

a) **Abiotic components**: abiotic components are the inorganic and organic components present in the air, water and soil, either they remain in the abiotic phase or they are absorbed by plants and thus entered the biotic phase. The biotic organism after their death and decay they are returned back to the nature.



2.2 Structure of Ecosystem

a) **Producers**: producers include all the autotrophic organisms, which can prepare their own food using the carbon dioxide, water and mineral salts from the atmosphere. These structure of ecosystem include the following organisms:

i) **Photosynthetic bacteria**: These types of bacteria have chlorophyll and can prepare food with the help of solar energy, such as green sulphur bacteria.

ii) **Chemo-synthetic bacteria**: These types of bacteria are devoid of chlorophyll but can prepare their food by the oxidation of inorganic search tenses like ammonia, nitrates or ferrous carbonate et cetera.

iii) **Phytoplankton**: the floating green plants which may be microscopic like the green

algae Volvox or microscopic like Lemna and they are major producers of all aquatic structure of ecosystem.

iv) **Land Plants**: land plans include all the herbs, shrubs and trees and provide energy for the running of all terrestrial structure of ecosystem.

b) **Consumers**: The consumers are heterotrophic organisms cannot prepare their own food, but depend on the producers for their nourishment. There are different types of consumers depending upon their feeding habits and they may be defined as follows: –

i) **Primary consumers**: primary consumers also called the first-order consumers which are herbivores and directly feed on green plants. They include zooplanktons like protozoa, Daphnia, Benthonic or bottom feeders like snails, Arthropods, insects like grasshoppers, birds and mammals like rabbit, dear, cow etc.

ii) **Secondary consumers**: these are also known second-order consumers which animals feed on primary consumers. They include the frogs and fishes in grassland and pond ecosystem. Wolves, Tigers, moles can also serve as secondary consumers in terrestrial structure of ecosystem.

iii) **Tertiary consumers**: they the third- order consumers are upper graded consumers which feed on secondary consumers. They are the upper graded consumers in an ecosystem, snakes in grassland to assist them are Tertiary consumers barred the peacocks form the final consumers which consumes the snakes. Sharks form the Tertiary consumers in ocean ecosystem, Eagles can also serve as Tertiary consumers in terrestrial ecosystems. **Decomposers**: the heterotrophic organisms like fungi and bacteria, which breakdown complex organic macromolecules of dead organisms to comparatively simpler substances are called as decomposers. They convert complex organic substances to simply organic forms and hence they are also called Micro-consumers or reducers. The simpler substances can also be absorbed by the microorganisms and they produce secondary metabolites like vitamins and antibiotic and they are called as **ectocrines**.

Following are the main functions of the decomposers: –

1) Production of food.

2) Recycling of nutrients by mineralization dead organic tissues.

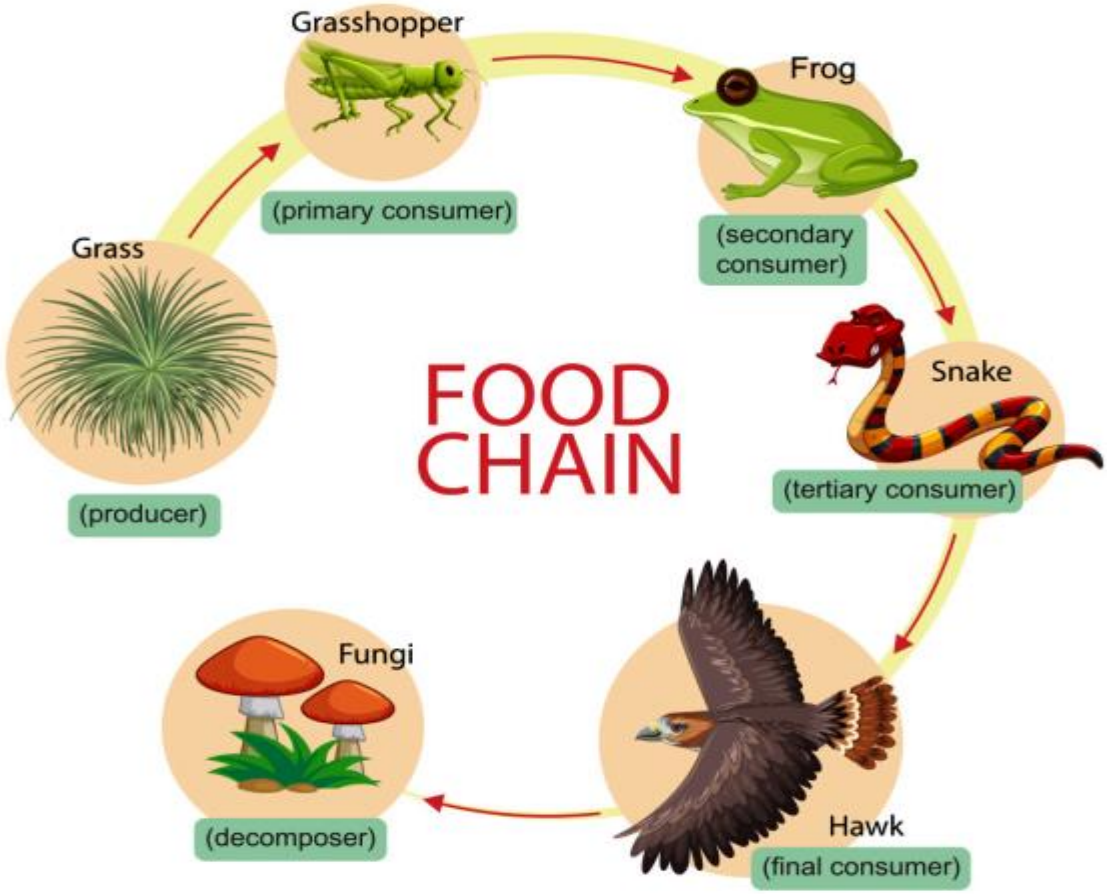
3) Production of the ectocrine materials.

So, in this way in the **structure of ecosystem** the producers, consumers and decomposers are considered as they are functional kingdoms of nature, which interact closely with the abiotic factors.

2.3 Food chain:

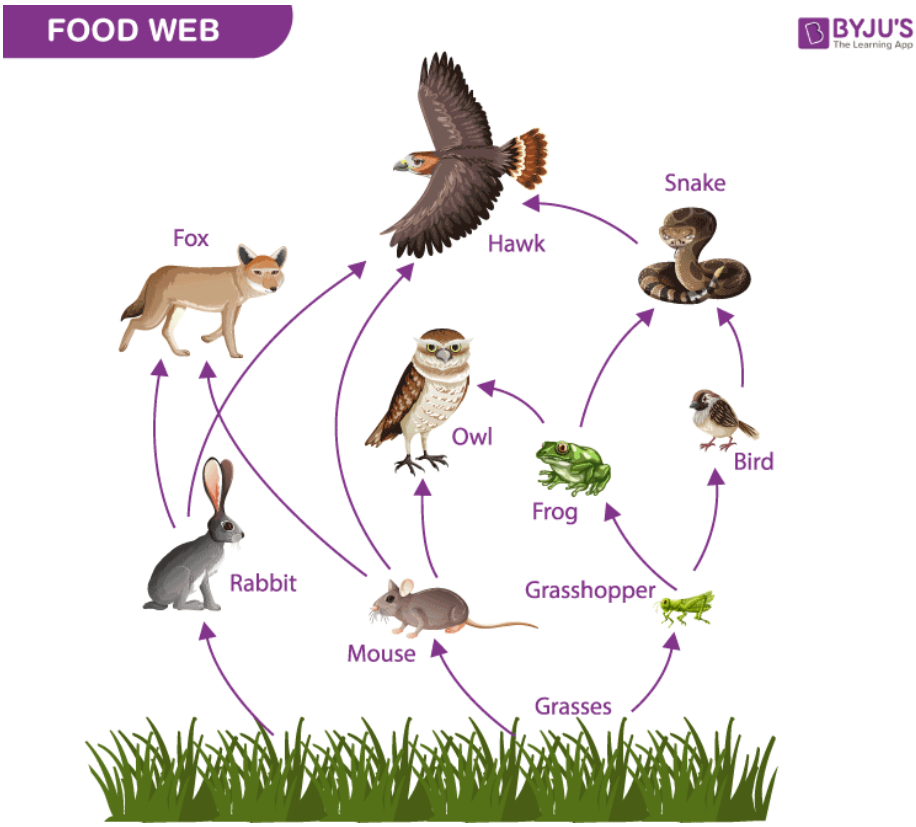
A food chain refers to the order of events in an ecosystem, where one living organism eats another organism, and later that organism is consumed by another larger organism. The flow of nutrients and energy from one organism to another at different trophic levels forms a food chain.

The food chain also explains the feeding pattern or relationship between living organisms. Trophic level refers to the sequential stages in a food chain, starting with producers at the bottom, followed by primary, secondary and tertiary consumers. Every level in a food chain is known as a trophic level.



2.4 Food Web:

Several interconnected food chains form a food web. A food web is similar to a food chain but the food web is comparatively larger than a food chain. Occasionally, a single organism is consumed by many predators or it consumes several other organisms. Due to this, many trophic levels get interconnected. The food chain fails to showcase the flow of energy in the right way. But, the food web is able to show the proper representation of energy flow, as it displays the interactions between different organisms.



2.5 Types of Food Chain

There are two types of food chains, namely the detritus food chain and the grazing food chain. Let's look at them more closely:

- **Detritus food chain:** The detritus food chain includes different species of organisms and plants like algae, bacteria, fungi, protozoa, mites, insects, worms and so on. The detritus food chain begins with dead organic material. The food energy passes into decomposers and detritivores, which are further eaten by smaller organisms like carnivores. Carnivores, like maggots, become a meal for bigger carnivores like frogs, snakes and so on. Primary consumers like fungi, bacteria, protozoans, and so on are detritivores which feed on detritus.

- **Grazing food chain:** The grazing food chain is a type of food chain that starts with green plants, passes through herbivores and then to carnivores. In a grazing food chain, energy in the lowest trophic level is acquired from photosynthesis.

In this type of food chain, the first energy transfer is from plants to herbivores. This type of food chain depends on the flow of energy from autotrophs to herbivores. As autotrophs are the base for all ecosystems on Earth, the majority of ecosystems in the environment follow this kind of food chain.

3 Energy Flow Through Ecosystems

Virtually every task performed by living organisms requires energy. In general, **energy** is defined as the ability to do work, or to create some kind of change. Energy exists in different forms. Examples include light energy, kinetic energy, heat energy, potential energy, and chemical energy.Energy is required by most complex metabolic pathways (often in the form of adenosine triphosphate, ATP), especially those responsible for building large molecules from smaller compounds, and life itself is an energy-driven process. Living organisms would not be able to assemble macromolecules (proteins, lipids, nucleic acids, and complex carbohydrates) from their monomeric subunits without a constant energy input.

It is important to understand how organisms acquire energy and how that energy is passed from one organism to another through **trophic interactions**. Trophic interactions in a community can be represented by diagrams called **food chains** and **food webs**. Food webs illustrate how energy flows directionally through ecosystems, including how efficiently organisms acquire it, use it, and how much remains for use by other organisms of the food web.

4 How Organisms Acquire Energy in a Food Web

Energy is acquired by living things in three ways: **photosynthesis**, **chemosynthesis**, and the consumption and digestion of other living or previously living organisms by **heterotrophs**.

Photosynthetic and chemosynthetic organisms are both grouped into a category known as **autotrophs** (or **producers**): organisms capable of synthesizing their own food (more specifically, capable of using inorganic carbon as a carbon source). Cells run on the chemical energy found mainly in carbohydrate molecules the majority of which are produced by autotrophs. Photosynthetic autotrophs (photoautotrophs) use sunlight as an energy source, whereas chemosynthetic autotrophs (chemoautotrophs) use inorganic molecules as an energy

source. Autotrophs are critical for all ecosystems. Without these organisms, energy would not be available to other living organisms and life itself would not be possible. The energy that is harnessed by autotrophs enters the communities continuously and is transferred from one organism to another.

Photoautotrophs, such as plants, algae, and photosynthetic bacteria, serve as the energy source for a majority of the world's ecosystems. These ecosystems are often described by grazing food webs. Photoautotrophs harness the solar energy of the sun by converting it to chemical energy in the form of ATP (and NADP) (figure 2). The energy stored in ATP is used to synthesize complex organic molecules, such as glucose.

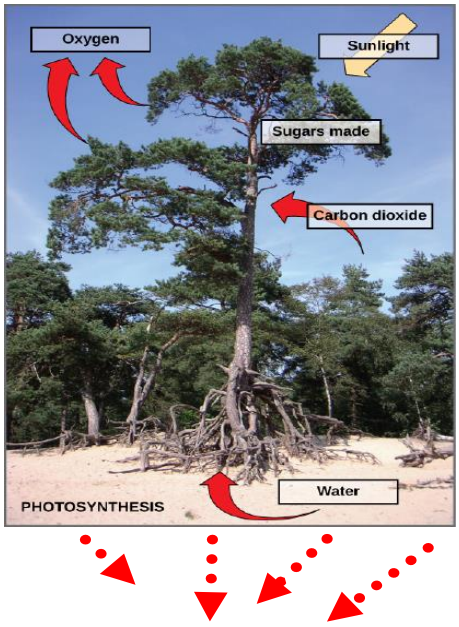


Figure 2: Photosynthesis uses solar energy, carbon dioxide, and water to release oxygen and to produce energy-storing sugar molecules. Image and caption by OpenStax (CC-BY). Access for free at openstax.org.

Chemoautotrophs are primarily bacteria that are found in rare ecosystems where sunlight is not available, such as in those associated with dark caves or hydrothermal vents at the bottom of the ocean (Figure 3). Many chemoautotrophs in hydrothermal vents use hydrogen sulfide (H_2S), which is released from the vents as a source of chemical energy. This allows chemoautotrophs to synthesize complex organic molecules, such as glucose, for their own energy and in turn supplies energy to the rest of the ecosystem.

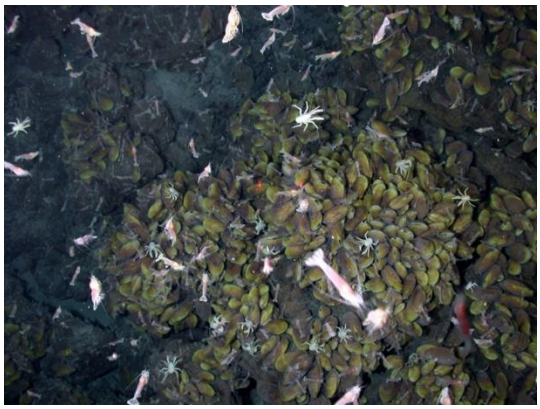


Figure 3: Swimming shrimp, a few squat lobsters, and hundreds of vent mussels are seen at a hydrothermal vent at the bottom of the ocean.

As no sunlight penetrates to this depth, the ecosystem is supported by chemoautotrophic bacteria and organic material that sinks from the ocean's surface. This picture was taken in 2006 at the submerged NW Eifuku volcano off the coast of Japan by the National Oceanic and Atmospheric Administration (NOAA). The summit of this highly active volcano lies 1535 m below the surface.

Heterotrophs **(consumers)**, like animals, fungi, and various microorganisms depend on producers, either directly or indirectly. For example, a deer obtains energy by eating plants (figure 4). A wolf eating a deer obtains energy that originally came from the plants eaten by that deer. Using this reasoning, all food eaten by humans can be traced back to producers that carry out photosynthesis (figure 5).

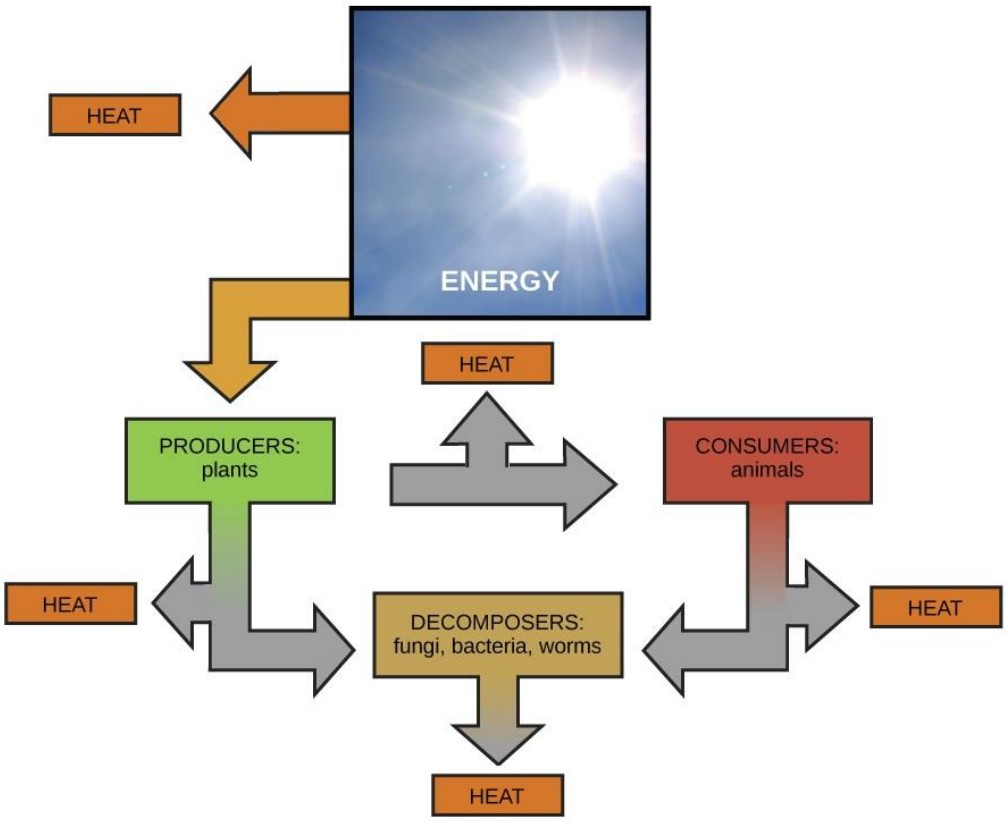


Figure 4**:** The energy stored in carbohydrate molecules from photosynthesis passes through the food chain. The predator that eats these deer is getting energy that originated in the photosynthetic vegetation that the deer consumed. (credit: Steve VanRiper, U.S. Fish and Wildlife Service).

Figure 5**:** Ultimately, most life forms get their energy from the sun. This flow chart shows energy from the sun being captured by producers, such as plants, through photosynthesis. The energy is transferred to the consumers of the producers, such as animals. Energy can be obtained from producers directly (herbivores eat plants) or indirectly (carnivores eat herbivores). Decomposers eventually breakdown of dead organisms, including plant and animal material, and contribute to the nutrient pool. Fungi and bacteria are decomposers, and worms

are detritivores (not shown). During each energy transfer, some of the energy in the system is lost as heat.

Consumers can be classified based on whether they eat animal or plant material (figure 6). Consumers that feed exclusively on animals are called **carnivores**. Lions, tigers, snakes, sharks, sea stars, spiders, and ladybugs are all carnivores. **Herbivores** are consumers that feed exclusively on plant material, and examples include deer, koalas, some bird species, crickets, and caterpillars. Herbivores can be further classified into **frugivores** (fruit-eaters), **granivores** (seed eaters), **nectivores** (nectar feeders), and **folivores** (leaf eaters). Consumers that eat both plant and animal material are considered **omnivores**. Humans, bears, chickens, cockroaches, and crayfish are examples of omnivores.

Figure 6**:** Carnivores like the lion (top left) eat primarily meat. The ladybug (lower left) is also a carnivore that consumes small insects called aphids. Herbivores, like the mule deer (middle) eat primarily plant material. Omnivores like the bear (top right) and crayfish (bottom right) eat both plant and animal based food. Lion by Kevin Pluck; ladybug by Jon Sullivan; mule deer by Bill Ebbesen; bear by Dave Menke; crayfish by Jon Sullivan. All from OpenStax (CC-BY). Access for free at openstax.org.

Dead producers and consumers are eaten by **detritivores** (which ingest dead tissues) and **decomposers** (which further break down these tissues into simple molecules by secreting digestive enzymes). Invertebrate animals, such as worms and millipedes, are examples of detritivores, whereas fungi and certain bacteria are examples decomposers.

5 Ecosystem Productivity

Productivity within an ecosystem can be defined as the percentage of energy entering the ecosystem incorporated into biomass in a particular trophic level. Biomass is the total mass, in a unit area at the time of measurement, of living or previously living organisms within a trophic level. Ecosystems have characteristic amounts of biomass at each trophic level. For example, in the English Channel ecosystem the primary producers account for a biomass of 4 g/m^2 (grams per meter squared), while the primary consumers exhibit a biomass of 21 g/m^2.

The productivity of the primary producers is especially important in any ecosystem because these organisms bring energy to other living organisms by photoautotrophy or chemoautotrophy. The rate at which photosynthetic producers incorporate energy from the sun is called **gross primary productivity**. In a cattail marsh, plants only trap 2.2% of the energy from the sun that reaches them. Three percent of the energy is reflected, and another 94.8% is used to heat and evaporate water within and surrounding the plant. However, not all of the energy incorporated by producers is available to the other organisms in the food web because producers must also grow and reproduce, which consumes energy. At least half of the 2.2% trapped by cattail marsh plants is used to meet the plants own energy needs.

Net primary productivity is the energy that remains in the producers after accounting for the metabolic needs of the producers and heat loss. The net productivity is then available to the primary consumers at the next trophic level. One way to measure net primary productivity is to collect and weigh the plant material produced on a m^2 (about 10.7 ft^2) of land over a given interval. One gram of plant material (e.g., stems and leaves), which is largely the carbohydrate cellulose, yields about 4.25 kcal of energy when burned. Net primary productivity can range from 500 $kcal/m^2/yr$ in the desert to 15,000 $kcal/m^2/yr$ in a tropical rain forest.

The loss of energy between trophic levels is illustrated by the pioneering studies of Howard T. Odum in the Silver Springs, Florida, ecosystem in the 1940s (Figure 15.5.1015.5.10). the gross primary productivity (total energy accumulated by the primary producers) was 20,810 $kcal/m^2/yr$ (figure 15.5.j15.5.j). The net primary productivity (energy available to consumers) was only 7,632 $kcal/m^2/yr$ after accounting for energy lost as heat and energy require to meet the producer's metabolic needs. . The primary consumers generated 3368 $kcal/m^2/yr$, the secondary consumers generated 383 $kcal/m^2/yr$, and the tertiary consumers only generated 21 $kcal/m^2/yr$. Thus, there is little energy remaining for another level of consumers in this

ecosystem.

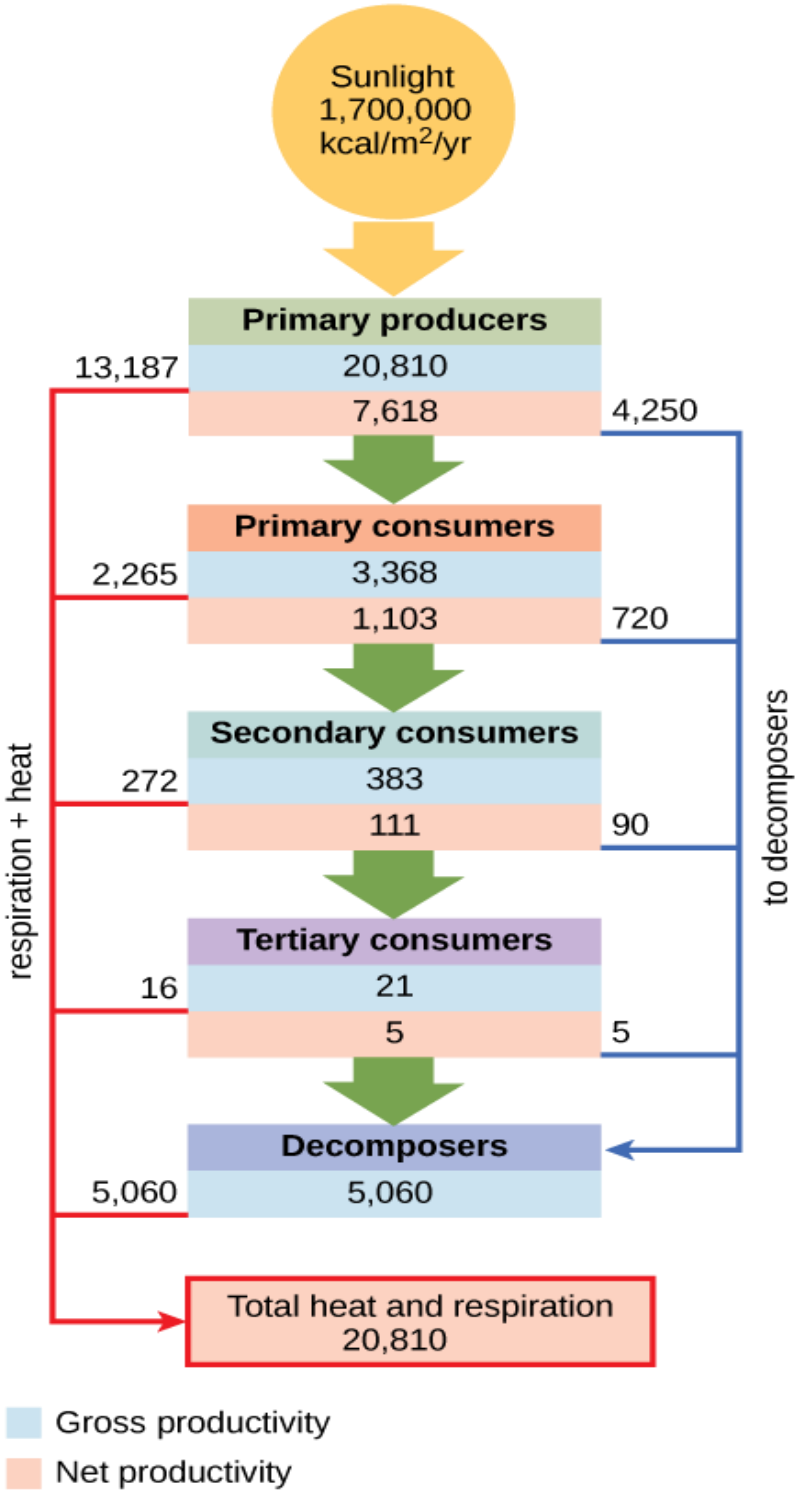


Figure 7: The flow of energy through a spring ecosystem in Silver Springs, Florida. The gross productivity (blue) for each trophic level is listed just above the net productivity (red). Notice that the energy decreases with each increase in trophic level. The energy content of primary

producers (gross productivity) is 20,810 kcal/m^2/yr. The gross productivity of primary consumers is much smaller, about 3,368 kcal/m^2/yr. The gross productivity of secondary consumers is 383 kcal/m^2/yr, and the gross productivity of tertiary consumers is only 21 kcal/m^2/yr. The net productivity of each trophic level is less than the gross productivity because some energy is used to meet metabolic needs (respiration), and some energy is lost as heat. For example, the net productivity of primary consumers was 1,103 kcal/m^2/yr, only about a third of the gross productivity. Some of the energy in each trophic level (a total of 5,060 kcal/m^2/yr) is transferred to decomposers. All of the energy initially captured by primary producers (20,810 kcal/m^2/yr) is eventually released from the system.

5.1 Ecological Efficiency: The Transfer of Energy between Trophic Levels

As illustrated in Figure 7, large amounts of energy are lost from the ecosystem from one trophic level to the next level as energy flows from the primary producers through the various trophic levels of consumers and decomposers. The main reason for this loss is the second law of thermodynamics, which states that whenever energy is converted from one form to another, there is a tendency toward disorder (entropy) in the system. In biologic systems, this means a great deal of energy is lost as metabolic heat when the organisms from one trophic level consume the next level. In the Silver Springs ecosystem example (Figure 15.5.1015.5.10), we see that the primary consumers produced 1103 kcal/m^2/yr from the 7618 kcal/m^2/yr of energy available to them from the primary producers. The measurement of energy transfer efficiency between two successive trophic levels is termed the **trophic level transfer efficiency** (TLTE) and is defined by the formula:

$$\text{TLTE} = \frac{\text{production at present trophic level}}{\text{production at previous trophic level}} * 100$$

In Silver Springs, the TLTE between the first two trophic levels was approximately 14.8 percent. The low efficiency of energy transfer between trophic levels is usually the major factor that limits the length of food chains observed in a food web. The fact is, after four to six energy transfers, there is not enough energy left to support another trophic level. In the Lake Ontario example shown in Figure 46.1.5, only three energy transfers occurred between the primary producer, (green algae), and the apex consumer (Chinook salmon).

Ecologists have many different methods of measuring energy transfers within ecosystems. Some transfers are easier or more difficult to measure depending on the complexity of the ecosystem and how much access scientists have to observe the ecosystem. In other words, some ecosystems are more difficult to study than others, and sometimes the quantification of energy transfers has to be estimated.

Another main parameter that is important in characterizing energy flow within an ecosystem is the **net production efficiency**. Net production efficiency (NPE) allows ecologists to quantify how efficiently organisms of a particular trophic level incorporate the energy they receive into biomass; it is calculated using the following formula:

$$\text{NPE} = \frac{\text{net consumer productivity}}{\text{assimilation}} * 100$$

Net consumer productivity is the energy content available to the organisms of the next trophic level. Assimilation is the biomass (energy content generated per unit area) of the present trophic level after accounting for the energy lost due to incomplete ingestion of food, energy used for respiration, and energy lost as waste. Incomplete ingestion refers to the fact that some consumers eat only a part of their food. For example, when a lion kills an antelope, it will eat everything except the hide and bones. The lion is missing the energy-rich bone marrow inside the bone, so the lion does not make use of all the calories its prey could provide.

Thus, NPE measures how efficiently each trophic level uses and incorporates the energy from its food into biomass to fuel the next trophic level. In general, cold-blooded animals (**ectotherms**), such as invertebrates, fish, amphibians, and reptiles, use less of the energy they obtain for respiration and heat than warm-blooded animals (**endotherms**), such as birds and mammals. The extra heat generated in endotherms, although an advantage in terms of the activity of these organisms in colder environments, is a major disadvantage in terms of NPE. Therefore, many endotherms have to eat more often than ectotherms to get the energy they need for survival. In general, NPE for ectotherms is an order of magnitude (10x) higher than for endotherms. For example, the NPE for a caterpillar eating leaves has been measured at 18 percent, whereas the NPE for a squirrel eating acorns may be as low as 1.6 percent.

5.2 **Modeling Ecosystems Energy Flow: Ecological Pyramids**

The structure of ecosystems can be visualized with ecological pyramids, which were first described by the pioneering studies of Charles Elton in the 1920s. Ecological pyramids show the relative amounts of various parameters (such as number of organisms, energy, and biomass) across trophic levels.

Pyramids of numbers can be either upright or inverted, depending on the ecosystem. As shown in Figure 7, typical grassland during the summer has a base of many plants and the numbers of organisms decrease at each trophic level. However, during the summer in a temperate forest, the base of the pyramid consists of few trees compared with the number of primary consumers, mostly insects. Because trees are large, they have great photosynthetic capability, and dominate other plants in this ecosystem to obtain sunlight. Even in smaller numbers, primary producers in forests are still capable of supporting other trophic levels.

Another way to visualize ecosystem structure is with pyramids of biomass. This pyramid measures the amount of energy converted into living tissue at the different trophic levels. Using the Silver Springs ecosystem example, this data exhibits an upright biomass pyramid (Figure 8), whereas the pyramid from the English Channel example is inverted. The plants (primary producers) of the Silver Springs ecosystem make up a large percentage of the biomass found there. However, the phytoplankton in the English Channel example make up less biomass than the primary consumers, the zooplankton. As with inverted pyramids of numbers, this inverted pyramid is not due to a lack of productivity from the primary producers, but results from the high turnover rate of the phytoplankton. The phytoplankton are consumed rapidly by the primary consumers, thus, minimizing their biomass at any particular point in time. However, phytoplankton reproduce quickly, thus they are able to support the rest of the ecosystem.

Pyramid ecosystem modeling can also be used to show energy flow through the trophic levels. Notice that these numbers are the same as those used in the energy flow compartment diagram in Figure 8. Pyramids of energy are always upright, and an ecosystem without sufficient primary productivity cannot be supported. All types of ecological pyramids are useful for characterizing ecosystem structure. However, in the study of energy flow through the ecosystem, pyramids of energy are the most consistent and representative models of ecosystem structure (Figure 8).

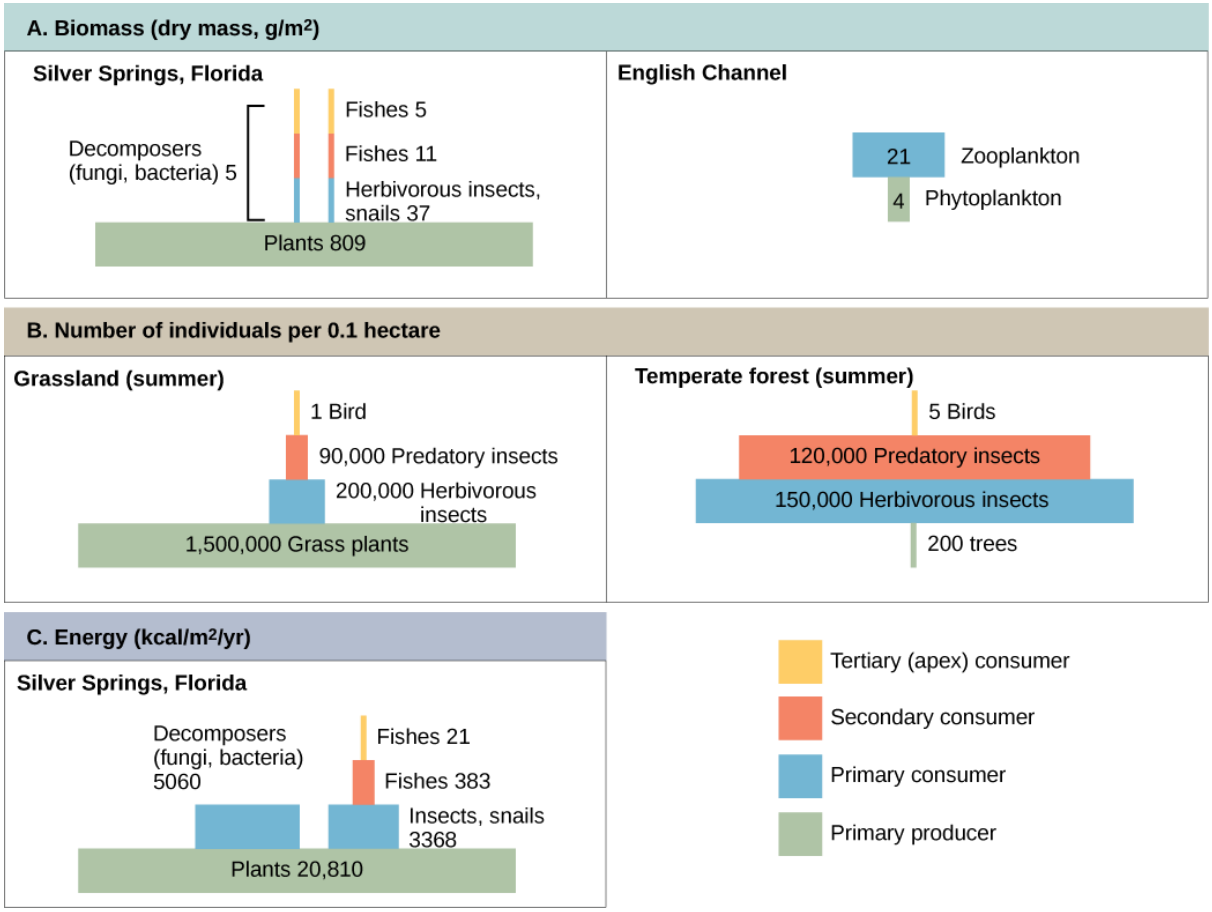


Figure 8**:** Ecological pyramids depict the (a) biomass, (b) number of organisms, and (c) energy in each trophic level.

6 Biogeochemical Cycles

Biogeochemical cycles, also known as nutrient cycles, describe the movement of chemical elements through different media, such as the atmosphere, soil, rocks, bodies of water, and organisms. Biogeochemical cycles keep essential elements available to plants and other organisms.

Energy flows directionally through ecosystems, entering as sunlight (or inorganic molecules for chemoautotrophs) and leaving as heat during energy transformation between trophic levels. Rather than flowing through an ecosystem, the matter that makes up organisms is conserved and recycled. The **law of conservation of mass** states that matter is neither created nor destroyed. For example, after a chemical reaction, the mass of the products (ending molecules) will be the same as the mass of the reactants (starting molecules). The same is true in an ecosystem. Matter moves through different media, and atoms may react to form new molecules, but the amount of matter remains constant.

The biogeochemical cycles of four elements—carbon, nitrogen, phosphorus, and sulfur—are discussed below. The cycling of these elements is interconnected with the water cycle. For example, the movement of water is critical for the leaching of sulfur and phosphorus into rivers, lakes, and oceans. Today, **anthropogenic** (human) activities are altering all major ecosystems and the biogeochemical cycles they drive.

6.1 The Carbon Cycle

Carbon is the basic building block of all organic materials, and therefore, of living organisms. The carbon cycle is actually comprised of several interconnected cycles: one dealing with rapid carbon exchange among living organisms and the other dealing with the long-term cycling of carbon through geologic processes (figure 9). The overall effect is that carbon is constantly recycled in the dynamic processes taking place in the atmosphere, at the surface and in the crust of the earth. The vast majority of carbon resides as inorganic minerals in crustal rocks. Other **reservoirs** of carbon, places where carbon accumulates, include the oceans and atmosphere. Some of the carbon atoms in your body today may long ago have resided in a dinosaur's body, or perhaps were once buried deep in the Earth's crust as carbonate rock minerals.

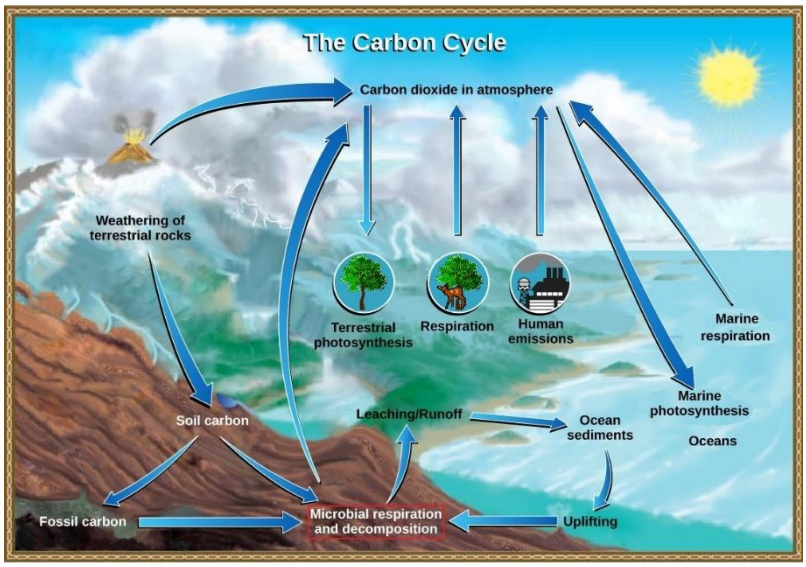


Figure 9: Carbon dioxide in the atmosphere is converted to organic carbon through photosynthesis by terrestrial organisms (like trees) and marine organisms (like algae). Respiration by terrestrial organisms (like trees and deer) and marine organisms (like algae and fish) release carbon dioxide back into the atmosphere. Additionally, microbes that decompose dead organisms release carbon dioxide through respiration. Weathering of terrestrial rocks also

brings carbon into the soil. Carbon in the soil enters the water through leaching and runoff. It can accumulate into ocean sediments and reenter land through uplifting. Long-term storage of organic carbon occurs when matter from living organisms is buried deep underground and becomes fossilized. Volcanic activity and, more recently, human emissions stored carbon back into the carbon cycle. Modified from John M. Evans and Howard Perlman, USGS using tree and deer (both public domain).

7 Carbon Cycles Slowly between Land and the Ocean

On land, carbon is stored in soil as organic carbon in the form of decomposing organisms or terrestrial rocks. Decomposed plants and algae are sometimes buried and compressed between layers of sediments. After millions of years fossil fuels such as coal, oil, and natural gas are formed. The **weathering** of terrestrial rock and minerals release carbon into the soil.

Carbon-containing compounds in the soil can be washed into bodies of water through **leaching.** This water eventually enters the ocean. Atmospheric carbon dioxide also dissolves in the ocean, reacting with water molecules to form carbonate ions (CO_3^{2-}). Some of these ions combine with calcium ions in the seawater to form calcium carbonate ($CaCO_3$), a major component of the shells of marine organisms. These organisms eventually die and their shells form sediments on the ocean floor. Over geologic time, the calcium carbonate forms limestone, which comprises the largest carbon reservoir on Earth.

Carbonate also precipitates in sediments, forming carbonate rocks, such as limestone. Carbon sediments from the ocean floor are taken deep within Earth by the process of **subduction**: the movement of one tectonic plate beneath another. The ocean sediments are subducted by the actions of **plate tectonics**, melted and then returned to the surface during volcanic activity. Plate tectonics can also cause **uplifting**, returning ocean sediments to land.

8 Carbon Cycles Quickly between Organisms and the Atmosphere

Carbon dioxide is converted into glucose, an energy-rich organic molecule through **photosynthesis** by plants, algae, and some bacteria (figure 9). They can then produce other organic molecules like complex carbohydrates (such as starch), proteins and lipids, which animals can eat. Most terrestrial autotrophs obtain their carbon dioxide directly from the atmosphere, while marine autotrophs acquire it in the dissolved form (bicarbonate, HCO_3^-).

(a) (b) (c)

Figure 10: (a) Plants, (b) algae, and (c) certain bacteria, called cyanobacteria, are can carry out photosynthesis. Algae can grow over enormous areas in water, at times completely covering the surface. (credit a: Steve Hillebrand, U.S. Fish and Wildlife Service; credit b: "eutrophication&hypoxia"/Flickr; credit c: NASA; scale-bar data from Matt Russell)

Plants, animals, and other organisms break down these organic molecules during the process of **aerobic cellular respiration**, which consumes oxygen and releases energy, water and carbon dioxide. Carbon dioxide is returned to the atmosphere during gaseous exchange. Another process by which organic material is recycled is the decomposition of dead organisms. During this process, bacteria and fungi break down the complex organic compounds. Decomposers may do respiration, releasing carbon dioxide, or other processes that release methane (CH_4).

Photosynthesis and respiration are actually reciprocal to one another with regard to the cycling of carbon: photosynthesis removes carbon dioxide from the atmosphere and respiration returns it (figure 11). A significant disruption of one process can therefore affect the amount of carbon dioxide in the atmosphere.

Photosynthesis Equation						
Carbon dioxide	+	Water	SUNLIGHT →	Sugar	+	Oxygen
$6CO_2$		$6H_2O$		$C_6H_{12}O_6$		$6O_2$

Figure 11: This equation means that six molecules of carbon dioxide (CO_2) combine with six molecules of water (H_2O) in the presence of sunlight. This produces one molecule of glucose ($C_6H_{12}O_6$) and six molecules of oxygen (O_2).

Cellular respiration is only one process that releases carbon dioxide. Physical processes,

such as the eruption of volcanoes and release from **hydrothermal vents** (openings in the ocean floor) add carbon dioxide to the atmosphere. Additionally, the **combustion** of wood and fossil fuels releases carbon dioxide. The level of carbon dioxide in the atmosphere is greatly influenced by the reservoir of carbon in the oceans. The exchange of carbon between the atmosphere and water reservoirs influences how much carbon is found in each.

9 Importance of the Carbon Cycle

The carbon cycle is crucially important to the biosphere. If not for the recycling processes, carbon might long ago have become completely sequestered in crustal rocks and sediments, and life would no longer exist (figure 9). Photosynthesis not only makes energy and carbon available to higher trophic levels, but it also releases gaseous oxygen (O_2). Gaseous oxygen is necessary for cellular respiration to occur. Photosynthetic bacteria were likely the first organisms to perform photosynthesis, dating back 2-3 billion years ago. Thanks to their activity, and a diversity of present-day photosynthesizing organisms, Earth's atmosphere is currently about 21% O_2. Also, this O_2 is vital for the creation of the ozone layer, which protects life from harmful ultraviolet radiation emitted by the sun. Ozone (O_3) is created from the breakdown and reassembly of O_2.

Figure 12: Decomposers will break down the organic compounds in this fallen tree at Cliffs of the Neuse State Park in Wayne County, North Carolina, releasing carbon dioxide into the atmosphere. Decomposition ensures that carbon dioxide will be available in the atmosphere for photosynthetic organisms, which then provide carbon for consumers. Image by Gerry Dincher (CC-BY-SA).

The global carbon cycle contributes substantially to the provisioning ecosystem services upon which humans depend. We harvest approximately 25% of the total plant biomass that is produced each year on the land surface to supply food, fuel wood and fiber from croplands, pastures and forests. In addition, the global carbon cycle plays a key role in regulating ecosystem services because it significantly influences climate via its effects on atmospheric CO_2 concentrations.

10 Human Alteration of the Carbon Cycle

Atmospheric CO_2 concentration increased from 280 parts per million (ppm) to 413 ppm

between the start of industrial revolution in the late eighteenth century and 2020. This reflected a new flux in the global carbon cycle—anthropogenic CO_2 emissions—where humans release CO_2 into the atmosphere by burning fossil fuels and changing land use. Fossil fuel burning takes carbon from coal, gas, and oil reserves, where it would be otherwise stored on very long time scales, and introduces it into the active carbon cycle. Land use change releases carbon from soil and plant biomass pools into the atmosphere, particularly through the process of deforestation for wood extraction or conversion of land to agriculture. In 2018, the additional flux of carbon into the atmosphere from anthropogenic sources was estimated to be 36.6 gigatons of carbon (GtC = 1 billion tons of carbon)—a significant disturbance to the natural carbon cycle that had been in balance for several thousand years previously. High levels of carbon dioxide in the atmosphere cause warming that results in climate change. (See Threats to Biodiversity and Climate Change for more details.)

11 The Nitrogen Cycle

All organisms require nitrogen because it is an important component of nucleic acids, proteins, and other organic molecules. Getting nitrogen into living organisms is difficult. Plants and algae are not equipped to incorporate nitrogen from the atmosphere (where it exists as tightly bonded, triple covalent N_2) although this molecule comprises approximately 78 percent of the atmosphere. Because most of the nitrogen is stored in the atmosphere, the atmosphere is considered a reservoir of nitrogen.

The nitrogen molecule (N_2) is quite inert. To break it apart so that its atoms can combine with other atoms requires the input of substantial amounts of energy. **Nitrogen fixation** is the process of converting nitrogen gas into ammonia (NH_3), which spontaneously becomes ammonium (NH_4^+). Ammonium is found in bodies of water and in the soil (figure 11) .

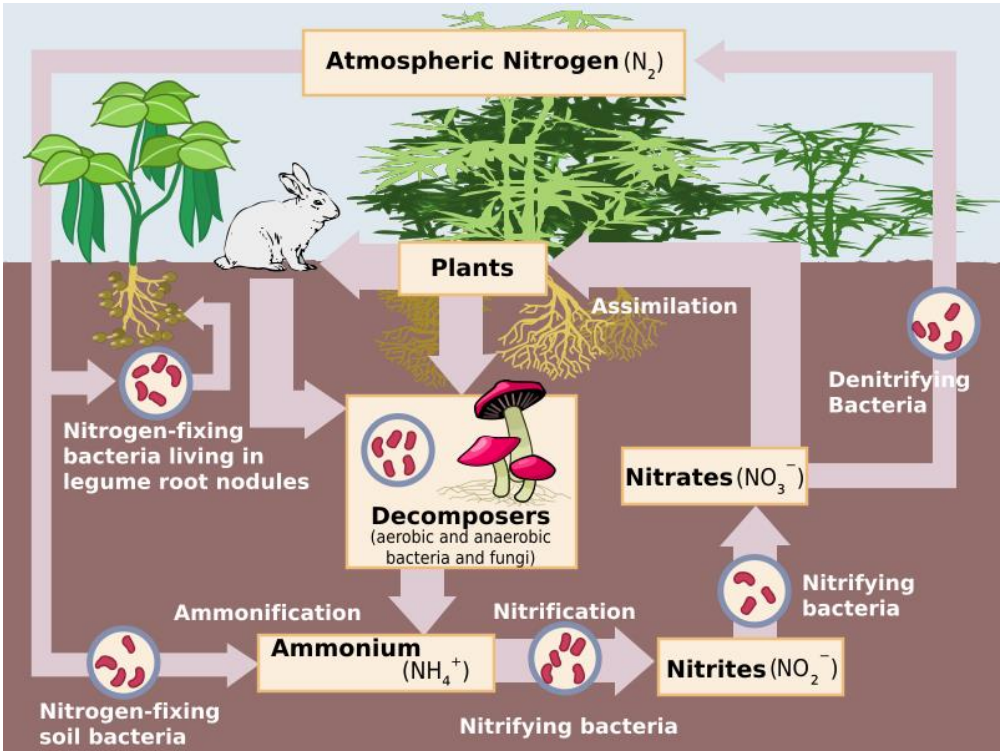


Figure 13: In the nitrogen cycle, nitrogen-fixing bacteria in the soil or legume root nodules convert nitrogen gas (N_2) from the atmosphere to ammonium (NH_4^+). Nitrification occurs when bacteria convert ammonium to nitrites (NO_2^-) and then to nitrates (NO_3^-). Nitrates re-enter the atmosphere as nitrogen gas through denitrification by bacteria. Plants assimilate ammonium and nitrates, producing organic nitrogen, which is available to consumers. Decomposers, including aerobic and anaerobic bacteria and fungi, break down organic nitrogen and release ammonium through ammonification. (credit: "Nitrogen cycle" by Johann Dréo & Raeky is licensed under CC BY-SA 3.0)

Three processes are responsible for most of the nitrogen fixation in the biosphere. The first is **atmospheric fixation** by lightning. The enormous energy of lightning breaks nitrogen molecules and enables their atoms to combine with oxygen in the air forming nitrogen oxides. These dissolve in rain, forming nitrates, that are carried to the earth. Atmospheric nitrogen fixation probably contributes some 5-8% of the total nitrogen fixed. The second process is **industrial fixation.** Under great pressure, at a temperature of 600°C (1112°F), and with the use of a **catalyst** (which facilitates chemical reactions), atmospheric nitrogen and hydrogen can be combined to form ammonia (NH_3). Ammonia can be used directly as fertilizer, but most of it is further processed to urea and ammonium nitrate (NH_4NO_3).

The third process is **biological fixation** by certain free-living or symbiotic bacteria. Some

form a symbiotic relationship with plants in the legume family, which includes beans, peas, soybeans, alfalfa, and clovers (figure 12). Some nitrogen-fixing bacteria even establish symbiotic relationships with animals, e.g., termites and "shipworms" (wood-eating bivalves). Nitrogen-fixing cyanobacteria are essential to maintaining the fertility of semi-aquatic environments like rice paddies. Although the first stable product of the process is ammonia, this is quickly incorporated into protein and other organic nitrogen compounds.

Figure 14: Nitrogen-fixing bacteria live in the spherical nodules of this soybean root. Image by United Soybean Board (CC-BY).

Ammonium is converted by bacteria and archaea into nitrites (NO_2^-) and then nitrates (NO_3^-) through the process of **nitrification**. Like ammonium, nitrites and nitrates are found in water and the soil. Some nitrates are converted back into nitrogen gas, which is released into the atmosphere. The process, called **denitrification**, is conducted by bacteria.

Plants and other producers directly use ammonium and nitrates to make organic molecules through the process of **assimilation**. This nitrogen is now available to consumers. Organic nitrogen is especially important to the study of ecosystem dynamics because many processes, such as primary production, are limited by the available supply of nitrogen.

Consumers excrete organic nitrogen compounds that return to the environment. Additionally dead organisms at each trophic level contain organic nitrogen. Microorganisms, such as bacteria and fungi, decompose these wastes and dead tissues, ultimately producing ammonium through the process of **ammonification.**

In marine ecosystems, nitrogen compounds created by bacteria, or through decomposition, collects in ocean floor sediments. It can then be moved to land in geologic time by uplift of

Earth's crust and thereby incorporated into terrestrial rock. Although the movement of nitrogen from rock directly into living systems has been traditionally seen as insignificant compared with nitrogen fixed from the atmosphere, a recent study showed that this process may indeed be significant and should be included in any study of the global nitrogen cycle.

Human activity can alter the nitrogen cycle by two primary means: the combustion of fossil fuels, which releases different **nitrogen oxides** into the atmosphere, and by the use of artificial fertilizers in agriculture. Atmospheric nitrogen (other than N_2) is associated with several effects on Earth's ecosystems. Nitrogen oxides (HNO_3) can react in the atmosphere to form nitric acid, a form of **acid deposition**, also known as acid rain. Acid deposition damages healthy trees, destroys aquatic systems and erodes building materials such as marble and limestone. Like carbon dioxide, nitrous oxide (N_2O) causes warming resulting in climate change.

Humans are primarily dependent on the nitrogen cycle as a supporting ecosystem service for crop and forest productivity. Nitrogen fertilizers are added to enhance the growth of many crops and plantations (figure 13). The enhanced use of fertilizers in agriculture was a key feature of the green revolution that boosted global crop yields in the 1970s. The industrial production of nitrogen-rich fertilizers has increased substantially over time and now matches more than half of the input to the land from biological nitrogen fixation (90 megatons = 1 million tons of nitrogen each year). If the nitrogen fixation from legume crops is included, then the anthropogenic flux of nitrogen from the atmosphere to the land exceeds natural fluxes to the land. Fertilizers are washed into lakes, streams, and rivers by surface runoff, resulting in saltwater and freshwater **eutrophication**, a process whereby nutrient runoff causes the overgrowth of algae, the depletion of oxygen, and death of aquatic fauna.

Figure 15: Fertilizer containing nitrogen is conventionally applied at large scales in agriculture.

Image by Bob Nichols, USDA Natural Resources Conservation Service (public domain).

11.1 The Phosphorus Cycle

Several forms of nitrogen (nitrogen gas, ammnoium, nitrates, etc.) were involved in the nitrogen cycle, but phosphorus remains primarily in the form of the phosphate ion (PO_4^{3-}). Also in contrast to the nitrogen cycle, there is no form of phosphorus in the atmosphere. Phosphorus is used to make nucleic acids and the phospholipids that comprise biological membranes.

Rocks are a reservoir for phosphorus, and these rocks have their origins in the ocean. Phosphate-containing ocean sediments form primarily from the bodies of ocean organisms and from their excretions. However, volcanic ash, aerosols, and mineral dust may also be significant phosphate sources. This sediment then is moved to land over geologic time by the uplifting of Earth's surface (figure 14). The movement of phosphate from the ocean to the land and through the soil is extremely slow, with the average phosphate ion having an oceanic residence time between 20,000 and 100,000 years.

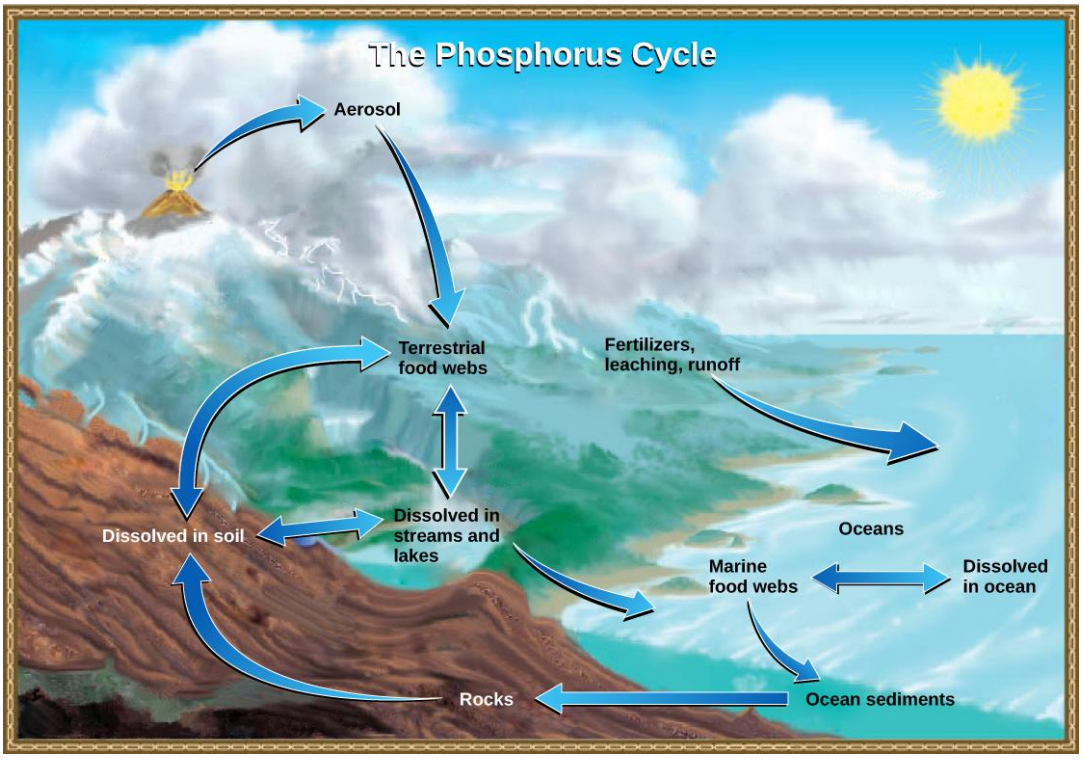


Figure 16: In nature, phosphorus exists as the phosphate ion (PO_4^{3-}). Phosphate enters the atmosphere from volcanic aerosols, which precipitate to Earth. Weathering of rocks also releases phosphate into the soil and water, where it becomes available to terrestrial food webs. Some of the phosphate from terrestrial food webs dissolves in streams and lakes, and the

remainder enters the soil. Phosphate enters the ocean via surface runoff, groundwater flow, and river flow, where it becomes dissolved in ocean water or enters marine food webs. Some phosphate falls to the ocean floor where it becomes sediment. If uplifting occurs, this sediment can return to land. (credit: modification of work by John M. Evans and Howard Perlman, USGS)

Marine birds play a unique role in the phosphorous cycle. These birds take up phosphorous from ocean fish. Their droppings on land (**guano**) contain high levels of phosphorous and are sometimes mined for commercial use. A 2020 study estimated that the **ecosystem services** (natural processes and products that benefit humans) provided by guano are worth $470 million per year.

Weathering of rocks releases phosphates into the soil and bodies of water. Plants can assimilate phosphates in the soil and incorporate it into organic molecules, making phosphorus available to consumers in terrestrial food webs. Waste and dead organisms are decomposed by fungi and bacteria, releasing phosphates back into the soil. Some phosphate is leached from the soil, entering into rivers, lakes, and the ocean. Primary producers in aquatic food webs, such as algae and photosynthetic bacteria, assimilate phosphate, and organic phosphate is thus available to consumers in aquatic food webs. Similar to terrestrial food webs, phosphorus is reciprocally exchanged between phosphate dissolved in the ocean and organic phosphorus in marine organisms.

The movement of phosphorus from rock to living organisms is normally a very slow process, but some human activities speed up the process. Phosphate-bearing rock is often mined for use in the manufacture of fertilizers and detergents. This commercial production greatly accelerates the phosphorous cycle. In addition, runoff from agricultural land and the release of sewage into water systems can cause a local overload of phosphate. The increased availability of phosphate can cause overgrowth of algae. This reduces the oxygen level, causing eutrophication and the destruction of other aquatic species.

11.2 Eutrophication and Dead Zones

Eutrophication occurs when excess phosphorus and nitrogen from fertilizer runoff or sewage causes excessive growth of algae. Algal blooms that block light and therefore kill aquatic plants in rivers, lakes, and seas. The subsequent death and decay of these organisms depletes dissolved oxygen, which leads to the death of aquatic organisms such as shellfish and fish. This process is responsible for **dead zones**, large areas in lakes and oceans near the mouths of rivers that are periodically depleted of their normal flora and fauna, and for massive fish kills, which often occur during the summer months (figure 15). There are more than 500 dead zones worldwide. One of the worst dead zones is off the coast of the United States in the Gulf of Mexico. Fertilizer runoff from the Mississippi River basin created a dead zone, which reached its peak size of 8,776 square miles in 2017. Phosphate and nitrate runoff from fertilizers also negatively affect several lake and bay ecosystems including the Chesapeake Bay in the eastern United States.

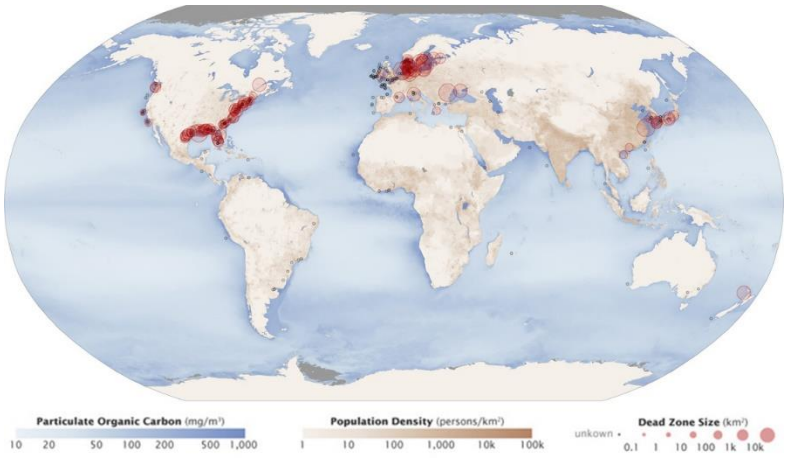


Figure 17: Dead zones occur when phosphorus and nitrogen from fertilizers cause excessive growth of microorganisms, which depletes oxygen and kills fauna. This map shows dead zones around the world in 2008. Worldwide, large dead zones are found in coastal areas of high population density. (credit: NASA Earth Observatory)

11.3 Everyday Connection: Chesapeake Bay

The Chesapeake Bay has long been valued as one of the most scenic areas on Earth; it is now in distress and is recognized as a declining ecosystem. In the 1970s, the Chesapeake Bay was one of the first ecosystems to have identified dead zones, which continue to kill many fish and bottom-dwelling species, such as clams, oysters, and worms (figure 16). Several species

have declined in the Chesapeake Bay due to surface water runoff containing excess nutrients from artificial fertilizer used on land. The source of the fertilizers (with high nitrogen and phosphate content) is not limited to agricultural practices. There are many nearby urban areas and more than 150 rivers and streams empty into the bay that are carrying fertilizer runoff from lawns and gardens. Thus, the decline of the Chesapeake Bay is a complex issue and requires the cooperation of industry, agriculture, and everyday homeowners.

(a) (b)

Figure 18: This (a) satellite image shows the Chesapeake Bay, an ecosystem affected by phosphate and nitrate runoff. A (b) member of the Army Corps of Engineers holds a clump of oysters being used as a part of the oyster restoration effort in the bay. (credit a: modification of work by NASA/MODIS; credit b: modification of work by U.S. Army)

Of particular interest to conservationists is the oyster population; it is estimated that more than 200,000 acres of oyster reefs existed in the bay in the 1700s, but that number has now declined to only 36,000 acres. Oyster harvesting was once a major industry for Chesapeake Bay, but it declined 88 percent between 1982 and 2007. This decline was due not only to fertilizer runoff and dead zones but also to overexploitation. Oysters require a certain minimum population density because they must be in close proximity to reproduce. Human activity has altered the oyster population and locations, greatly disrupting the ecosystem.

The restoration of the oyster population in the Chesapeake Bay has been ongoing for several years with mixed success. Not only do many people find oysters good to eat, but they also clean up the bay. Oysters are filter feeders, and as they eat, they clean the water around them. In the

1700s, it was estimated that it took only a few days for the oyster population to filter the entire volume of the bay. Today, with changed water conditions, it is estimated that the present population would take nearly a year to do the same job.

Restoration efforts have been ongoing for several years by non-profit organizations, such as the Chesapeake Bay Foundation. The restoration goal is to find a way to increase population density so the oysters can reproduce more efficiently. Many disease-resistant varieties (developed at the Virginia Institute of Marine Science for the College of William and Mary) are now available and have been used in the construction of experimental oyster reefs. Efforts to clean and restore the bay by Virginia and Delaware have been hampered because much of the pollution entering the bay comes from other states, which stresses the need for inter-state cooperation to gain successful restoration.

The new, hearty oyster strains have also spawned a new and economically viable industry—oyster aquaculture—which not only supplies oysters for food and profit, but also has the added benefit of cleaning the bay.

12 The Sulfur Cycle

Sulfur is an essential element for the molecules of living things. As part of the amino acid cysteine, it is critical to the three-dimensional shape of proteins. As shown in Figure 17, sulfur cycles among the oceans, land, and atmosphere. Atmospheric sulfur is found in the form of sulfur dioxide (SO_2), which enters the atmosphere in three ways: first, from the decomposition of organic molecules; second, from volcanic activity and geothermal vents; and, third, from the burning of fossil fuels by humans.

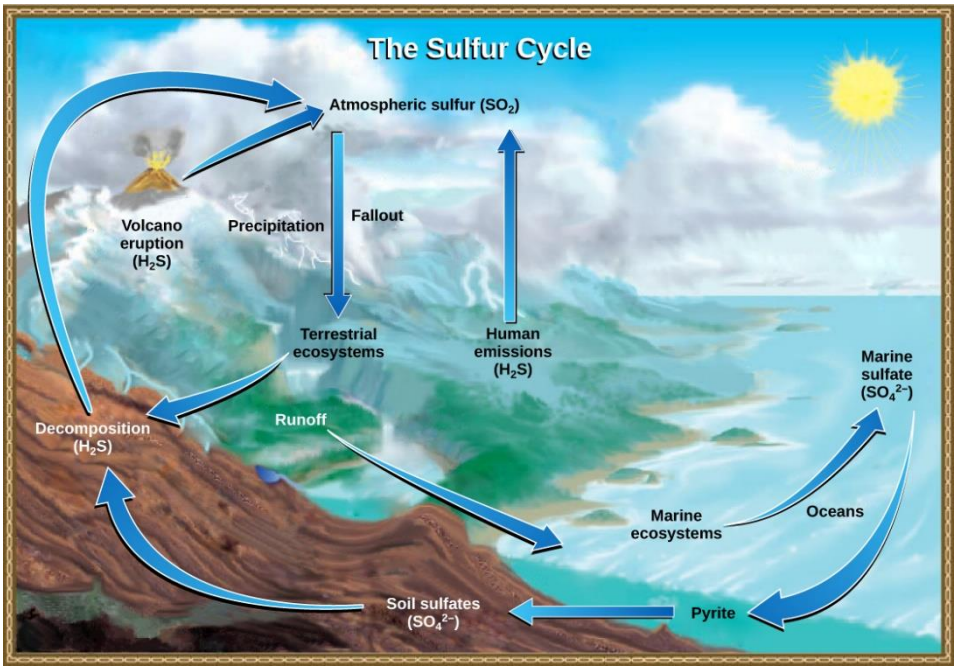


Figure 19: The sulfur cycle. Sulfur dioxide (SO_2) from the atmosphere is dissolved in precipitation as weak sulfuric acid or falls directly to Earth as fallout. This releases sulfates (SO_4^{2-}) into the soil and water. Soil sulfates can be carried as runoff into the water. Marine sulfate can form pyrite, and this can break down to release soil sulfates. Organisms in terrestrial and marine ecosystems assimilate sulfate, adding sulfur to organic molecules, such as proteins (not shown). Decomposition of these organisms returns sulfates to the soil. Microorganisms can convert sulfates to hydrogen sulfide (H_2S) and vice versa. Decomposition, volcanic eruptions, and human activities (including burning fossil fuels) can release hydrogen sulfide (H_2S) or sulfur dioxide into the atmosphere. (credit: modification of work by John M. Evans and Howard Perlman, USGS).

On land, sulfur is deposited in four major ways: precipitation, direct fallout from the atmosphere, rock weathering, and geothermal vents. Atmospheric sulfur is found in the form of sulfur dioxide (SO_2), and as rain falls through the atmosphere, sulfur is dissolved in the form of weak sulfuric acid (H_2SO_4). Sulfur can also fall directly from the atmosphere in a process called **fallout**. Also, as sulfur-containing rocks weather, sulfur is released into the soil. These rocks originate from ocean sediments that are moved to land by the geologic uplifting of ocean sediments. Terrestrial ecosystems can then make use of these soil sulfates (SO_4^{2-}), which enter the food web by being taken up by plant roots. When these plants decompose and die, sulfur is released back into the atmosphere as hydrogen sulfide (H_2S) gas.

Sulfur enters the ocean in runoff from land, from atmospheric fallout, and from hydrothermal

vents. Some ecosystems rely on microorganisms using sulfur as a biological energy source (in contrast to ecosystems with photosynthetic producers). This sulfur then supports marine ecosystems in the form of sulfates.

Human activities have played a major role in altering the balance of the global sulfur cycle. The burning of large quantities of fossil fuels, especially from coal, releases sulfur dioxide, which reacts with the atmosphere to form sulfuric acid. Like nitric acid, sulfuric acid contributes to acid deposition.

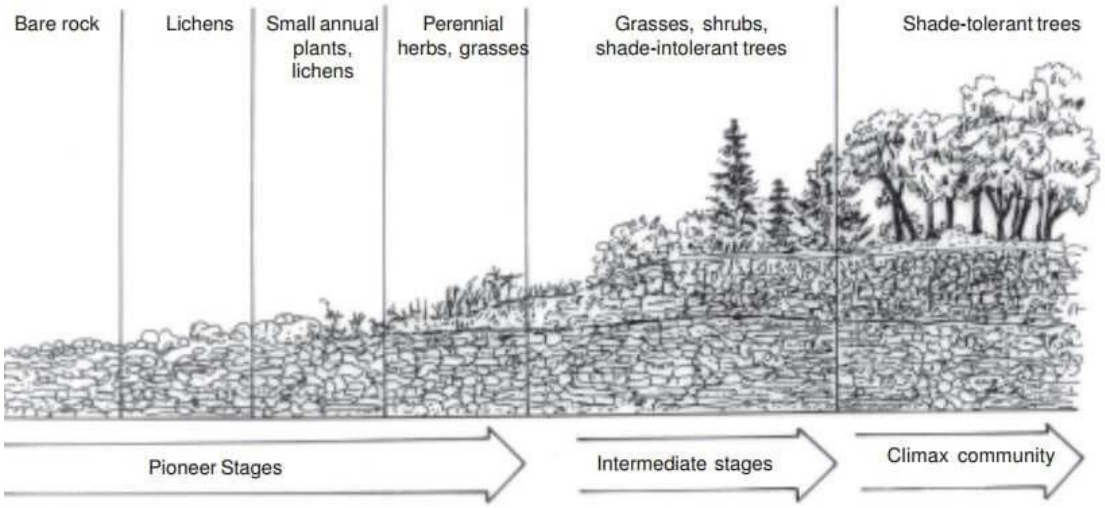
13 Functions of Ecosystem

1. **Ecological succession or ecosystem development**
2. **Homeostasis (or cybernetic) or feedback control mechanisms**
3. **Energy flow through the food chain (next post)**
4. **Nutrient cycling (biogeochemical cycles) (next post)**

14 Ecological Succession

- The process by which communities of plant and animal species in an area are **replaced or changed** into another over a period of time is known as **ecological succession**.
- Succession is a universal process of **directional change in vegetation**, on an ecological time scale.
- Succession occurs due to large scale changes or destruction (natural or manmade).
- The process involves a progressive series of changes with one community replacing another until a **stable, mature, climax community** develops.

15 Stages



Primary Succession (Picture Credits: NIOS Environment)

- The first plant to colonize an area is called the **pioneer community**.
- The final stage of succession is called the **climax community**.
- **A climax community is stable, mature, more complex and long-lasting**.
- The stage leading to the climax community is called **successional stages or seres**.
- Each transitional community that is formed and replaced during succession is called a **stage in succession or a seral community**.
- Succession is characterized by the following: **increased productivity, the shift of nutrients from the reservoirs, increased diversity of organisms**, and a **gradual increase in the complexity of food webs**.
- **Succession would occur faster in area existing in the middle of the large continent**. This is because here seeds of plants belonging to the different **seres** would reach much faster.

16 Primary Succession

- Primary succession takes place an over **where no community has existed previously**.
- Such areas include rock outcrops, newly formed deltas and sand dunes, emerging volcano islands and lava flows, glacial moraines (muddy area exposed by a retreating glacier), etc.

- In primary succession on a terrestrial site, the new site is first colonised by a few hardy **pioneer species** that are often **microbes, lichens and mosses**.

- The pioneers over a few generations alter the habitat conditions by their growth and development.

17 Q. Lichens, which are capable of initiating ecological succession even on a bare rock, are actually a symbiotic association of

a. algae and bacteria

b. algae and fungi

c. bacteria and fungi

d. fungi and mosses

Explanation

- Lichen are plant-like organisms that consist of a **symbiotic association of algae (usually green) or cyanobacteria and fungi**.

- Fungi provide shelter, water and minerals to the algae and, in return, the alga provides food.

Answer: b) Algae and Fungai

- The pioneers through their death any decay leave patches of organic matter in which small animals can live.

- The organic matter produced by these pioneer species produce organic acids during decomposition that dissolve and etch the substratum releasing nutrients to the substratum.

- Organic debris accumulates in pockets and crevices, providing soil in which seeds can become lodged and grow.

- The new conditions may be conducive to the establishment of additional organisms that may subsequently arrive at the site.

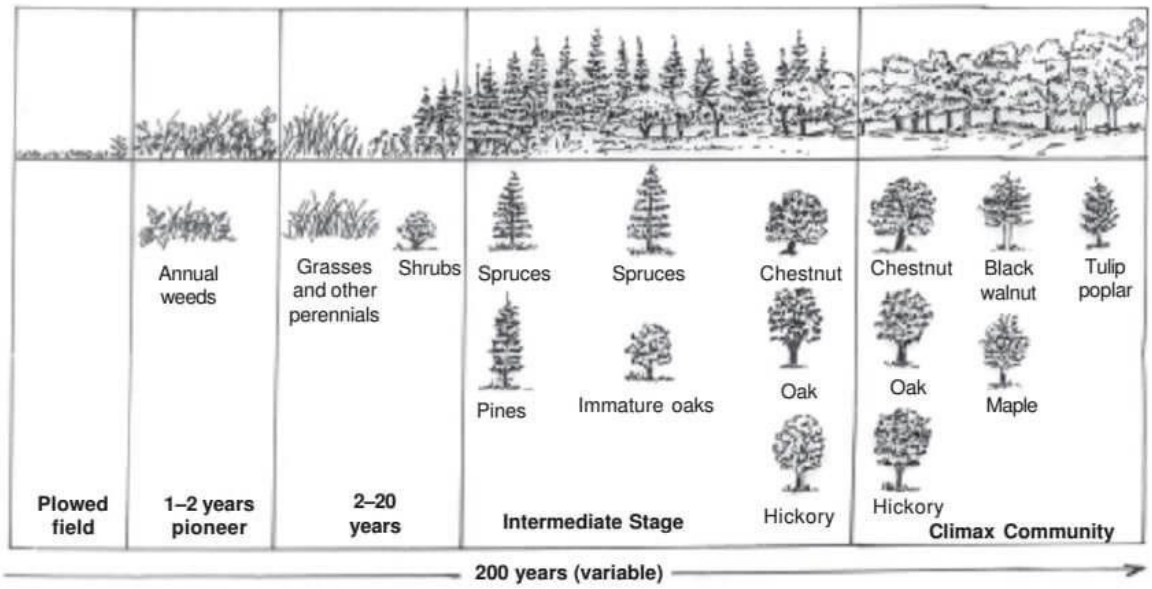
- As the community of organisms continues to develop, it becomes **more diverse, and**

competition increases, but at the same time, **new niche opportunities develop**.

- The pioneer species disappear as the habitat conditions change and **invasion of new species** progresses, leading to the replacement of the preceding community.

18 Secondary Succession

- Secondary succession is the sequential development of biotic communities **after the complete or partial destruction of the existing community**.



Secondary Succession (Picture Credits: NIOS Environment)

- A mature or intermediate community may be destroyed by natural events such as floods, droughts, fires, or storms or by human interventions such as deforestation, agriculture, overgrazing, etc.

- This abandoned land is first invaded by hardy species of grasses that can survive in bare, sun-baked soil.

- These grasses may be soon joined by tall grasses and herbaceous plants. These dominate the ecosystem for some years along with mice, rabbits, insects and seed-eating birds.

- Eventually, some trees come up in this area, seeds of which may be brought by wind or animals.

- And over the years, a forest community develops. Thus, an abandoned land over a period

becomes dominated by trees and is transformed into a forest.

19 Difference Between Primary and Secondary Succession

- Unlike in the primary succession, the secondary succession starts on a well-developed soil already formed at the site. Thus, secondary succession is **relatively faster**.

20 Autogenic and Allogenic Succession

- When succession is brought about by living inhabitants of that community itself, the process is called **autogenic succession**, while change brought about by outside forces is known as **allogenic succession**.

- Autogenic succession is driven by the biotic components of an ecosystem.

- Allogenic succession is driven by the abiotic components (fire, flood) of the ecosystem.

21 Q. In the grasslands, trees do not replace the grasses as a part of an ecological succession because of

a. insects and fungi

b. limited sunlight and paucity of nutrients

c. water limits and fire

d. None of the above

Explanation:

- Grasses have one good trick to monopolise a place. In the dry season the grasses dry up and cause fires which destroy other plant species and their seeds.

- Also, grasslands develop in regions with scanty rainfall where plant growth cannot be achieved.

- Though forests form the climax community in most of the ecosystems, **in the grassland ecosystem grasses form the climax community**. Thanks to fire and lack of water.

- **Grasslands are almost irreversible** once deforestation in water-scarce areas gives way

to grasslands.

Answer: c) water limits and fire

22 Autotrophic and Heterotrophic succession

- Succession in which, initially the green plants are much greater in quantity is known as autotrophic succession; and the ones in which the heterotrophs are greater in quantity is known as heterotrophic succession.

23 Succession in Plants

- Succession that occurs on land (dry areas) where moisture content is low for e.g. on a bare rock is known as **xerarch**.

- Succession that takes place in a water body, like ponds or lake is called **hydrarch**.

- Both hydrarch and xerarch successions lead to medium water conditions (**mesic**) – neither too dry (xeric) nor too wet (hydric).

- With time the xerophytic habitat gets converted into a **mesophyte** (plat needing only a moderate amount of water).

24 Succession in Water

- In primary succession in water, the pioneers are the small phytoplankton, and they are replaced with time by free-floating angiosperms, then by rooted hydrophytes, sedges, grasses and finally the trees.

- The climax again would be a forest. With time the water body is converted into land.

- Another important fact is to understand that **all succession whether taking place in water or on land, proceeds to a similar climax community – the mesic**.

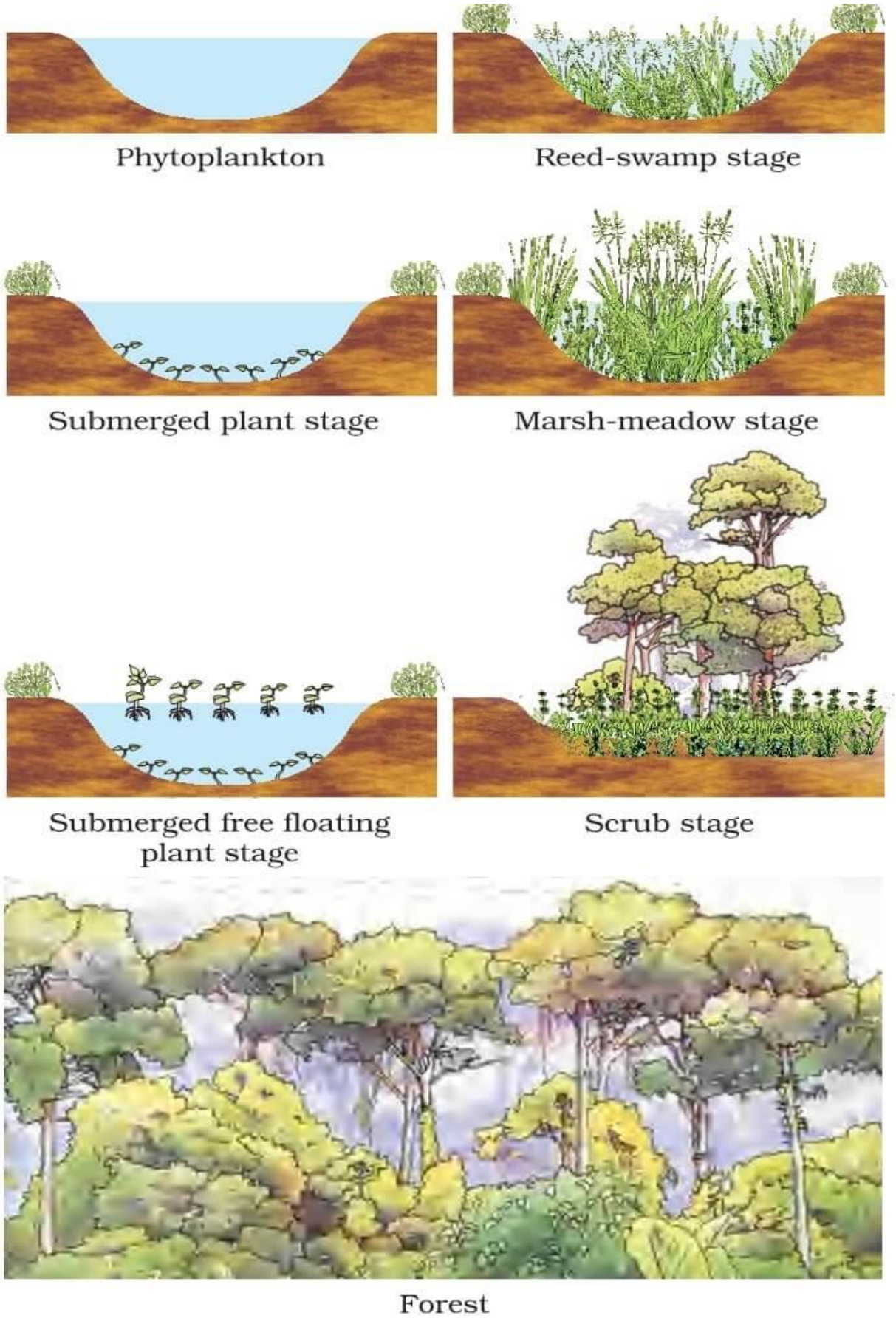


Figure 14.5 Diagramatic representation of primary succession

25 Homeostasis in Ecosystem

26 Homeostasis

- Homeostasis is the **maintenance of stable equilibrium**, especially through physiological (through bodily part functions. E.g. Cooling your body through sweating processes.

- Organisms try to maintain the constancy of its internal environment despite varying external environmental conditions that tend to upset their homeostasis.

27 Regulate

- Some organisms can maintain homeostasis by physiological (sometimes behavioural – migrating to tree shade) means which ensures constant body temperature, constant osmotic concentration, etc.

- All birds and mammals and a very few lower vertebrate and invertebrate species are indeed capable of such regulation (**thermoregulation and osmoregulation**).

- The 'success' of mammals is largely due to their **ability to maintain constant body temperature** and thrive whether they live in Antarctica or the Sahara Desert.

- Plants, on the other hand, do not have such mechanisms to maintain internal temperatures.

28 Conform

- An overwhelming majority of animals and nearly all plants cannot maintain a constant internal environment. Their body temperature changes with the ambient temperature.

- In aquatic animals, the osmotic concentration of the body fluids changes with that of the ambient water osmotic concentration. These animals and plants are simply conformers.

29 Why these conformers had not evolved to become regulators?

- Thermoregulation is energetically expensive for many organisms. This is particularly true for small animals like shrews and hummingbirds.

- Heat loss or heat gain is a function of surface area. Since **small animals have a larger surface area relative to their volume**, they tend to lose body heat very fast when it is cold outside; then they have to expend much energy to generate body heat [a lot of food goes into

heat generation] through metabolism.

This is the main reason why **very small animals are rarely found in polar regions**.

30 Migrate

- The organism can move away temporarily from the stressful habitat to a more hospitable area and return when a stressful period is over

- Every winter the famous **Keoladeo National Park (Bhartpur) in Rajasthan** hosts thousands of migratory birds coming from Siberia and other extremely cold northern regions.

31 Suspend

- In bacteria, fungi and lower plants, various kinds of thick-walled **spores** are formed which help them to survive unfavourable conditions – these germinate on the availability of suitable environment.

- In higher plants, seeds and some other vegetative reproductive structures serve as means to tide over periods of stress besides helping in dispersal.

- In animals, the organism, if unable to migrate, might avoid the stress by escaping in time. The familiar case of bears going into hibernation during winter is an example of an escape in time.

- Some snails and fish go into **aestivation** to avoid summer-related problems – heat and desiccation.

Under unfavourable conditions, many zooplankton species in lakes and ponds are known to enter diapause, a stage of suspended development.

- In ecology, the term homeostasis applies to the **tendency for a biological system to resist changes**.

- Ecosystems are capable of maintaining their state of equilibrium.

- They can regulate their own species structure and functional processes.

- This capacity of the ecosystem of **self-regulation** is known as homeostasis.

- For example, in a pond ecosystem, if the population of zooplankton increases, they consume a large number of the phytoplankton and as a result, food would become scarce for zooplankton.

- When the number of zooplanktons is reduced because of starvation, the phytoplankton population start increasing.

- After some time, the population size of zooplankton also increases, and this process continues at all the trophic levels of the food chain.

- Note that in a homeostatic system, **negative feedback mechanism** induced by the **limiting resource** (here its scarcity of food) is responsible for maintaining stability in an ecosystem.

- However, the homeostatic capacity of ecosystems is not unlimited as well as not everything in an ecosystem is always well regulated.