What is an ecosystem

Introduction

The climatic regions of the Earth gave origin to a large variety of natural environments. Each habitat is formed by a community of animals and plants, called ecosystem, that, in order to survive, must adapt to the surrounding environment exploiting its resources as best they can. 550 million years ago plants began to grow on the Earth, creating the first environment that was suited for animal life; initially mosses and ferns were dominant, then conifers developed, and then flowering plants. At the same time, also herbivorous animals evolved and the foundations for the complex ecosystems of today were laid..

Terrestrial biomes

The ecosystem: a complex system

An ecosystem is a complex system composed of organisms living in a given habitat. Plants and animals are the biotic components of the ecosystem, while the subsoil, water, air, light, temperature, the climate, rains are part of the **abiotic components**. In an ecosystem, the **biotic components** that inhabit it and the abiotic ones establish a set of relationships with each other that characterise the ecosystem itself and bring it to a temporarily “balanced” state.
According to their task within an ecosystem, the biotic components (living organisms) can be divided into:
• **producers** (plants, algae and some bacteria): these are “autotrophic” organisms that produce by themselves the organic matter they need to live and grow, using such simple inorganic molecules as water, carbon dioxide (CO_2) and nitrates
• **consumers** are defined as “hetero-trophic” organisms, since they cannot produce their own nourishment, but feed on producers (for instance, the herbivore consumers, such as cows and sheep, that eat grass) or on other consumers (carnivore consumers, such as lions or man)
• **decomposers** are fungi and bacteria that feed themselves by decomposing the tissues of dead organisms.
Each ecosystem contains a given amount of **organic matter** that includes all its vegetal and animal organisms: the weight of such matter is called ‘biomass’, and is calculated dry and per surface unit occupied by the ecosystem.

Energy transfer

The relations between the different components of an ecosystem are so close that, if one of them is damaged, the whole ecosystem is affected. The main relations are those established between energy flows and nutrient flows. The ecosystem is an open system as far as energy is concerned, that is energy continuously gets in and out of the system. The energy enters mainly from the sun, goes through and biotic community and its food chain, and goes out as heat, organic matter and resulting organisms. More into detail, the organisms produced are able to catch and use the solar energy in order to transform some inorganic compounds into organic compounds, through the photosynthesis. These compounds are used by producers in two ways: to live and to grow (the organic compounds form new structural elements of plant like leaves and new branches). Herbivores, by eating vegetables, absorb their organic substances and metabolise them, i.e. transform them into other organic substances that can be used for all vital functions (breathing, movements, body temperature, and many others) and use them as structural material in order to grow. Carnivore animals behave quite similarly, eating other animals. The process goes on in this way, from one category of organisms to another one. The transfer of energy through the food chain determines some heat to be lost into the environment, according to the second thermodynamics principle. This means that carnivores will have less energy, while eating, than herbivores, that in turn will receive from their food less energy than the amount used by plants when they metabolise their food (the organic matter that is formed thanks to the photosynthesis process). The energy transfer percentage for a trophic level to the next one is defined as “ecological efficiency” or efficiency of the food chain.

The trophic chain

There are two types of food chains: the pasture chain and the waste chain. The first part of green plants passes through the pasturing herbivores, then moves to the first.-level carnivores that fed on herbivores, then to second-level carnivores that feed on other carnivores. The second part of the dead organic matter passes through the micro-organisms, from these they move to the animals that feed on waste, then finally to their predators, that is, carnivore animals. Food chains are tightly interconnected, this is why we speak of a trophic (or food) network. In natural ecosystems, the organisms that take food from the sun through the same number of passages are considered as being part of the same trophic level. So, the green plants (producers) are the first trophic level, the organisms that feed on plants are the second level (primary consumers), carnivores are the third level and carnivore predators are the fourth level (secondary and tertiary consumers). The source and quality of the energy available determines the type and number of organisms and the development processes for all levels.

Nutrients

Differently from energy that gets in and out of the ecosystem according to a linear process, the matter follows a circular route, passing from the abiotic section to living organisms, and then comes back to the abiotic section. These routes are defined as biogeochemical cycles. Carbon, hydrogen, nitrogen, phosphorous, and calcium are necessary to living organisms in large quantities and therefore they are defined as macronutrients. Other elements like iron, magnesium, manganese and zinc, etc. are necessary in lower quantities and for this reason they are defined as micronutrients. This division is purely academic, as organisms, in order to grow and reproduce, need all those substances in different quantities, according to the physiological moment of their development. Essential substances vary from species to species. Both the numeric development of a population and the individual growth of the organism depend on the element or compound that is present in the environment in the lowest quantity: the limiting factor.

Primary productivity

The primary productivity of an ecosystem is defined as the speed at which the solar energy is turned into an organic substance by chlorophyll in the photosynthesis.
It is defined as follows:
•**gross primary productivity (GPP)**, the total photosynthesis speed (therefore also called total photosynthesis);
• **net primary productivity (NPP)**, the speed at which the organic matter produced is stored, net of that used by the plant to live (therefore also called apparent photosynthesis);
• **net productivity of the community (NPC)**, it is the speed at which the organic matter not used by herbivore and carnivore animals is stored;
• **secondary productivity (SP)**, it is the speed at which the organic matter is stored by consumers (i.e. the heterotrophic organisms that have not photosynthesis capability) for energy purposes.
A high primary productivity rate in the ecosystems is obtained when the physical factors (for instance: water, nutrients and climate) are favourable. The presence of some forms of secondary energy can also help to increase the primary productivity rate. An example is that of estuaries, one of the most productive ecosystems in the world. In estuaries, freshwater encounters seawater. The plants that live there form a wide photosynthetic carpet. Trunks and roots trap large amounts of food particles and, once their vital cycle is over, they decompose, thus supplying the ecosystem with more organic matter. Here, secondary energy is provided by the effect of tides, that on one side promotes the fast flow of nutrients and on the other side promotes the disposal of the produced waste, so that the organisms that live there (sea bass, gilthead, mullet, clam larvae) do not spend energy to find food or dispose of waste and can grow more quickly.

Changes in the food chain

Technological innovations applied to agriculture in the fight against crop-damaging parasites led to the use of large quantities of pesticides for long periods of time. These substances are toxic and their accumulation varied the balance of

the biosphere, as they have harmful effects on organisms, man included. DDT is a substance that, when introduced into the environment, provoked damages to the ecosystem, creating a phenomenon of pesticide pollution at world level. Researches that studied the quantity of DDT that is present in the environment, confirmed its presence in fish all around the world, in Eskimo populations, animals that live in polar regions and mother's milk. This passage of DDT through the different levels of the food chain is made possible by the fact that the molecule keeps unaltered, as it does not degrade easily. As a consequence, at each different level (from plants to insects, from insect-eating birds to predator mammals), the concentration of DDT in organisms increased by 10 times. That is to say that, is the mass of the organisms becomes a tenth, the concentration of the pesticide increases by ten times.
The damages caused by DDT on organisms are alarming: when the molecule reaches the sea, DDT slows algae photosynthetic activity, bird eggs get fragile and break easily during hatching because they lack calcium, the number of individuals is reduced and human organs and systems are damaged.

An altered ecosystem

In Borneo, the use of DDT caused the alteration of the ecosystem, directly affecting men. The wide use of DDT to kill malaria-carrying mosquitoes killed all insects, including those that are useful to men, like cockroaches. These insects are the main food for lizards, therefore the number of lizards dramatically dropped, as well as the number of felines that ate lizards. Felines also kept mice population under control. The reduction of felines lad to an increase in the number of mice, that in over-population conditions transmit dangerous diseases to man.
Borneo, after DDT disinfestations campaigns, was affected by infectious epidemics that caused more victims than malaria.

Biomes

Ecosystems are everywhere: a wood, a lake, a river, a lawn, a beach, the sea, even the green areas of our towns. Briefly, every centimetre of our planet is or belongs to an ecosystem. Ecosystems can markedly vary in size. The temperate forest that covers most of North America, Europe and Northern Asia, and the cavity filled with water and life of a beech from the same forest are both considered as ecosystems (in this case, a "micro-ecosystem").
The Earth itself may be regarded as one big ecosystem. The division into smaller and more neatly defined ecosystems is necessary for target studies, but in fact the limits of ecosystems normally blur into each other and many organisms may be part of different ecosystems at different times. For instance, freshwater becomes brackish water near the coast, so the sea ecosystem and the freshwater ecosystem are connected to each other by energy and food flows. The boundaries of an ecosystem may also vary in time, due to a number of disrupting factors, such as the disappearance of a species, man's work, the introduction of exotic species in an ecosystem and others. In ideal conditions, areas having consistent physical and chemical characteristics should have well-defined and easily recognisable ecosystems. But such consistent conditions cannot be found in nature. Especially in the case of terrestrial ecosystems, it is easier to identify associations of ecosystems. In particular, closely related ecosystems that share the same biogeochemical cycles and have similar abiotic components are called "**biomes**". Terrestrial ecosystems can therefore be grouped into many biomes.

Ecosystems on Earth

According to the type of vegetation that mainly characterizes them , ecosystems can be recognized and divided into:
• deserts
• savannahs
• steppe
• temperate forest
• tropical forest
• boreal forest (taiga)
• tundra
• mediterranean vegetation
Water ecosystems can instead be divided into:

• freshwater ecosystems: lakes and ponds, rivers and torrents, marshes and swamps;
• marine ecosystems: reef; oceans, continental plateaus, nutrient upstream-flowing areas, estuaries.
But there are not only natural ecosystems on Earth, there are also those that have been artificially created by man as soon as his development led him to organise his social life and way of living and producing in specific manners.
Artificial ecosystems can be divided into:
• urban-industrial ecosystems (metropolises);
• rural ecosystems (small towns);
• agro-ecosystems (farmlands).

The ecological succession

The history of an ecosystem from birth to maturity is called **ecological succession**. The ecological succession is essentially an uninterrupted sequence of changes in the biotic and abiotic components of an area, which leads to a stable ecosystem (the one that is defined as the "climax"), in which components are balanced, i.e. no one prevails over the others, making then disappear. The sequence of communities that replace each other with time within the ecosystem is called "sere" and the different transition stages are called “seral stages”. It is the populations themselves that sometimes alter the environment in which they live and cause themselves to disappear in favour of other species of organisms. Examples of this type of evolutionary process can be easily found in nature, where the formation of any new environment (due to a fire in a wood, to the detour of a river, a deserted farmland, etc.) initially causes the so-called **"pioneer"** organisms to spread, i.e. organisms that can grow despite the harsh conditions of the area (few nutrients). The living activity of these first organisms alters the environment, creating new conditions that are favourable to other, more demanding, organisms. The latter develop, often causing the pioneer organisms to disappear. **To understand it better**
For instance, moss, lichens and grass are often pioneer species on solidified lava or rocky substrata. These organisms can actually break up the rocky substrata to take the minerals they need to survive. In addition, once dead, they provide that organic matter that decomposes into the “soil”, that will be used by the vegetal species that will settle there at a later stage to feed on and grow. An example of an ecological succession is what happens on sandy dunes: the first vegetal species that settle there are very adaptable and can use the very few nutrients available. These first pioneer species fix the sand through their root apparatuses, making the dunes more stable and, once dead, enrich the soil with organic matter. This creates a richer environment, which is fitter to sustain the life of the more demanding organisms that slowly replace the pioneer ones, the composition of the species becomes more and more diversified and more and more complex natural feeding and competition processes develop.

An artificial ecosystem

The agro-ecosystem A typical example of an artificial ecosystem is a farmland or agro-ecosystem. This is a natural system altered by man through farming. It differs from a natural ecosystem for four reasons:
• **it is simpler**, because the farmer gives priority to one type of plant only, fighting against all those animal and vegetal species that might damage it;
• **the energy** is supplied by man, through machinery, fertilisers, plant chemicals, selected seeds, farming practices
• **the biomass** (harvest) is removed when ripe. This makes the ecosystem an open system, i.e. one that depends on external sources to reintroduce fertilising substances, fit for feeding a new process of birth and development of organic matter (the plants). A natural ecosystem fertilises itself, instead, since the biomass remains in its original place
• **the use of polluting substances**, such as chemical fertilisers, parasite killers and other non-biodegradable chemicals, that build up in the ecosystem or disperse in the subsoil, sometimes seriously polluting underground water-bearing layers, seas and rivers.
A house is also a small artificial ecosystem. Items, food, solar energy, water, etc. come from the outside and the solid

and liquid waste generated by human activities is disposed of outside. The same applies to the city. It depends on external sources for the supply of food, building materials and other resources it needs to develop, and disposes of its waste outside (dumping grounds and incinerators), that do not contribute, therefore, to the survival of the city as an ecosystem.

Man and ecosystems

The ecosystem is important for men

Terrestrial and water ecosystems are complex and perfectly organised natural “factories” that produce all that is required for life on Earth and to cover man’s basic requirements: food, fibres, water. Some of these functions of the ecosystems are essential to man, such as air and water depuration, climate control, the nutrient cycle, soil fertility. In addition, some ecosystems (beaches, woods, lakes, high mountains, secluded valleys) are our ideal places for recreation, tourism and meditation, so we can say that the ecosystems have permitted our society and economy to develop. 50% of the world’s population are still engaged in farming, forestry and fishing. This proportion becomes 70% if we take the sub-Sahara, Asian and Pacific countries alone. 25% of the world’s countries have economies that still depend, almost entirely, on the sectors above. Farming alone produces 1.3 trillion dollars of food and fibres a year.

Man and the ecosystem

The human processes of farming, industrial production and consumption (or use) of commodities are carried out by similar rules as those of the matter and energy flows of the natural ecosystems. Also in the production and consumption of commodities, matter and energy are derived from nature, pass through the productive processes and get to the consumption stage. Waste and scrap are generated and disposed of in the environment during the production and consumption of commodities. The main differences in the matter and energy flows of natural and human artificial ecosystems are:

• the speed at which resources are taken from nature and waste is given back to nature (excessive exploitation of exhaustible and renewable natural resources);

• quality of materials involved in this flow (pollution).

Both factors often prevent the artificial ecosystems from expanding, and, lacking control and corrective measures, they risk destroying their life and perhaps that of many other natural ecosystems. The speed at which natural resources are taken away is actually so high as to cause these resources to quickly disappear, so that no new productive processes can be fed. The amount and speed at which waste is produced often largely exceed the depuration and assimilation ability of the environment, also because much of this waste is non-biodegradable in the short term.