CHAPTER 2

Biodiversity, Wildlife and Endangered Plants and Animals

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Introduction

It is clear that the concept of biodiversity is formed by combining the terms biology and diversity. Considering the depth of concept, it may come to mind that it is a measure of the diversity of species. In this case, biodiversity can be defined as the diversity of life defined through the quantity of distinct species in a particular region. However, although this definition is correct, it is an incomplete definition. The deficiency stems from the complex and abstract nature of biology and life. Although there is some certainty that biology is the branch of science that studies life, there is no certainty about where life begins and ends. In this case, life and the diversity of living things need to be addressed from a broader perspective.

From what we know so far, apart from the blue planet Earth, there is no life anywhere else in space. Although it is said that there are candidate planets that are thought to be able to provide the living environment that the Earth provides for us, the investigations do not seem promising in terms of vitality or suitability for life. That is, what is necessary for life can only be met by the world. Living things can exist within the balance of life established in interaction with other living and non-living elements in the surrounding environment. The environmental conditions that affect life and the differences in genetic characteristics acquired through participation result in the diversity of living things.

Scientists' studies so far show that the world began to take shape 5.5 billion years ago. The available evidence indicates that life on earth began 1.5-2 billion years ago. It is understood that life began in a simple form and then evolved over the years into highly complex organisms. In this process, many living species have existed on earth. Most of these creatures could not keep up with the changing environmental conditions and disappeared. However, by adapting to the conditions, the surviving species continued their existence by diversifying. For example, the reptile class, which is represented in 4 ordos such as snakes, lizards, turtles and crocodiles today, was represented in 20 ordos in the Jurassic Period 200 million years ago. As reptile ordos that do not exist today disappeared, they pioneered the bird and mammal classes. Thus, the earth began to take its present shape about 1 million years ago, with the spread of dicotyledonous herbaceous plants and the dominance of mammals over vertebrate animal species. In other words, while some species disappeared due to natural reasons in the adventure of life, some

species continued to live, while some species changed over the years and led to different species, while some species remained unchanged until today as fossil species. However, life has shown great variation and diversity since its inception (Brooker et al., 2020).

When life is considered theoretically, it appears as an abstract concept that is not easy to understand. Because it is seen as a very difficult situation to decide where the vitality begins in the vitality organization that exists in a living thing. It is said that the smallest building block of life in school learning is the cell. However, it is known that structures such as viruses, prions, and virions also gain vitality in a cell. Despite the passing of years, the viability of viruses is still a matter of debate. On the other hand, the viability of the molecules or organelles that make up the cell, known as the building blocks of life, is also a matter of debate. In fact, the idea that organelles such as mitochondria and chloroplasts originate from bacteria that enter the cellular structures, which are the ancestors of eukaryotic cells, through endocytosis further complicates the limit of life. In this context, biological diversity will be discussed as a concept and its importance will be emphasized. Then, threats to biodiversity, natural life and conservation of biodiversity will be discussed in this chapter.

Biodiversity

Biodiversity can be expressed as the vitality characteristics of living things in a living environment, their habitats and the abundance of ecological relations that occur in these habitats or the diversity of life. Biodiversity is found everywhere in the desert, mountain, ocean, garden, the inside of our hands, the bottom of our feet, etc. and means more than the diversity of species (Alonso, Dallmeier, Granek & Raven, 2001). Therefore, understanding biological diversity only as species diversity would be an incomplete definition in terms of the continuity, interactions and functions of species. There are three types of biodiversity that should be considered: genetic, species and ecosystem diversity (Erten, 2004).

Genetic Diversity

The diversity or inherited properties of genes present in a population is called the genetic diversity that that population has. Figure 1 shows ladybugs with different body colors. The diversity of body colors is due to the diversity seen in the body color genes of ladybugs. Ladybugs differ from each other not only in their body color. There are other distinctive features as well. These properties may include factors that strengthen the immune system, increase nutritional capacity, and facilitate survival. Of course, ladybugs with features that facilitate living conditions have a higher chance of surviving and multiplying. Thus, genes with superior characteristics spread to the population. However, when factors limiting genetic diversity arise, the population's capacity to adapt or survive in devastating conditions is curtailed (Biggs et al., 2007).

Figure 1. Ladybugs with Various Body Colors

Species Diversity

The quantity of various species that have been surviving at a specific habitat and the relative abundance of each species is called species diversity. Figure 2 shows a habitat inhabited by various species. The habitat photographed here has a high species diversity consisting of several species. There is a tremendous diversity of vertebrate species such as elephants, zebras and deer, as well as other animals such as birds, plants and invisible bacteria. However, the distribution of species diversity does not show homogeneity on earth. It is especially high in the equatorial regions and decreases towards the poles (Karabal, 2011).

Figure 2. A Habitat Rich in Species Diversity

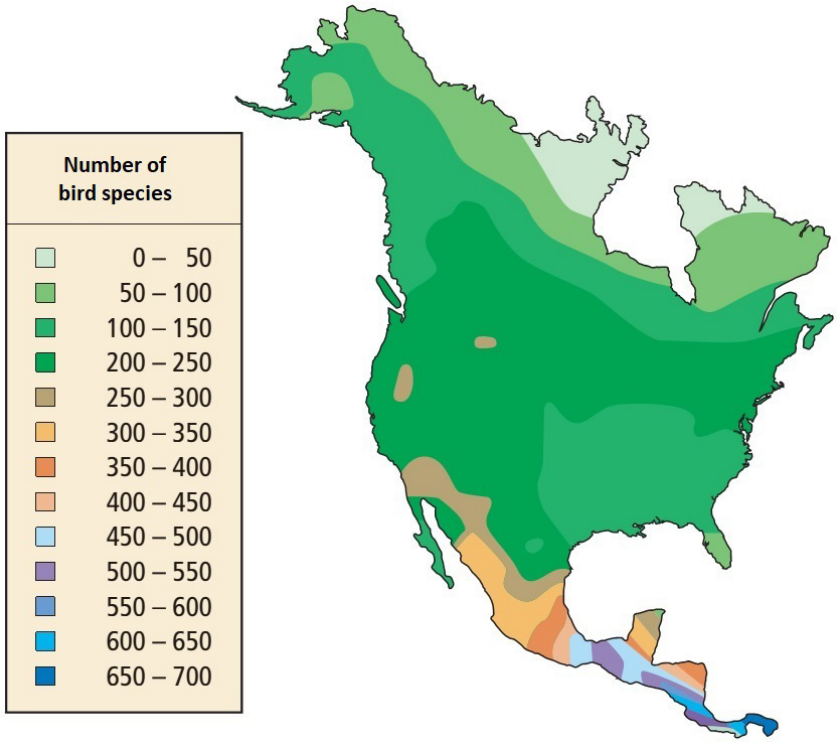

Figure 3. Bird Species Distribution in North and Central America

Ecosystem Diversity

The layer of the earth where living things live is called the biosphere. In the biosphere, there are ecological units called ecosystems, which consist of living and non-living elements that form a self-sufficient system with the living things it contains. The amount of ecosystem in a particular region is called **ecosystem diversity**. In the ecosystem, the emphasis is on living things and the inanimate environment with which they interact. For instance, Anatolia as an ecosystem includes different characteristics that make it possible for the Anatolian leopard, shown in Figure 4, to survive. All ecosystems in the world have features that make it possible for various organism communities to survive (Bulut, 2019).

Figure 4. Anatolian Leopard Living in a Certain Ecosystem.

Importance of Biodiversity

Many people, countries, organizations and institutions strive to conserve existing biodiversity and leave a rich biodiversity to the upcoming generations. There are also economic, ecological, aesthetic and cultural reasons for preserving biodiversity.

Economic Value

Nature meets human needs. In other words, some living things in nature are consumed by humans. Consumable species are traded and a price can be drawn. Valuable species are man-made or protected to avoid extinction. However, species that do not have direct commercial value should also be protected. Because the ecosystem is a whole. Living things interact with each other. A tobacco extinction that is neglected because it has no commercial value will also negatively affect species with commercial value. This negativity should be addressed in a broad framework, from the decrease in yield to the extinction of the commercial species. In addition, species that do not have economic value because they remain in the wild can function as gene banks for their close relatives. Genes of wild species can gain functionality in overcoming the problems that may be encountered in the future. For example, corn seeds are sold to farmers every year and produced by growing them. The genomes of the seeds prepared by genetic engineering are programmed to obtain the highest yield. However, most of the time, the reproduction of plants growing from these seeds has been restricted or produced as clones. In other words, an emerging disease will be effective in all plants. However, *Teosinte sterilene*, a relative of the modernized maize plant, grows in the wild and has high virus resistance (Figure 5). Plant pathologists have developed maize varieties resistant to viral diseases using these wild species (Starr et al., 2018).

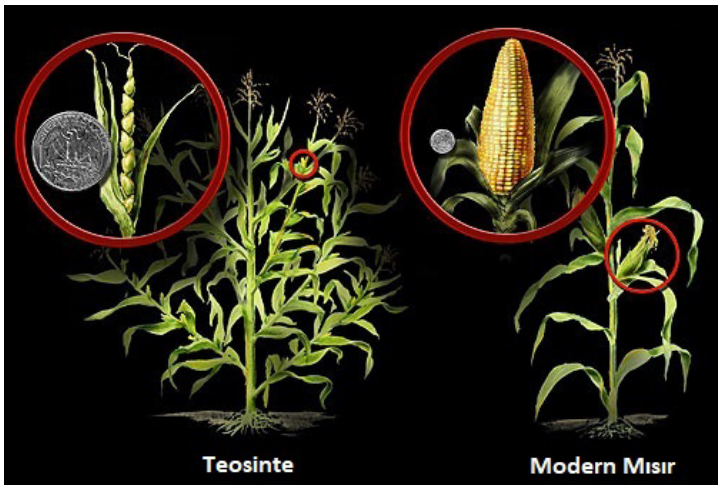

Figure 5. Teosinte and Modern Maize Plants

In addition, biologists are becoming more and more aware of how to pass on the genes that drives hereditary traits among the members of species. Today, scientists can

determine the characteristics of a living thing, identify the gene region responsible for the relevant feature, and transfer these genes to another living thing and make it work. Characterization, duplication and transfer of genes is the subject of genetic engineering. Genetic engineering has produced crops which have strength against insect damage, advantages to cope with diseases and extra quality in terms of nutrient capacity. Despite all this progress, most wild plant and animal species haven't determined in terms of genetical diversity. If wild species go extinct, the opportunity to exploit the genes that they have will be lost. Therefore, even species that are currently considered to be of no economic value must be protected as they may gain importance for economic or research purposes in the future (Dilbirliği, 2007).

Although it can be produced under laboratory conditions today, the source of the drugs we use is other living things and nature. For example, penicillin, a powerful antibiotic, was obtained from a bread mold. The substance, salicin, obtained from the willow tree, was used as a pain reliever. A version of this drug, known today as aspirin, is synthesized in laboratories. On the other hand, the leaves of the propeller flower plant have been used to obtain an extract that increases the survival chances of patients with leukemia by five times (Figure 6). Scientists continue to find solutions to diseases by making use of plants and other organisms that can be used because of their properties (Raven et al., 2019).

Figure 6. Propeller Flower Plant used in the Treatment of Leukemia

Ecological Value

In a balanced and healthy ecosystem, activities such as energy flow, matter cycle, and food chain take place depending on biological diversity. The uptake and return of energy and nutrients, in other words, the provision of energy and nutrient cycles, occur with the presence of biological diversity. Considering the requirements such as the amount of oxygen, nitrogen, carbon dioxide and water in the living environments of living things and the effect of these elements on environmental cleanliness, the importance of biological diversity will be understood. The greater the biodiversity enable the greater the contribution to environmental cleanliness. Clean air, clean water and clean soil are

the basic requirement and basic result of biodiversity. While saprophytes decompose waste materials, green plants use carbon dioxide in the air to create the oxygen necessary for living things and prevent global warming because they hold atmospheric carbon (Kurumlu, 2008).

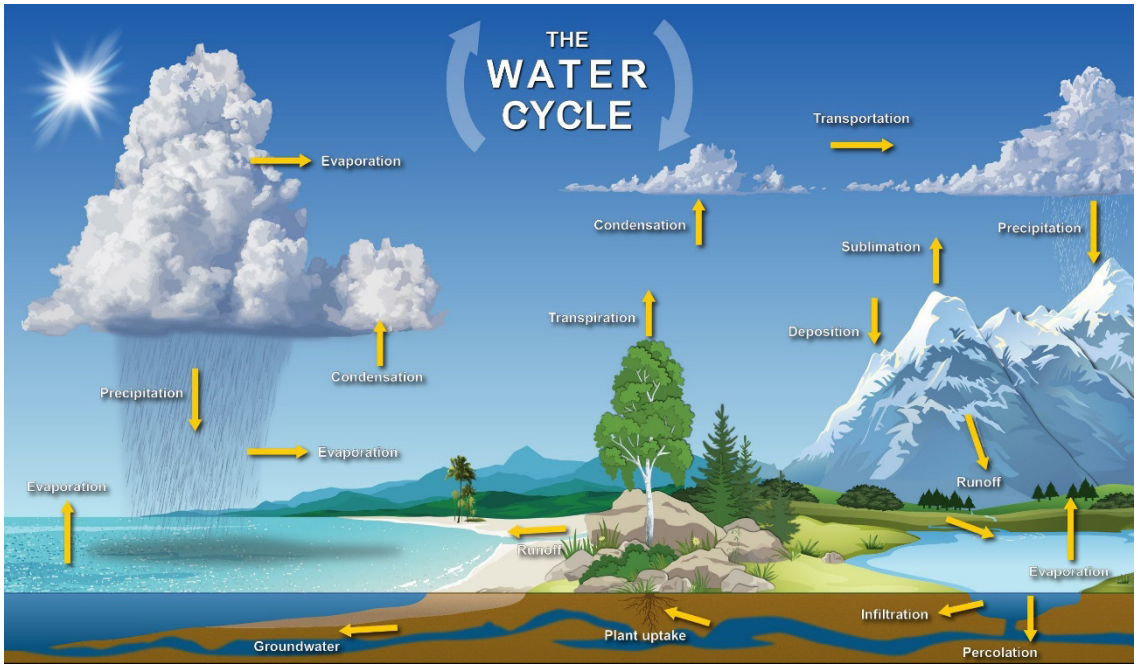

Figure 7. Water Cycle

In addition to these, the presence of various filtering creatures in the waters ensures that the water resources are clean, from the rivers to the oceans. In addition, trees clean the air by absorbing greenhouse gases. One of the most striking importance of biological diversity on ecosystem is that it protects the physical environment from environmental disasters such as floods and erosion. Soils that are moist or wet are difficult to be dragged by external forces, so the probability of erosion in an area with plenty of forest will be very low, as forests keep the soils moist. The biodiversity of trees in a forest is highly effective on the matter cycle and food chain in that ecosystem. Microorganisms feed on fallen tree leaves. As a result of this feeding, called decay or decomposition, the leaves turn into humus and mix with the soil. Plants grown in humus-rich soils can take up plenty of minerals from the soil. In addition, the water holding capacity of humus soils is higher than other soils. Similarly, some plant species fix the free nitrogen in the air through the bacteria that settle in the tubers in their roots and contribute to the nitrogen cycle of the ecosystem. As can be understood from all these examples, biological diversity is the basic element of ecological functions that ensure the continuation of life (Çepel, 1997).

Aesthetic and Cultural Value

The interaction of human beings with the environment they live in is not limited to the exchange of matter and energy. The environment we live in also has an impact on

the human mind and thoughts. People are often positively affected by the beauties of a healthy ecosystem (Figure 8). When people encounter a deserted or barren landscape, they have different emotions. Aesthetics, which emerged as a result of the diversity and harmony of living things, has undoubtedly reflected on human thoughts and works over time. Lines, motifs and structures inspired by nature have become a part of human life and are engraved on the basic building blocks of human culture (Karabal, 2011).

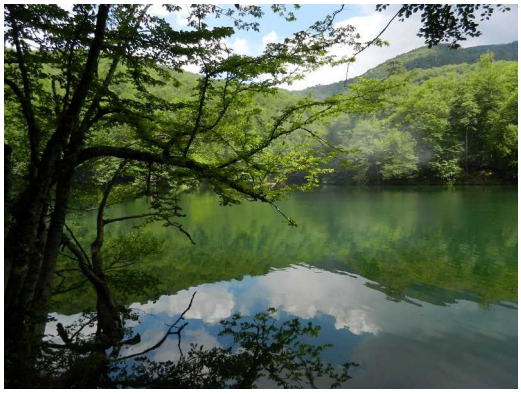

Figure 8. A View from Büyükgöl in Yedigöller Region

Threats to Biodiversity

Living things continue their lives on earth under the influence of many factors. The composition of the factors affecting living things determines the environmental conditions. Environmental conditions can make certain living species advantageous over others. The same conditions can have limiting or destroying effects on other living things. The environmental conditions prevailing on earth are not static. Moreover, environmental conditions are not the same for all parts of the earth. Furthermore, environmental conditions show great changes in geological time periods and threaten the life of certain living species.

Mass Extinctions

Extinction, like speciation, is a natural process. Species constantly appear and disappear. Based on a variety of evidence, scientists estimate that %99 of all ever-lived species are now extinct. Extinctions took place in some periods in a way that affected a large part of the organisms on earth. Large extinction rate increases experienced in the history of life are defined as mass extinctions (Solomon et al., 2019).

There have been five major mass extinctions estimated to have been completed in the last 500 million years. These major mass extinctions also mark the boundaries of geological time periods (Figure 9). The mass extinction at the end of the Cretaceous period was most likely caused by an asteroid impact. The largest mass extinction in terms of extinct species occurred at the end of the Permian. The mass extinction at the end of the Permian

occurred after increased volcanic activity in what is now Siberia released large amounts of carbon into the atmosphere. Thus, the warming in the oceans is thought to cause the release of methane gas (natural gas) from the frozen sediments in the depths of the ocean. As a result, the oceans were deprived of oxygen, and methane sprayed to the air caused explosive fires on land. (Mader & Windelspecht, 2017).

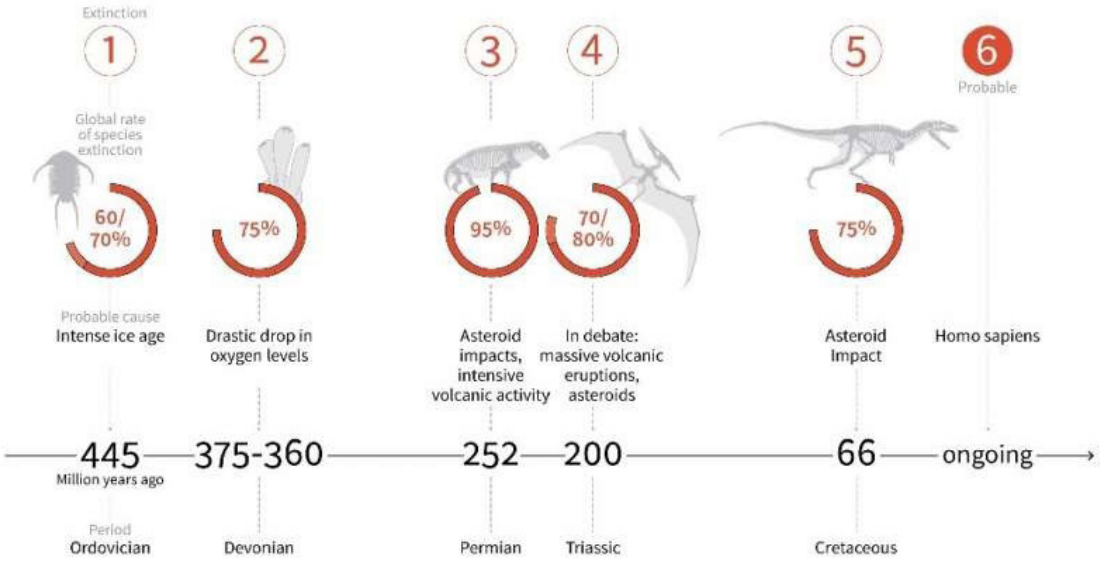

Figure 9. Massive Extinctions

Mass extinctions affect all living species. However, living species differ according to the periods in which they appear on the earth's scene, their tendency to diversify or create new species, and the duration of their resistance to environmental conditions. When the measure of success for any living species is considered as the number of species, it is seen that not all living species are equally successful. Figure 10 shows how the number of species in some main living groups has changed over time. With the diversification of angiosperm plants towards the end of the Mesozoic, the number of species diversity in the gymnosperm groups decreased or disappeared (Biggs et al., 2007).

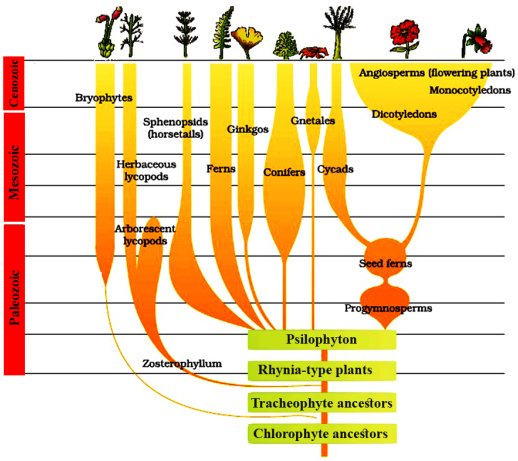

Figure 10. Variation of Plant Species Diversity over Geological Times (URL6, 2021).

Sixth Major Mass Extinction

Some data obtained by scientists indicate that a mass extinction has now begun and is continuing at an accelerating rate. The current extinction rate is estimated to be 100 to 1,000 times greater than the extinction rate that should have been in normal times. The rate of extinction in the time period we live in is at the same level as the five major mass extinctions in the past. But unlike previous extinctions, the current extinction is not the inevitable result of a physical disaster such as an explosion or an asteroid impact. Humans are the driving force behind the current increase in extinction rate, and human actions are determinants of this extinction (Brooker et al., 2020).

Indirect evidence points to the decline in biodiversity experienced by humans entering the habitats of living things. For example, the arrival of people in Australia about forty thousand years ago encountered with the onset of the extinction of the continent's largest marsupials, birds and lizards. In North America, the arrival of humans about 15,000 years ago was followed by the extinction of large herbivores such as camels, giant ground sloths, mammoths, and mastodons (relatives to elephants). Carnivores such as lions and saber-toothed cats have also disappeared (Raven et al., 2019).

According to one of the respected hypotheses, humans preyed on herbivorous species such as mammoths, directly causing their decline. The decline in mammoth numbers has led to the extinction of other predatory species that preyed on them. Evidence that humans hunted such creatures supports the hypothesis. For example, a spearhead was found embedded in the rib of a 13,800-year-old mastodon fossil. However, not all researchers are convinced that hunting was the sole or most important factor in the extinction of such creatures. The death of these animals can also be attributed to climate change, a meteorite impact, or the effects of human-made pathogens. Continuous examination of areas dated to the time of extinction will help clarify the relative importance of these factors (Bulut, 2020).

Perhaps more recent extinctions are more clearly attributable to humans. For example, in the 1600s, Dutch sailors came to the island of Mauritius in the Indian Ocean, where the dodo, a flightless bird, is abundant. About 80 years after the arrival of the sailors, the dodo birds became extinct. It is a real case that sailors ate Dodo birds. However, the destruction of nests and habitats by rats, cats and pigs brought in by sailors is likely to have a greater impact on this extinction (Solomon et al., 2019).

Figure 11. Dodo Bird Model

Current Biodiversity and Threats

The number of existing species currently existing on earth is not known exactly. Estimates of the number of living species suggest it could be between 5 million and 50 million. About 2 million of the species that dominate the earth have been named and classified. In other words, it was discovered and examined by scientists and accepted as a species, believing that it met the criteria of being a species. Simply, it is not yet known how much biodiversity the earth actually has. However, scientists working especially in areas related to the classification of living things are in a race to discover new living species and to reveal the diversity of life in the world. However, naming a living thing does not mean that it has been extensively studied or known with all its characteristics (Brooker et al., 2020).

There are also scientists who work on determining which species will become extinct if the existing biodiversity is not preserved. A species that is currently at a high risk of extinction in the nature is called an endangered species. Species that are supposed to become extinct in the near future are called threatened species. All rare species are threatened. Some species have always been rare. If there has been a decrease of more than 50 percent in the number of species belonging to a species in the last ten years, or if the probability of extinction of a species in the wild is more than 20 percent in the last 20 years, that species is recorded as an endangered species (Bulut, 2020). The statistics on the number of threatened species are presented in Table 1

Table 1. List of Globally Threatened Species

	Number of Classified Species	Number of Species Evaluated for Threat	Number of Species under Threat
Vertebrates			
Mammals	5.416	4.863	1.094
Birds	9.956	9.956	1.217
Reptiles	8.420	1.385	422
Amphibians	6.199	5.915	1.808
Fishes	30.000	3.119	1.201
Invertebrates			
Insects	959.000	1.255	623
Mollusks	81.000	2.212	978
Crustaceans	40.000	553	460
Corals	2.175	13	5
Other	130.200	83	42
Plants			
Algae	15.000	92	79
Ferns	13.025	211	139
Open-seeded	980	909	321
Angiosperm	258.650	10.771	7.899
Protists			
Green algae	3.715	2	0

Red algae	5.956	58	9
Brown algae	2.849	15	6
Fungi			
Lichens	10.000	2	2
Mushrooms	16.000	1	1

Factors Threatening Biological Diversity

It has been addressed that the increasing extinction ratio today is different from mass extinctions in the past. The current high extinction rate is due to human activities. There has been a tremendous decrease in the number of species living on earth in the extinctions that have occurred so far. After the extinction events, the remaining species started to diversify again and a new balance was established. However, unlike the last balance established after the last mass extinction about 66 million years ago, it is thought that the process of establishing a balance after the extinction will be different this time. Because the human factor causes the conditions in nature to change at a rate that the adaptation capacity of living things cannot reach. This change makes it necessary to discuss the factors that threaten biological diversity (Çakır, 2019).

Overexploitation

Nature embraces human beings with all its generosity, meets their needs and becomes a home for them. On the other hand, people consume what is offered to them and often think only of their own needs. However, life; The order in nature is knitted with many events that are interrelated and keep each other in balance. Excessive consumption of species with commercial value is at the forefront of human-induced events. Excessive consumption or use can cause extinction of the species. For instance, 27 species of sturgeon are represented, with a wide distribution in Europe, Asia and North America (Figure 12). There are 5 species in the Black Sea waters of our country. Sturgeon is hunted and consumed because of its quality caviar and meat. In addition, the spawning grounds of the sturgeon, which prefer rivers to lay their eggs, have been destroyed due to the stone processing facilities and dams built on the river, and have become one of the endangered species. Similarly, the white rhino is one of the five rhino species in danger of extinction. White rhinos are hunted for their horns. Historically, overuse has been the predominant reason for extinction (Biggs et al., 2007).

Figure 12. Overused Species: a. Sturgeon (Ustaoğlu Tiril, 2021) b. White Rhino

Habitat loss

If the living house or environment does not meet the needs, one either move from there or continue to stay and condemned to inadequacies until death. Habitats are the homes of living things. The habitat in which a species lives can be degraded as a result of natural processes or by human hands. Humans are destroying or degrading habitats for the purpose of urbanization or opening up more agricultural areas (Raven et al., 2019).

Destruction of habitat

Habitats, which are the home of living things, are eliminated for reasons such as creating settlements or making room for agricultural land. There are some habitats which are considered to be very important for the biodiversity. One of these places are tropical rainforests. Tropical forests contain most of biodiversity found on the earth. To put it in numbers, rainforests host more than half of the world's biodiversity.In fact, estimates show that more than half of all species in the world live in tropical rainforests. The elimination of a large part of a natural forest of great importance will lead to the extinction of many species on earth due to habitat loss (Karabal, 2011).

Habitat degradation

The conditions prevailing in the habitats that host various species are built on very fine balances. Sometimes the habitat's conditions protect the habitat from extinction, but can upset the balance in the habitat. The destruction of habitat, but the deterioration of its balance, is called habitat degradation. degradation can occur in a number of factors that the habitat has and affects living species. Let us suppose that in an aquatic ecosystem, as shown in Figure 13, there is a decrease in fish population due to hunting. In this case, the herons and elephant seal populations that feed on fish will decrease due to famine-related reasons. In addition, there will be an undesirable increase in the populations of plankton and crustaceans consumed by the fish. These creatures, which have an important role in the balance of the habitat, are called keystone species. These species can create a chain effect that leads to a disruption of the balance (Bulut, 2019).

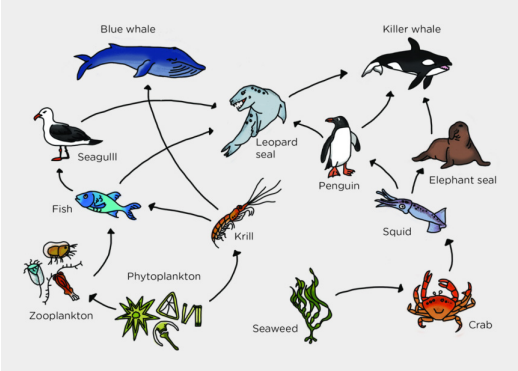

Figure 13. Food Web and Keystone Species in a Habitat

Habitat fragmentation

Habitats are ecosystem units with their own specific conditions. Habitat conditions allow some species to live, while not allowing or limiting the survival of some species. Features such as habitat size, opportunities provided by the habitat, and climate have a direct impact on biodiversity. Habitats are also not fixed ecological units. Their conditions may vary. Even a habitat can be divided into smaller parts for various reasons. This phenomenon is called habitat fragmentation (Starr, Taggart & Evers, 2018). Newly formed habitat fragments limit living things because organisms prefer to stay inside habitat pieces. Habitat fragmentation causes various problems with life. First, a smaller habitat will have less biodiversity. Because changing habitat sizes will cause some living species to stay in other habitat parts or not be able to adapt to newly formed conditions. In addition, habitat fragmentation reduces an individual's chances of reproduction. A smaller piece of habitat will have limited breeding options. This will mean a narrowing of genetic diversity. Decreased genetic diversity will make the population more susceptible to disease and disaster. Adaptation abilities of living things will be limited. Finally, the edge effect will be felt more in smaller habitat fragments. Conditions at the edges of a habitat are not the same as conditions inside. External factors are more effective at the margins (Figure 14).

Figure 14. A Terrain with Habitat Fragmentation

Pollution

The presence of a certain substance in an undesirable environment is called pollution. The substance in an undesirable environment is called a pollutant. pollutants can interact with the components in the environment they enter and cause undesirable changes in the environment. If it is considered for biological systems, pollutants are effective on air, soil and water environments. Pollutants, on the other hand, can show a wide variety of properties and cause devastating changes in biological environments for living things.

Most pollutants do not occur naturally. It can occur intentionally or unintentionally as a result of human activities. For example, pesticides are the leading chemicals used to reduce the effects of agricultural pests. Pesticide is applied to the land to be protected. The pesticide exerts its toxic effect on the target organism. The pesticide taken into the body by the target organism is normally processed and excreted as a result of metabolic activities. However, it has been determined that some pesticides accumulate in the soil and are taken into the body by other living things other than the target organisms. Since the pesticides taken into the body cannot be excreted, they accumulate in the tissues. With the consumption of organisms with pesticide accumulation in their tissues, an increasing amount of substance will be encountered as the upper trophic level in the food chain is reached. The increase in the concentration of a substance as the upper trophic steps in the food pyramid are climbed is called **biological magnification**. For example, a pesticide such as DDT (dichloro-diphenyltrichloroethane) was used extensively in agricultural lands for a period of time. DDT, which is a highly effective pesticide, has accumulated in living tissues as well as the desired effects. Figure 15 shows the accumulation of DDT concentration in the food chain and its increase towards upper trophic levels in an ecosystem. The use of DDT pesticides is prohibited when its harmful effects occur (Solomon et al., 2019).

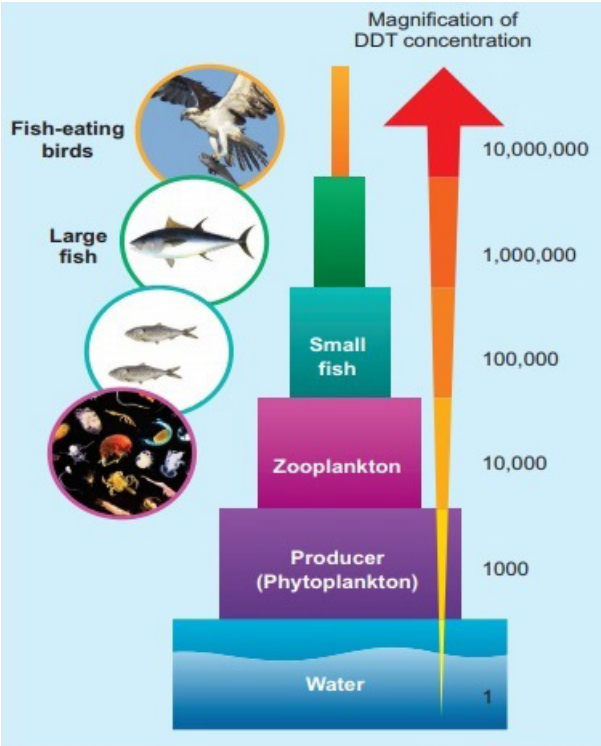

Figure 15. Increased DDT Concentration in the Food Chain with Biological Growth

Acid rain

A large amount of sulfur dioxide is released by the combustion of fossil fuels such as coal. Similarly, fuels used in vehicles are of fossil origin and when they are burned, nitrous oxide is released into the air. These substances react with water and some compounds in

the atmosphere to form nitric and sulfuric acids. Acid rain is the precipitation of acidic compounds formed in the atmosphere as a result of the compounds released into the air by the burning of sulfurous and nitrogenous fuels. Acid rain is actually effective on all surfaces. It has a corrosive effect on monuments and statues made of metal. More importantly, by affecting the soil, it destroys the nutritive compounds for plants, destroys plant tissues and slows down plant growth (Figure 16). Acid rains also disrupt the acid balance in the waters and cause mass death in rivers or lakes (Brooker et al., 2020).

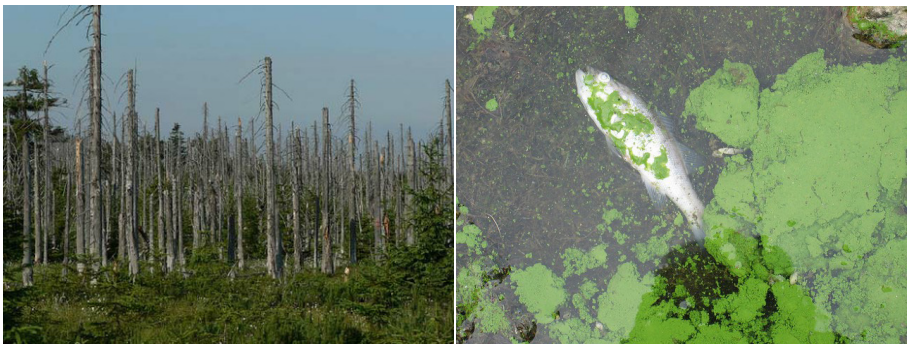

Figure 16. The Effect of Pollution on Living Things

Eutrophication

Contrary to popular belief, most of the oxygen in the biosphere is released by algae, not plants. Algae are organisms that have a high rate of photosynthesis. When suitable conditions are created, they consume a very high amount of oxygen, perform photosynthesis and release carbon dioxide. Mixing of manure, sewage or other chemicals rich in nitrogen and phosphorus into streams encourages algae growth. During development, algae deplete the underwater environment in terms of oxygen. In addition, the processes of death and decay of algae reduce the oxygen rate. In this case, other underwater creatures die by drowning (Figure 16). In some cases, algae even release toxins that limit the aquatic habitat for other creatures. This phenomenon, characterized by algae covering the aquatic habitat and overgrowth, is called eutrophication (Brooker et al., 2020).

Introduced (exotic) species

Certain biotic and abiotic factors prevail in every environment. Living things develop and reproduce when conditions are suitable for them. Thus, species living in a unique balance in each habitat develop over the years. Introduced species are non-native species that come from outside to any habitat. In fact, the introduced species is harmless in its habitat. Because the balances in its own habitat are enough to keep the species in balance within certain limits. But since it has no predator in a new habitat, it invades the habitat by multiplying disturbingly by other creatures. The increase in temperature due to global warming causes fish species, whose natural environment is the Red Sea and the Indian

Ocean, to spread to the warming Mediterranean waters. For example, the lionfish from Mediterranean waters, which is not a predator, consumed the young of other fish as food and became an important introduced species of the region (Figure 17). Since introduced species cause extinction of species in the habitats they dominate, they are at the top of the world's ecology agenda. Countries take various measures to limit introduced species. For example, in recent years, a monetary reward has been introduced to encourage the fishing of pufferfish, whose population has been increasing in the eastern Mediterranean in recent years. However, such measures are not among the measures aimed at eliminating the source of the problem (Mader & Windelspecht, 2017).

Figure 17. Introduced Lionfish

Conservation of Natural Life and Biodiversity

Natural is a term used to express the phenomena that occur as a result of processes occurring in nature without human touch. Natural life, on the other hand, is used to express that an ecosystem is in balance, that the balance has developed as a result of natural processes, and that people live carefully and respectfully to this balance. It can be easily predicted that living things will live in environments where natural life exists, increasing their numbers and diversity. Therefore, natural life and biodiversity must be protected (Stoltze & Schraer, 1987).

Natural Resources

No matter how far humanity moves away from nature, no matter how much the influence of man on nature increases, no matter how far the world civilization level goes, the existence of human beings depends on the existence of nature from the first day of its existence. However, many resources of nature, which are used for free, now give the signals of extinction. For a sustainable life, the possibilities and benefits of nature should

be considered within the economy and give the necessary value to nature. However, the increase in the world population day by day has caused our environment to become more polluted and the consumption of natural resources to increase day by day. Despite the increase in the human population, the earth still has enough natural resources and production for all living things. However, there is injustice in the distribution of production and natural resources. As seen in Figure 18, North American and European countries lead the world in energy consumption. Developed and developing countries take a large part of the production. Underdeveloped countries, on the other hand, spend their natural resources rudely in order to increase their welfare. However, the use of natural resources necessitates a plan that takes care of the rights of all living things (Gould, Keeton & Gould, 1996).

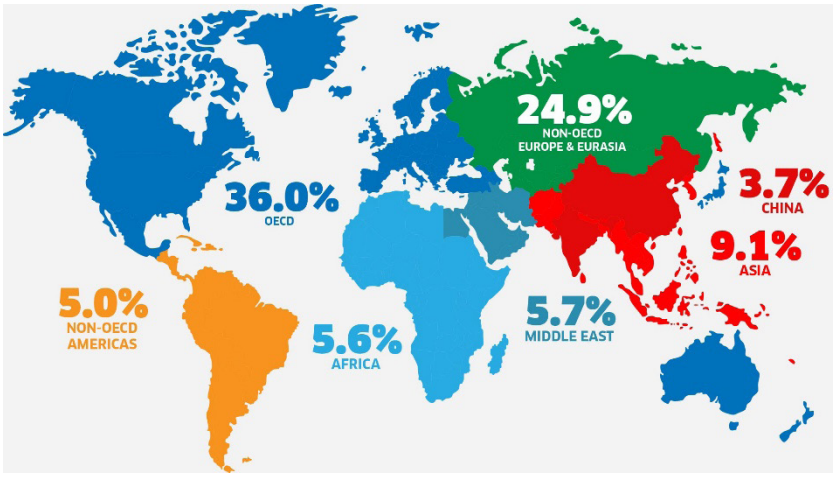

Figure 18. Distribution of world energy consumption by regions

Renewable resources

Long term management of natural resources should be made taking into account the difference between the two natural resource groups – renewable and non-renewable resources. Resources that are renewed by nature at a faster rate than they are consumed are called renewable resources. Solar energy is renewable because its source is endless. Clean air and water can also be renewed at a faster rate than they are consumed. Unfortunately, the resources found in nature stand in a fine balance established under the influence of various factors and are never infinite. If consumption exceeds its regenerative capacity, resources are depleted (Karabal, 2011).

Non-renewable resources

Resources that are in a limited number in nature or that require a long process to renew nature are called non-renewable resources. It is difficult to renew the underground richness that took years to form. For example, it is known that the hard coal resources that exist today were formed as a result of the carbonization of the vegetation covering the

earth during the Paleozoic era, 500-600 million years ago. It is believed that a substance called pristane with a high carbon content, whose formation is estimated to have started in this period, is also effective in the formation of petroleum. The grouping of a resource according to its renewal status differs depending on the context considered. A living species has a chance to reproduce and regenerate until its last members are destroyed. In this context, living species are renewable resources. However, when the last member of the species disappears, it becomes non-renewable. For example, in a forest ecosystem, living things live together in interaction with each other. However, when trees are cut down and forests are destroyed, their habitats are destroyed for many living things. Only species native to a particular forest area can be destroyed by clearing that forest habitat (Bulut, 2019).

Figure 19. Use of natural sources a. A destroyed forest b. A crop field

Sustainable use

By ignoring other living things, man uses all the richness of the earth for his own benefit, comfort and even to prevail in the struggle for supremacy. Despite the negative behavior of man, nature has always found a way to repair itself and continue to live. **Sustainable use** is the consumption of natural resources in accordance with nature's self-renewal rate by keeping up with the rhythm of nature (Figure 19b). Sustainable use requires taking responsibility for issues such as the responsible use of resources, recycling and nature protection (Goodenough & McGuire, 2014).

Conservation of Biodiverse Areas

As can be seen, human activities deeply affect many ecosystems. Many efforts are being made around the world to support the natural life and increase the survival opportunities of living things.

Protected areas

Scientists draw attention to the importance of creating protected areas that can contribute to biological diversity. In this direction, natural areas have been determined and taken under protection by giving various statuses. These areas are called National Parks, Nature Protection Areas, Natural Monuments, Nature Parks, Wildlife Protection Areas, Wildlife

Development Areas, Conservation Forests, Gene Conservation Forests, Seed Stands, In-Forest Resting Areas, Fisheries Production Areas and Protected Areas. In addition, in recent years, countries have established seed banks to preserve their genetic diversity. While the seeds are disappearing due to natural reasons, on the other hand, they are in extinction due to the alienation from organic farming practices. Establishment of seed reserves to be used when necessary is important in terms of preventing species loss (Dilbirliği, 2007).

Hotspots for biodiversity

Every living thing tends to live in an environment where it can develop and reproduce best. Various conditions in different parts of the earth increase the chance of survival of certain species in those regions, while limiting the chances of survival of some species. In fact, some living species only live in a certain region of the earth where conditions are suitable for them. Species that live only in a certain geographical region on earth are called endemic species. Some other species may show a wider spread on the earth or may live in various geographical regions on earth. Considering that the geographical regions and the widths of the habitats are not equal, it is understood that the biological diversity on earth does not show a homogeneous distribution. Some regions may be rich in biodiversity, while others may remain poor. Areas on Earth that are rich in endemic species and are facing significant habitat loss are called **hotspots**. Some scientists argue that the protection and rescue of hotspots where biodiversity is seen at the highest level should be emphasized by considering that the intervention possibilities are limited. On the other hand, some of the scientists disagree on the grounds that concentrating funds for species conservation in hotspots does not solve serious problems occurring elsewhere. These scientists are of the opinion that funds are better be used in various parts of the globe without focusing on biodiversity hotspots (Solomon et al., 2019).

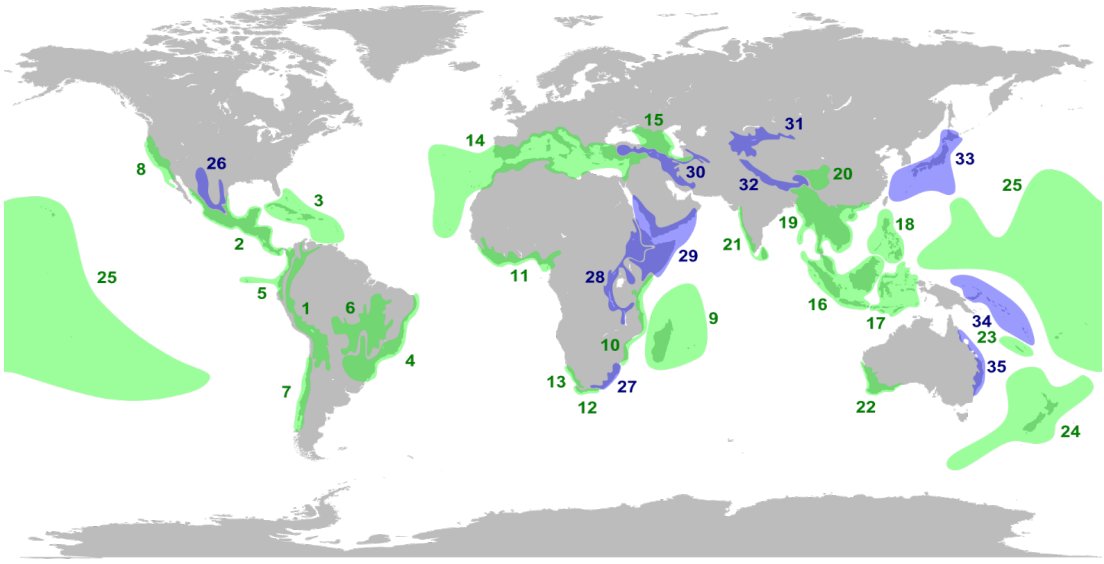

Figure 20. Biodiversity Hotspots

Corridors between habitat fragments

Environmental scientists say that they will contribute to the protection of biological diversity by constructing corridors or passages between areas that have been separated from each other and turned into separate habitat parts (Figure 21). Corridors enable habitants to move safely from one part to another. A larger habitat is obtained by the formation of passages between the habitat fragments. A wider habitat means greater genetic diversity. However, the creation of passages also brings some risks for the habitat. For example, disease seen in one part of the habitat may spread to other parts. In addition, the multi-segmented but single structure of the habitat is an edge effect-enhancing factor. The edge effect increase has a negative effect on the health of the habitat (Reece et al., 2014).

Figure 21. A Corridor Connecting Parts of the Habitat

Regeneration of Ecosystems

It is the biotic and abiotic factors that keep an ecosystem alive. When species diversity in the ecosystem is damaged, these factors are also degraded. For example, the use of land taken from cleared forests in agricultural lands results in low yields. Abandoned lands cannot be used for agricultural purposes after mineral exploration and extraction processes. Living things lose their lives and habitats as a result of detergents, toxins and petroleum products polluting natural habitats. However, habitats can renew themselves after a while even after the harmful effect disappears (Figure 22). The renewal period does not change depending on whether the harmful effect is related to natural or human factors. The type of harmful factor and the size of the habitat in which it is effective determine the renewal period. Of course, the longer the renewal period should be expected for the larger the affected habitat. Environmental scientists developed some methods called bioremediation and biological augmentation to accelerate the recovery process in the damaged habitats (Starr, Taggart & Evers, 2018).

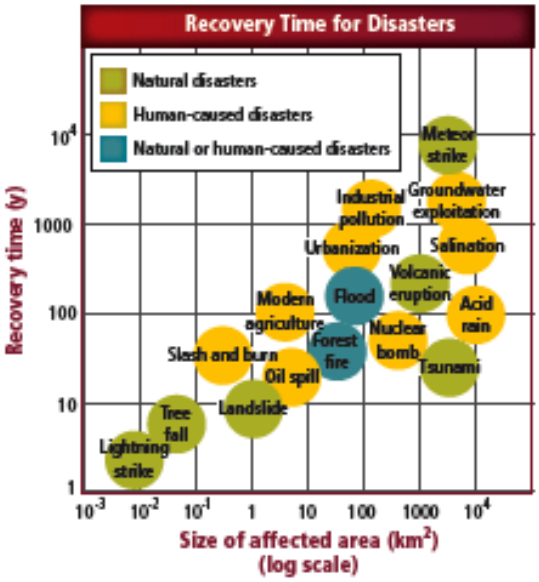

Figure 22. Recovery Time After a Disaster

Biological recovery

Biological remediation is the use of living organisms in clearing contaminated habitat. Fossil fuels such as petroleum may be released into the environment as a result of leakages that occur during the extraction, transportation, processing and storage (Figure 23a). The size of the leaked amount can sometimes reach a level that can be considered a natural disaster. While oil covers aquatic ecosystems, preventing light and gas ingress, it can also mix with the soil at the bottom, contaminating the underground table and groundwater. Among the many microorganisms naturally found underground, some have the ability to decompose this oil into carbon dioxide. Through inclusion of microorganisms and beneficial substances, scientists have succeeded in increasing the ratio of clean the habitat and have made a breakthrough that will greatly reduce pollution in the oil spill area within a few years (Mason et al., 2017).

Figure 23. Bioremediation Samples: a. Oil Spill b. Aphid-Eating Ladybug

Some plants tend to accumulate toxins such as heavy metals in their tissues. The accumulating plants are useful for the removal of toxins from unhealthy habitats. As plants grow and develop naturally in unhealthy habitats, they continue to accumulate

toxic substances in the soil in their tissues. By harvesting plants of a certain size, toxic substances are completely removed from the soil. Biological remediation is a relatively new practice. However, it shows great promise in transforming damaged ecosystems into healthy ecosystems (Biggs et al., 2007).

Biological Augmentation

Each ecosystem has its own nutrient chain. In this chain, each species has its own role known as ecological niche. Some of them can be producers and some are consumers. Some consumers consume producers and some consume other consumers. Most of the consuming consumers are predators. In healthy ecosystem production and consumption rates are in balance. But somehow some species can break this chain. In these cases, scientist find a way to make the ecosystem healthy again through placing predator of chain breaker species. This placement is called biological augmentation. For example, aphids, settle on the leaves and young shoots of plants and eat them. It is an undesirable situation especially on vegetables, fruits and other plant species with commercial value. If it is not intervened in time, it may cause plant loss as well as reducing the quality of the product. Aphids can also transfer diseases from a plant to another. The natural predators of aphids are ladybugs. So, aphids' population can be taken under control through ladybugs (Figure 23b). Also, ladybugs do not reduce product quality.and aphids are removed from the fields (Brooker et al., 2020).

Conventions Concerning the Conservation of Natural Life and Biodiversity

The balance of natural life can be disturbed for various reasons, especially the desire of people to dominate nature and to spend resources only for their own comfort. Natural life is under threat all over the world due to reasons such as climate change, nuclear energy, genetically modified organisms, urbanization or urbanization that we have heard frequently in recent years. The local use of carbon-based fossil fuels in various parts of the world has caused the temperature to increase by several degrees all over the world, and the species that have established a very tight life balance with each other have been affected or destroyed. While the emerging life problem is affecting the whole world, its solution is sought locally. For example, in order to reduce the use of fossil fuels that cause global warming, it is necessary to raise awareness of people and mobilize thoughts. It is also clear that the protection of natural life and biological diversity in a particular region cannot be left solely to the efforts of human groups living in that region or interested in solving the problem. For this reason, international conventions have been accepted for the conservation of natural life and biodiversity (Bulut, 2019). The agreements made for the protection of biological diversity, their responsible institutions, their years, and contents are presented in Table 1.

Table 2. Conventions for Conservation of Natural Life and Biodiversity

Convention	Responsible Institutions	Year	Content
Convention on Biological Diversity	United Nations Environment Program	1992	Conservation of biodiversity
Cartegana Biosafety Protocol	United Nations	2000	Use of genetically modified organisms
CITES	United Nations Environment Program	1973	Control of international trade in endangered species
Barcelona Convention	United Nations Environment Program	1976	Protection of the marine environment and coasts of the Mediterranean
Framework Convention on Climate Change (UNFCC)	United Nations	1994	Protecting the world's climate system
Convention to Combat Desertification	United Nations	1994	Preventing desertification in arid countries, especially in Africa
European Landscape Convention	European union	2000	Conservation of the European landscape
Bern Convention	European union	1979	Conservation of important species and habitats in Europe
Ramsar Convention	Independent	1971	Protection of wetlands important to waterfowl

Eco-Friendly Person Activities

Investigation of Fallen Leaves

Aim: It is aimed to examine the plant diversity in our close environment through research.

Materials: fallen leaves, bag, gloves

Method:

- ☐ Augmented reality apps
- ☑ Experimental applications
- ☐ E-learning applications

- ☑ Observation
- ☐ Computational science applications
- ☐ Activities those content is brought through games
- ☐ Activities whose content is gained through artistic activities
- ☑ Collaborative group work

- ☐ Mobil apps
- ☐ Game-based apps
- ☐ Measurement and evaluation activities
- ☐ Field work
- ☐ Sporting events
- ☐ Other methods and techniques

Plan: Students are told that they will work in groups in this activity. Each group is given a small bag of dry fallen leaves. It will be easy to find dry leaves that fall in autumn. First, students in each group are asked to classify the leaves. Second, they are asked to make guesses about which trees the leaves belong to. For estimates, systematic books, diagnostic keys or reliable internet sources can be used. Third, students are asked to find out whether the predicted or identified leaves belong to native or introduced species. Fourth, they are asked to comment on whether there is an introduced species in the habitat by looking at the number of leaves of the same species. Fifth, they are asked to calculate index of biodiversity using the formula below.

Index of biodiversity =

Finally, each of the groups is asked to submit a written report on these five steps.

Biodiversity Court

Aim: It is aimed to research the factors that threaten biodiversity and the measures that can be taken against the threats.

Materials: paper, pen

Method: Simulation drama, role play

- ☐ Augmented reality apps
- ☐ Experimental applications
- ☐ E-learning applications

- ☐ Observation
- ☐ Computational science applications
- ☑ Activities those content is brought through games
- ☐ Activities whose content is gained through artistic activities
- ☑ Collaborative group work
- ☐ Mobil apps
- ☐ Game-based apps
- ☐ Measurement and evaluation activities
- ☐ Field work

- ☐ Sporting events
- ☑ Other methods and techniques

Plan: Students are asked to stage a courtroom. Students are informed that they will take on roles such as judge, bailiff, clerk, defendant, plaintiff, lawyers, experts, jury and audience for this activity. In the settlements, a biodiversity threat that students are thought to be familiar with is determined and the subject of the case is shaped. For example, in a classroom with students living in an area close to the thermoelectric power plant, the court case is based on the plant's harm to biodiversity. Plaintiff expresses his arguments as to how the thermoelectric plant is a threat to biodiversity and blames the plant. The defendant expresses the necessity of the power plant and the measures taken. Opinions of experts and experts may be requested. Lawyers defend their clients. The judge conducts the hearing. As a result, a reasoned decision is reached by asking the jury for its decision. Thus, students review biodiversity in all its dimensions.

Chapter Summary

Biodiversity is not limited to the living species around us. It is a much broader framework concept that includes all the biological units that make up living things, as well as the species that we cannot see with the naked eye, as well as the biotic and abiotic factors surrounding them. This framework includes the living species themselves, their genetic units, and the ecosystem they interact with and are a part of.

It is important to determine the biodiversity of a particular region or ecosystem. Because some species are used directly by humans. The needed species are collected or cultivated by human hands and traded. Although some species do not have commercial value, they have an important place in the ecological balance. The extinction of specific species, such as keystone species, causes the ecosystem to lose its health. In that case, it is necessary to act by considering the needs of all living things in an ecological unit. However, it is possible to keep nature and life sustainable by taking care of biodiversity.

In order to maintain biodiversity, the factors that threaten the health of the ecosystem should be determined first. The prevailing factors in the world are never static. The factors that affect the living life are built on fine balances. Changes force living things to change. Species that can adapt to the new situation that occurs as a result of change continue to live. Changes have followed a natural process until now. As a result of the great changes seen on earth, great mass extinctions have occurred 5 times in the last 500 million years. According to scientists, factors such as meteorites, tectonic movements, very cold or very hot climate are responsible for these great extinctions. Again, according to some scientists, the sixth mass extinction process has started and continues in the current time period. Unlike other mass extinctions, this time the cause of extinction is

seen as the human species. Therefore, human behavior is very effective in determining the dimensions of extinction.

Humans continue to take actions that threaten natural life and biodiversity to a great extent. Actions such as excessive use of resources and biodiversity, destruction, fragmentation and pollution of natural habitats adversely affect living things. However, preferring renewable resources, creation of protected areas, biological improvement and protection of ecosystem balance will ensure the protection of natural life and biological diversity. Despite international conventions and efforts regulating actions and studies on the subject, natural life is still under threat.

As a result, the earth is home to many living species. Living things have changed and transformed over the years as a result of the balance they have established in their natural environment, creating today's living diversity. Studies have not yet reached a sufficient point to explain the biological diversity existing on earth. However, human actions threaten natural life and cause the rapid disappearance of biological diversity. Recognizing people's actions, taking responsibility for their actions and taking action so that wrong actions are not repeated will make natural life and biodiversity sustainable.

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