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BIODIVERSITY AND ITS CONSERVATION

Tutorial

for training students in the speciality

"101 Ecology"

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The tutorial contains basic theoretical information about the basic concepts of studying biodiversity, its classification, methods of assessment, and preservation. The indicated main threats and problems of today are related to the impoverishment of biodiversity. The tutorial is aimed at familiarizing future specialists with the basic principles of monitoring, inventory of species diversity and wealth, analysis of primary information, etc.

For students, postgraduates, teachers, and research staff of biological, ecological, and agricultural universities specializing in the field of ecology and environmental protection.

У навчальному посібнику викладено основні теоретичні відомості про базові концепції вивчення біорізноманіття, його класифікації, методи оцінки та збереження. Вказані основні загрози та проблеми сьогодення пов'язані зі збідненням біорізноманіття. Книга спрямована на ознайомлення майбутніх фахівців з базовими принципами моніторингу, інвентаризації видового різноманіття і багатства, аналізу первинної інформації та ін.

Для студентів, аспірантів, викладачів та наукових співробітників біологічних, екологічних та аграрних вузів, які спеціалізуються в галузі екології та охорони навколишнього середовища.

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Animals and plants are a kind of barometer. If it suddenly turns out that animals and plants are disappearing, then this is a warning: something is wrong with the ecosystem. Therefore, the protection of animals and plants, in its essence, is the protection of themselves... It is necessary to protect them, because if they go, we will go too.

Gerald Durrell,
a British zoologist

LIST OF ABBREVIATIONS

AIC of Ukraine – agro-industrial complex of Ukraine

UN – United Nations Organization

EMA – environmental management and audit system

IUCN – International Union for Conservation of Nature

IUCN – International Union for Conservation of Nature Red List

VU, EN, CR – categories of "threatened" in the international biodiversity list

NBSR – National Biodiversity Strategy

NRF – nature reserve fund of Ukraine

UkrBIN (Ukrainian Biodiversity Information Network) – the only open network for the accumulation and exchange of data on biodiversity in Ukraine

EASIN (European Alien Species Information Network) – European Alien Species Information Network

GBIF – Global Biodiversity Information Platform for Ukraine

EU – European Union

FSC – Forest Stewardship Council

Remote sensing – remote sensing of the earth

DNA – dioxyribonucleic acid

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PREFACE

The biodiversity of our planet is the product of a long evolution that has been developing through the complexity of the systemic organization of living organisms and the increase in their number and diversity of life forms. It is biodiversity that has become the potential on the basis of which the Earth's biosphere has been revived every time it has been on the verge of death. At the same time, the biological mass of living organisms and their diversity tended to grow and increase. However, this trend had a variable temporal character: periods of rapid growth were followed by sharp declines, which were caused by not always established global causes. In the initial periods of the biosphere formation, the species diversity of the biosphere increased, but then stabilized and has remained relatively constant until now.

Today, there is a significant reduction in biodiversity due to the elimination of species. Under the influence of anthropogenic factors, the rate of species extinction has exceeded the natural rate by many times. An irreversible and uncompensated process of destruction of the planet's unique gene pool is taking place. The destabilization of biota can lead to the loss of the biosphere's ability to maintain the necessary environmental quality and, ultimately, the sustainable development of civilization.

Awareness of biodiversity as a unique property of wildlife and its role in preserving life on Earth has become an integral part of modern views on the relationship between nature and society.

The problem of conservation and rational use of natural biodiversity has become one of the priorities for developed countries. Reputable international organizations, scientific institutions, and the progressive global community are involved in its solution. The future of countries, their sustainable development, and the preservation of the moral and ethical platform of civilization depend on success in this complex matter.

The textbook "Biodiversity and its Conservation" is designed for students majoring in Ecology and aims to familiarize future professionals with the basic principles of monitoring, inventorying species diversity, its ecological niches and habitats. Young scientists and specialists in biology, ecology, and agriculture should have a basic understanding of biogeography and evolutionary ecology, take into account diversity at different levels of life organization: molecular, genetic, cellular, taxonomic, ecological, and others, understand the patterns of anthropogenic transformation of flora and fauna, take into account the peculiarities of the spread of invasive species and predict their impact on species richness and stability of natural ecosystems, and assess possible risks.

The textbook "Biodiversity and its Conservation" presents scientific material on the classification, importance, current threats and measures to conserve biological diversity.

The theoretical course is supported by the practical work of the authors of the textbook, which enables future specialists to master the skills of collecting and analyzing primary information, assessing species diversity, and developing environmental measures for the conservation and restoration of biodiversity.

The textbook "Biodiversity and its Conservation" will be useful for undergraduate and graduate students of biological and environmental sciences.

INTRODUCTION

Biodiversity is one of the fundamental phenomena that characterizes the manifestations of life on the planet. The diversity of biological structures and processes is the basis for the organization of the biosphere in all its global manifestations. Biodiversity is the basis for the structural and functional organization of the living matter of the biosphere and its ecosystem components, which determines the stability and resilience of the latter to external influences.

Biodiversity is the national wealth of Ukraine, the conservation and sustainable use of which is recognized as one of the priorities of the state policy in the field of natural resources management, environmental safety and environmental protection, an essential condition for improving its condition and environmentally balanced socio-economic development.

Biodiversity plays a dominant role in the cycle of matter, energy and information that ensures environmental sustainability. It occupies the main areas of the planet and participates in various ecological processes, as well as plays a significant role in the functioning of ecosystems. Until recently, the role of biodiversity in biogeocenoses, and especially in its future, has not been studied. It is not known exactly how many species of biodiversity live on the planet. To date, about 1.5 million species have been described, while experts estimate that the planet is home to 5 to 100 million species. Given the anthropogenic and climatic factors that pose a threat to biodiversity, it is extremely important to study the state of fauna and flora, and to study and preserve the species biodiversity of Ukraine.

Conservation and sustainable use of natural resources is the main task of the current and future generations of humanity.

SECTION 1. BIODIVERSITY, ITS ESSENCE AND IMPORTANCE

1.1 Biological function of biodiversity in nature

The emergence of a diversity of living systems in the course of the biosphere's evolution was due to differences in the living conditions of organisms and their different functional roles in biocenoses. The existence of biodiversity on Earth is of fundamental importance.

1. Biodiversity provides the main functions of the biosphere:

- production of organic matter;
- destruction of organic matter;
- the course of biogeochemical cycles of substances and energy flows.

Groups of organisms - producers, consumers and reducers - form chains in which each species and each group performs certain functions. No single species and no single functional group can perform all the stages of biogeochemical cycles, this requires the interaction of all groups:

- producers - synthesis of organic matter;
- Consumptives - energy flow through the stages of the food goal;
- Reducers - destruction and mineralization of organic matter.

2. Biodiversity makes it possible to use environmental resources in the most efficient way. Each of the currently existing species is adapted to function most effectively in certain environmental conditions - its own ecological niche. At the same time, multispecies communities are able to use environmental resources to the fullest extent possible and with the least amount of competitive tension.

3. The presence of biodiversity ensures the continuity of the Earth's living cover, as Vernadsky put it: "Different types of ecosystems function in different climatic zones, and different environments of the biosphere (water, land, soil) are home to certain species of organisms adapted to them. Even within a single species, there is a variety of alleles, genotypes, geographic races, and populations that are adapted to specific conditions."

4. Biodiversity ensures the continuity of life in time. In different historical epochs, habitat conditions have changed and are still changing on Earth, but among organisms there have always been forms capable of existing in new conditions - pre-adapted to them, while other organisms that did not have such adaptations died out.

5. Biodiversity ensures biosphere homeostasis: each species in the ecosystem is under the regulatory influence of other species that prevent its excessive reproduction, which would harm the ecosystem. In species-poor communities, outbreaks of individual populations often occur, which has a devastating effect on ecosystems.

When attempts are made to reduce the biodiversity of ecosystems by limiting it to one or more species, as humans do in artificial ecosystems, such as agrocenoses, the efficiency of their use of environmental resources is reduced to the point where they cannot exist on their own without human input.

6. Biodiversity ensures the function of ecosystem development in the course of ecological succession and the restoration of communities after damage. In the course of succession, some species are gradually replaced by others that are more efficient in changed conditions. As a rule, the succession is completed by special (climax) species that are better adapted to stable conditions and environmental saturation. However, species characteristic of the early stages are not completely displaced, but form dynamic equilibrium systems with species of the mature community. When environmental conditions change or ecosystems are exposed to external stressors, the presence of species characteristic of different stages of succession allows ecosystems to heal damage faster.

The principle of humanity's interaction with the planet's biodiversity can be illustrated by taking into account the scale of human impact on natural systems and the role that biodiversity plays in sustaining life on Earth. The main condition for sustaining life on Earth is the ability of the biosphere to create and maintain a balance between the ecosystems that make up its composition. Within the biosphere, there must be geographically balanced ecosystems of lower rank. In other words, the Earth should have the required number of tundras, forests, deserts, etc. - as well as biomes, and within the tundra biome, the optimum number of tundras should be preserved, and within the coniferous forest biome, the optimum forest cover should be preserved. And so on down to the smallest ecosystems, such as meadows, forests, lakes, and others.

The functioning of the planet as a whole and its climate balance is determined by the interaction of water, carbon, nitrogen, phosphorus and other substances driven by the energy of ecosystems. Vegetation cover is the most important factor in preventing erosion, preserving topsoil, ensuring infiltration and replenishing groundwater reserves. Without a sufficient level of biodiversity in marsh ecosystems, it is impossible to prevent eutrophication of water bodies, and a high level of animal species diversity is the key to the sustainability of any ecosystem and the biosphere as a whole.

If we imagine that a human being is left alone on planet Earth, it is easy to foresee the further course of events: there is no food, hard ultraviolet radiation is increasing, which will no longer be delayed by the ozone layer, breathing becomes impossible due to lack of oxygen, and the climate turns out to be incompatible with life.

Millions of animal and plant species maintain the conditions necessary for life to continue on Earth. Perhaps fewer species could provide these conditions, but this is not known for certain. Nor is the limit beyond which the reduction of biodiversity will trigger an irreversible process of ecosystem destruction and life will be brought to the brink of extinction. When biodiversity is destroyed, there are no reliable ways to compensate for its loss.

A pragmatic view of biodiversity allows us to see it as an inexhaustible source of biological resources. Biological resources provide us with all kinds of products: food, fiber for clothing, building materials, dyes, synthetic substances, medicines, etc. They are the basis of most human activities, and the state of the global economy largely depends on them. Microorganisms, which play a vital role in many ecosystems, have contributed to progress in food production.

Modern medicine is showing an increased interest in biological resources in the hope of obtaining new treatments for dangerous diseases. The greater the diversity of living things, the greater the opportunities for drug discovery; and the history of medicine provides excellent examples of this possibility. Potentially, any species can have commercial value or be used in medicine and other industries.

In agriculture, the genetic diversity of cultivated plants is of great importance for the development of pest control methods. The centers of origin of cultivated plants are the places where people first introduced many traditional species into culture. In these areas, the connection between agricultural plants and their wild relatives can be clearly traced. Farmers are increasingly interested in crop genetic diversity, as one of the priorities of modern research is to develop methods to increase crop productivity and improve their adaptability to changing environmental conditions.

Biodiversity is also important for recreation. Beautiful landscapes, multi-species diverse ecosystems are the most important condition for the development of tourism and recreation. The rapid expansion of this type of activity is often the main source of income for the local population. Specific species of animals and plants are often the object of great interest.

In addition to the pragmatic aspects of biodiversity, aesthetic aspects should also be considered. The beauty inherent in biodiversity is a source of inspiration. Without aesthetic pleasure, many of our hobbies would lose their meaning, whether it is sport fishing, hunting, hiking or bird watching. People have a need to contemplate beautiful landscapes. And yet the aesthetic value of biodiversity is more than just admiring a beautiful landscape. What would happen to a person, his or her emotional state, his or her worldview, if instead of a beautiful lake or a pine forest, he or she saw only piles of garbage or a landscape disfigured by rough intervention? Apparently, the aesthetic side of biodiversity appreciation is not just about enjoying the beauty of individual landscapes; it is rather an organic need inherent in every human being, as the perception of diverse life forms objectively improves the quality of life.

1.2 Species biodiversity

The term "biodiversity" is often seen as synonymous with "species diversity," including "species richness," which is the number of species in a particular place or habitat. In general, biodiversity is usually assessed as the total number of species in different taxonomic groups.

Species diversity includes the entire set of species living on Earth. There are two main definitions of a species. The first is the morphological definition of a species: a species is a collection of individuals that differs from other groups in certain morphological, physiological or biochemical characteristics. Nowadays, differences in DNA sequences and other molecular markers are increasingly used to distinguish species that are almost identical in appearance (for example, bacteria). The second definition, the biological definition of a species, is a set of individuals between which there is free interbreeding, but no interbreeding with individuals of other groups.

The morphological definition of a species is commonly used in taxonomy, i.e. by systematic biologists who specialize in identifying new species and classifying species. The biological definition of a species is commonly used in evolutionary biology, as it is based more on measurable genetic relationships than on certain subjectively identified physical traits. However, in practice, it is difficult to use the biological definition of a species because it requires knowledge of the ability of individuals to interbreed, which is usually difficult to obtain.

The level of biodiversity on the planet is still unknown. According to generalized estimates, it includes approximately 1.5 million identified species. However, experts believe that the number of species of insects and microorganisms alone is between 5 million and 100 million. In other words, humanity still does not know how many species inhabit our planet. According to estimates, more than 5,000 species of arthropods, nematodes, and bacteria can live in the soil alone. Other estimates put the total known number of species on Earth at about 1.7 million, but the projected number could be as high as nearly 100 million. As a reasonable working estimate, the UN Commission proposed that this figure be 12.5 million (Table 1).

Table 1

The number of biodiversity species on the planet has been determined and projected

Classes	Known number of species	Projected number of species
Insects	950 000	8000 000
Fungi	70 000	1000 000
Arachnids	75 000	750 000
Nematodes	15 000	500 000
Viruses	5000	500 000
Bacteria	4000	400 000
Plants	250 000	300 000
Protozoa	40 000	200 000
Algae	40 000	200 000
Mollusks	70 000	200 000
Crustaceans	40 000	150 000
Vertebrates	45 000	50 000

The world as a whole (of all kinds) 1700 000 – 12500 000

Scientists are constantly describing and naming new species of animals, plants and microorganisms. No one can give the exact number of species living on the planet, but it is known that the number of animal species far exceeds the number of plant, fungal and bacterial species. It is also known that insects predominate among animals in terms of the number of registered species. Their diversity is such that in terms of the total number of species they surpass not only all other animals, but also plants and microorganisms combined. In the plant kingdom, the largest number is occupied by the angiosperms.

The diversity of biological species is a necessary condition for the stability of the cycles of synthesis, transformation and destruction of organic matter in the biosphere. In natural ecosystems, the biota maintains a balance between the production and destruction of organic matter with high precision. Biota plays a crucial role in rock destruction and soil formation. In addition, biota effectively manages the hydrological regime, soil, atmosphere, and water composition. It has been established that biota retains this ability to the fullest extent, as humanity uses no more than 1% of the net primary production of biota. The rest of the production should be used to support the vital activity of species that stabilize the natural environment.

In the twentieth century, humanity channeled a flow of biosphere energy into the anthropogenic channel. At the beginning of the twentieth century, humanity consumed about 1% of net biosphere production, and at the end of the same century this figure increased 10 times. As a result of human activity, biogeochemical cycles are disrupted: phytocoenoses are disturbed and their productivity decreases; the share of heterotrophic link in ecosystems increases, part of plant biomass is removed from the cycle in favor of humans. In addition, a huge amount of waste is being accumulated, which cannot be degraded by natural reductants. The processes of environmental degradation are increasing catastrophically. In 1900, natural ecosystems were destroyed on 20% of the land, and now they are destroyed on 63%. Marine ecosystems are also being destroyed, starting with inland seas. Many species of living organisms are disappearing from the face of the Earth. Lists of rare and endangered species ("red books") contain thousands of names.

1.3 Ecological (ecosystem) biodiversity

There is a huge range of biodiversity in terrestrial and aquatic ecosystems on the planet: from icy polar deserts to forests and from coral reefs to the open ocean.

The diversity of ecosystems can be classified either on functional or structural grounds.

Ecosystem diversity refers to the different habitats, biotic communities and ecological processes in the biosphere, as well as the enormous variety of habitats and processes within an ecosystem.

Quantitative indicators of biodiversity in ecosystems vary greatly depending on the influence of various factors. It should be noted that the biocenosis includes not only species that permanently live in the ecosystem, but also species that spend only part of their life cycle in it (for example, mosquito larvae, dragonflies).

The species composition and overall diversity of a biocenosis can be described only at a certain point in time, since species richness changes as a result of the processes of immigration and elimination of species that continuously occur in the biocenosis. At any given time, a biocenosis has a certain species richness.

One of the constituent parts of the natural environment is the relief of the earth's surface, existing in its continuous variability on the border of the three natural shells or spheres of our planet – the earth's crust, or lithosphere, atmosphere and hydrosphere. The earth's surface with its relief – picturesque or rugged mountains, vast plains with rivers winding smoothly through them, dunes and sand ridges of deserts, and alpine glaciers – is an arena of life, one of the most important components of the biosphere.

The more diverse the environmental conditions in a given region, the more time organisms have for evolutionary transformations, the more diverse their species composition. Relief and geological structure can create a variety of conditions within areas with a homogeneous climate. In hilly terrain, its slope and exposure determine the temperature and moisture content of the soil. On steep slopes, the soil is well drained, which often leads to a lack of moisture for plants, although in nearby lowlands the soil is saturated with moisture. In arid areas, in floodplains and along riverbeds, well-developed forest communities can often be observed, contrasting sharply with the surrounding desert vegetation. Different tree species grow on the warm and dry south-facing hillsides than on the cold and wet northern hills. The hilly terrain is often associated with the beauty of the landscape, which means that there are rich and diverse communities in the neighborhood.

Any landscape on the globe is subject to change under the influence of climatic conditions. They are also greatly influenced by the plant world. Landscapes in all their diversity have been formed over many millennia, as well as as a result of human activity. They are continuously changing due to the constant search for efficient forms of land use and mining. People build cities and pave roads. Thus, landscapes consist of a number of natural and cultural elements. They embody the collective memory of nature and those who inhabit it, forming a complex element of the environment.

Cultural landscapes are characterized by peculiar anthropogenic biocenoses. The problem of studying the structure and functioning of anthropogenic biocenoses is of great scientific interest. The fact is that anthropogenic biocenoses, which are formed and developed under the complex influence of natural and socio-economic factors, have their own characteristic features; the specific laws of their development are still poorly understood. We can mention such features inherent in anthropogenic biocenoses as oligodominance (a sharp predominance of one or more species in plant and animal diversity), instability of the system, which is expressed in sharp changes in the amount of biomass and production not only by seasons but also by years, increased vulnerability of the structure, given the relative simplicity and unambiguousness of the links between the components of the biocenosis. The latter is explained by the historically small age of anthropogenic biocenoses, whose structure usually does not reach the degree of complexity and balance observed in natural biocenoses. Therefore, drastic changes in conditions and impacts on an anthropogenic biocenosis at that time lead to radical disruptions in its structure or to its complete destruction. Knowledge of the regularities of the structure and life of anthropogenic biocenoses will allow us to regulate and guide the development of the geographical environment, increasingly involving humans in the sphere of human activity.

1.4 Biodiversity of Ukraine

Ukraine's biodiversity includes at least 74,000 species of plants, animals, and fungi (including more than 27,000 species of plants, more than 35,000 species of animals, and more than 12,000 species of fungi); new species are discovered annually. Ukraine's natural ecosystems include coniferous, mixed, and broadleaf forests, sub-Mediterranean sparse forests, forest-steppes, steppes, subalpine and alpine meadows (meadows, yayla), semi-deserts, sandy beaches, spits and dunes, and rocky slope ecosystems, underground cavities (caves), marshes, salt marshes and salt marshes, freshwater rivers and lakes, brackish water lakes and estuaries (estuaries), salt lakes and bays, rocky seashores, marine ecosystems of the Black and Azov Seas and the Kerch Strait.

According to various sources, the total area of forests is 14.5–16% of Ukraine's territory, including virgin and old-growth forests of the Carpathians (according to scientific data, more than 900 km^2). Other natural ecosystems account for 6–9% of the country's territory. Ukraine's land area is one of the largest in the world: as of January 1, 2016, 71% of Ukraine's territory is agricultural land; arable land covers 54% of Ukraine's territory. Ukraine has a mountainous system with a high altitude zonation (the Carpathians).

The river basins include the Danube, Dniester, Southern Bug, Dnipro, Vistula, Black Sea and Azov river basins. In general, Ukraine's biodiversity is under-researched, but endemic, rare, vulnerable, and endangered species have been identified, including migratory species. Among the endemic species of Ukraine are the sand and Podillia blind, Lindholm's lizard, Crimean pinch, Donetsk isofia, Klokov's birch, elderberry carnation, naked yarrow, Turchaninov's horsetail, etc. Today, 1409 species are assessed in the IUCN international list, of which 187 (13.3%) are categorized as "threatened (VU, EN, CR).

The National Red Data Book of Ukraine (2009 edition) includes 826 species of flora and 543 species of fauna. Some common European species have negative population dynamics and require special protection measures in Ukraine. Among them, 45 species of invertebrates and 61 species of vertebrates are endangered (0.2% of the total number of species), and 6 species of animals are extinct from the territory of Ukraine (0.01%). Among the protected species, 24 species of invertebrates and 17 species of vertebrates are endemic to Ukraine and regions such as the Carpathians (0.1%). Among the species with negative population dynamics are large wild animals (sturgeon, flounder, porpoise, bison, elk) (Fig. 1). Among plants and fungi, there are 179 endangered species (0.7%) and 10 species that have disappeared in nature (0.04%). Changes in biodiversity are also associated with the dynamics of habitats due to climate change and bioinvasions.

Fig.1 **Bison (*Bison bonasus* Linnaeus, 1758)**

The flora of Ukraine has more than 900 adventive species of vascular plants (15% of the country's flora). About 90 invasive species pose a threat, including more than 40 transformers. The Spanish red slug is among the massive invasive species of recent years. The Amur chub and rotan-head are spreading in fresh waters. Protected areas of various statuses have been created to protect biodiversity. Today, legally protected areas established under national legislation cover 6.6% of Ukraine's land area. In addition, in the exclusive economic zone of Ukraine in the Black Sea, there is a marine reserve "Zernov's Phyllophora Field" (4,025 km^2) with the world's largest accumulation of the unattached red algae phyllophora. The genetic resources of Ukrainian agricultural plants and animals are part of the world's heritage. In particular, local and endangered breeds include cattle (Ukrainian Whitehead, Ukrainian Grey, Lebedyn, Carpathian Brown, and Red Steppe), pigs (Myrhorod, Ukrainian Steppe White, Ukrainian Steppe Spotted), sheep (Sokil, Ukrainian Mountain Carpathian), and horses (Hutsul).

Fishing and hunting are well developed in Ukraine. Massive species predominate among the targets of fisheries: in freshwater bodies – tulka and silver crucian carp (introduced species), in the sea – sprat, hamsa and rapana (dangerous invasive species). Most populations of valuable commercial fish species are in a poor condition. The greatest impact on biodiversity occurs in agroecosystems as a result of economic activity, and ecosystem services are mainly associated with agricultural landscapes and forests.

1.4.1 Biodiversity structure of Ukraine

Occupying less than 6% of Europe's land area, Ukraine has approximately 35% of its biodiversity. This is due to the fact that Ukraine's territory is located in different natural zones, such as steppe, forest-steppe, broadleaf forest, and Mediterranean. The richness of landscapes in Ukraine increases in the following sequence: meadows, marshes, plains, steppes and forests. Representatives of more than 70 thousand taxa live in Ukraine.

The fauna of Ukraine includes more than 45 thousand species that belong to two high-ranking systematic taxa - vertebrates and invertebrates, with the number of the latter being much higher than the former. According to rough estimates, one third of the species, including fungi and insects, have not yet been described.

The second edition of the Red Data Book of Ukraine includes 511 species of plants and 382 species of animals. An effective indicator of the level of conservation of floral and faunal diversity is the conservation of rare species. Ukraine ranks fifth in terms of the number of globally vulnerable species in Europe. Thus, we have a significant potential for biodiversity conservation and restoration, i.e. our country can be considered as one of the powerful reserves for biodiversity restoration in the whole of Europe.

The forest-steppe zone covers about a third of Ukraine's territory and, despite significant anthropogenic pressure, it has preserved a diverse vegetation: forests formed by common oak (oak, hornbeam-oak, linden-oak), rock oak (in the southwestern part of the forest-steppe), and common hornbeam. Pine and oak-pine forests are found on the sandy soils of the second terrace of the Dnipro and its left-bank tributaries. Meadow vegetation forms in the river floodplains. Bogs are also confined to river floodplains and are mostly represented by tall herbaceous eutrophic species. Steppe vegetation (mainly meadow feather grass steppes) has been preserved only in the form of small fragments in areas inconvenient for plowing and intensive use and in the territories of the nature reserve fund.

In general, the vegetation cover of Ukraine is represented by forests, meadows, marshes, steppes, tomillyards, and shrubs (halo-, psammo-, calce-creto-, petrophilous, and aquatic communities). According to Yurii Sheliag-Sosonko, the price fund of forests in the Ukrainian Carpathians consists of 801 associations of 16 formations, Ukrainian Polissia – of 409 associations of 10 formations, Podillia part of the forest zone – of 246 associations of 12 formations, forest-steppe zone – of 405 associations of 13 formations and steppe zone – of 380 associations of 18 formations.

The allocation of the rare vegetation price fund of Ukraine will contribute to solving a number of issues in the field of forest conservation, including the development of forest protection regimes, maintaining phytogenetic potential, forming sustainable communities, stabilizing the ecological state of regions, etc.; the price fund of Ukraine is its national wealth.

As a result of economic activity, especially in the last century, there have been significant changes in landscapes and natural habitats. The area occupied by natural communities has sharply decreased to 29%, including forests – to 14.3% of the country's territory, the steppe as a natural biome has been virtually destroyed, and the hydrological conditions of the territory have undergone significant changes due to the construction of lowland hydroelectric power plants and the creation of reservoirs, the draining of Polissya swamps and the flooding of the steppe. There is anthropogenic pollution of large areas, including with heavy metals, radionuclides, and persistent organic compounds, and manifestations of devastation and synanthropization of ecosystems, which threatens to lose the gene, ethno- and ecological resources and creates social and environmental discomfort for the population.

Biodiversity of agricultural landscapes (agrobiodiversity) is a rather complex biological object that functions to some extent as a natural object, but in general it is quite dependent on the entire agricultural production process. Agrobiodiversity is also a rather diverse object that can be classified based on its biological properties, diversity and presence of various constituent elements.

Biodiversity in agroecosystems, as in any ecosystem, contains genetic fractions of biota – native (autochthonous), adventitious (allochthonous), and the latest, which is the result of their mutual penetration. In addition to these three, the biota of agroecosystems contains a cultigenic fraction, which was introduced by humans and cannot exist without anthropogenic support.

Landscape biodiversity has three components: wild biodiversity, genetic biodiversity, and associated biodiversity.

Wild biodiversity includes wild relatives of domestic plants and animals that live, for example, in the steppe or forest outside of rural areas, and can be used to breed new species of domestic plants or animals in the future. Soil microorganisms, pollinators, insect pests and predators, and other plants and animals associated with functions of importance to the local agroecosystem.

For example: decomposition of organic matter and return of nutrients to the nutrient cycle to maintain soil fertility for the sustainable development of plants and animals;

- *decomposition of pollutants to maintain clean air and water;*
- *mitigating the impact of climate effects;*
- *preservation of soil and water resources;*
- *pollination of agricultural crops;*
- *controlling the activity of crop pests.*

Genetic biodiversity includes:

Higher plants – crops and their wild relatives; plants growing on pastures and semi-natural grasslands; trees grown in agricultural landscapes; weeds;

Mammals – domestic and wild mammals that use agricultural landscapes as habitat;

Birds – domestic and wild birds that use agricultural landscapes as habitat;

Reptiles, amphibians and aquatic organisms also use agricultural landscapes as habitat;

Arthropods – pollinators, phytophages, entomophages, other arthropods (e.g. termites, ants);

Other macroorganisms such as earthworms; mollusks;

Microorganisms – soil bacteria, fungi, algae, nematodes, actinomycetes, pathogens, etc.

Associated biodiversity includes plants and animals that do not always support the key functions of the agroecosystem, but which use agricultural areas for food and shelter.

At the Fifth Conference of the Parties to the Convention on Biological Diversity (Nairobi, May 2000), a special program of work on biodiversity was included in the) in the special program of work on biodiversity, which is closely related to agriculture, agrobiodiversity is defined as "the diversity and variability of animals, plants and microorganisms at the genetic, species and ecosystem levels that are essential for maintaining essential agroecosystem functions, structure and processes that ensure food production and food security".

Features that distinguish agrobiodiversity from other biodiversity:

- agrobiodiversity is actively managed and many of its components would cease to exist if not for human intervention;
- indigenous knowledge and culture are an integral part of agrobiodiversity management;
- a significant number of economically successful farms are based on the cultivation of non-native crop varieties brought from other parts of the world (e.g., corn and potatoes were introduced to Europe from the Americas);
- the diversity of plant varieties and animal breeds used in agricultural production is as important as the diversity of wild plant and animal species;
- agrobiodiversity is closely linked to sustainable land use and conservation practices; protecting it by creating nature reserves alone is not sufficient.

A review of the main elements of agrobiodiversity allows us to build a generalized scheme (Table 2).

Table 2

Ecological structure of biodiversity

Level	Cultivated component	Spontaneous (natural) component
Genetic	1. Diversity within the plant varieties, microbial strains and animal breeds used	7. Genetic heterogeneity of wildlife populations in agroecosystems
Population	2. Diversity of plant varieties, microbial strains and animal breeds used in mass production	8. Diversity of genetically determined ecotypes, price populations, geographical races, subspecies, etc. among wild organisms
Species	3. Diversity of species of cultivated organisms used	9. Species diversity of wild organisms
Cenotic	4. Diversity of agrocenoses (agroecosystems)	10. Diversity of spontaneous communities on agricultural lands

Landscape	5. Diversity of farm types in terms of ecology (by the nature of metabolism and energy)	11. Diversity of preserved fragments of natural landscapes
Zonal	6. Diversity of zonal types of agriculture	12. Diversity of ecosystem types inherent in natural areas (biomes)

The diversity of crops is ensured to a greater extent by gene banks, i.e., through closed conditions rather than open conditions on farms.

The conservation of biodiversity is inextricably linked to the conservation of the natural environment – landscape diversity (diversity of habitats, econo-ecosystems, trophic chains). That is, landscapes should also be considered as ecosystems, which are subsystems of larger ecosystems within which biodiversity can be preserved.

With regard to the distribution of Ukraine's agrobiodiversity in the zonal context, it differs significantly within the natural zones of Polissya, Forest-Steppe and Steppe, as well as the mountain system of the Ukrainian Carpathians. Based on the dependence of the coenotic and species diversity of spontaneous phyto- and zoobiota of agrobiodiversity on soil and hydrological conditions, further analysis of its distribution by natural zonal and ecological features within the above zones is possible, but taking into account the degree of their transformation into disturbed natural or agroecosystems.

At the level of natural landscapes (including their parts developed for agriculture), the following main types can be distinguished: 1 – dismembered landscapes with broadleaf forests, 2 – leveled landscapes with broadleaf forests, 3 – dismembered landscapes with steppes, 4 – leveled landscapes with steppes and saline areas, 5 – sandy and peaty landscapes of Polissya and boreal terraces, 6 – sandy and meadow-chernozem landscapes of floodplains, 7 – landscapes of lowland marshes and deltas, 8 – mountainous forest landscapes of the Ukrainian Carpathians, 9 – highland landscapes of the Ukrainian Carpathians. These types of natural landscapes are subject to different agricultural production systems.

The basic basis for the conservation of agricultural landscape biodiversity is the rational use of soil cover, its protection and reproduction of fertility, as well as the preservation of soil diversity. The number of ecosystems found in a given area is determined by the condition of the soil cover. The diversity of soil cover is controlled by quantitative and qualitative indicators that characterize the direction of changes in the natural environment in space and time.

Different types of agroecosystems can include natural, spontaneous and agroecosystems. Thus, at the level of natural cenoses, there are cenoses with a natural structure and species composition; natural cenoses that have been modified to some extent; natural cenoses that have been transformed in a fundamental way; spontaneous cenoses formed on radically altered ecotopes, often with reduced productivity, and island spontaneous cenoses, the area of which is insufficient to support biodiversity, as well as ribbon cenoses (along roads, rivers, along the edges of fields, etc.).

Among the spontaneous cenoses and ecotopes, the following groups are distinguished: remnants of steppe vegetation (including ravines, gullies, banks, old fallow land), spontaneous meadows, wastelands and psammophytic communities, natural forest areas (variously modified, as well as naturalized plantings), young trees on unimproved land (spontaneous), shrubby secondary communities, marshes (undrained and drained), salt marshes, salt marshes, rocks, etc, abandoned quarries and peat mines, unused reservoirs, watercourses, and spontaneous vegetation in rural areas.

A certain share of agricultural landscapes is made up of anthropogenically unchanged lands and water bodies owned by agricultural producers, as well as lands and water bodies that have been removed from agricultural production or are planned by government programs for deforestation and re-naturalization. These lands are characterized by the highest level of biodiversity among agricultural lands. Although the biodiversity of these lands is not always included in the concept of agrobiodiversity (and sometimes loses its agrobiodiversity features over time), it is in most cases a source of replenishment of agrobiodiversity and actively interacts with it.

Ukraine's landscapes were maintained in a harmonious state only until the first half of the nineteenth century, after which systematic deforestation in the forest-steppe zone, land drainage in the Polish zone, and plowing in the steppe zone began.

In the process of anthropogenic transformation of the modern spontaneous biota, the role of agrolandscapes is wide and diverse, it is associated with the impoverishment, cosmopolitanization and unification of biota, serious evolutionary consequences and transformations in it caused by chemical, physical and biological pollution. The introduction and expansion of invasive species are processes of synanthropization of vegetation and animal population, the most important factor of which is human activity in the agro-sphere.

In terms of the structure of agricultural land, the following ratio of land is considered ideal for Ukraine: 1 – arable land: 1.6 – natural fodder lands: 3.6 – forests. But the real ratio is as follows: 1 – arable land: 0.23 – hayfields and pastures: 0.3 - forests. This ratio shows that the state of agricultural landscapes is extremely unbalanced. Based on this data, we can make an assessment of the ecological state of agricultural landscapes: Polissia is moderately deteriorated, Forest-Steppe is severely deteriorated with approaching catastrophic conditions, and Steppe is catastrophic; in general, it is severely deteriorated for Ukraine.

Some scientists see a way out of the difficult environmental situation in Ukraine in a gradual transition from existing low forest cover agro-landscapes to the formation of new forest-agrarian landscapes as highly productive, biologically sustainable and self-regulating systems. They are able to resist soil destruction and soil fertility decline, optimize the structure of land, and rationalize land use. Add to this the fact that forest-agricultural landscapes can become migration routes and shelters for biodiversity components. Experts estimate that in order to achieve this, shelterbelt forest cover needs to be increased to 30–40% in the next 10–15 years; as of 1996, it did not exceed 2.6%.

In the process of ecological conversion of agriculture in Ukraine, it is proposed to convert a certain part of currently plowed but low productive lands (saline, eroded, etc.) into fodder lands (hayfields and pastures) and reforestation. According to the calculations, the degree of plowing will thus decrease in the steppe zone from 81.3 to 60%, in the forest-steppe zone from 82.0 to 60.8%, in Polissya from 66 to 49%; on average in Ukraine – from 78.5 to 57.9%.

Ukraine has 32 million hectares of arable land, more than 71% of which is fertile black soil. However, in the process of agricultural use, soils are subject to various types of degradation. The degradation of Ukraine's soil cover has reached such a scale that it threatens its integrity and diversity. For example, certain soil types and subtypes are already disappearing within some landscapes, which threatens not only the efficiency of agricultural production and the food security of the state, but also has a negative impact on both the natural environment and biodiversity.

Thus, despite significant anthropogenic transformation, Ukraine's agricultural landscapes remain an important condition for preserving diversity.

1.4.2 Ecological communities and life forms of biodiversity

An important feature of all terrestrial animal communities is the abundance and diversity of arthropods, especially insects. Each type of ecosystem is characterized by its own set of species, among which dominants are the most abundant species in the biocenosis. Life form is a historically formed complex of biological, physiological and morphological properties of a species that determine a certain response to environmental influences.

The term "life form" was introduced into science by A. Humboldt in 1806. During the nineteenth century, the term was used in botany, and then became more widely used. Botanists Warming and Gamori suggested that ecological communities similar to plant life forms could be identified in animals.

An important step forward in the development of the problem of life forms was made by A. N. Formozov, who substantiated their characteristics by certain quantitative indicators – morphological, physiological, etc. In his works, A. N. Formozov proceeded from the fact that a species bears the imprint of the environment in which it lived and lives and to which it is usually well adapted. Hence the emergence of specific life or biological forms in certain landscapes, and similar landscapes on different continents may have their own sets of forms, which are quite similar in appearance and habits to the former, although very distant in systematic terms. Convergent evolution, the process of convergence of morphological, physiological, and other features, plays a major role in the formation of biological forms. This process can affect not only individual species, but also, in some respects, entire faunas or even biota. Within the same landscape zone, such as deserts, there are a number of specific life forms of animals that solve the problem of adaptation to desert landscapes in their own way. Convergent and parallel development is usually observed in related forms. This was explained, in particular, by I.I. Schmalhausen, who wrote: "for dissimilar organisms, the environment can never be the same, because different organisms occupy different positions in it, i.e., they treat it differently", so we cannot expect deep similarities in the adaptive reactions of such organisms.

In animals, life forms are groups of taxa, usually within the same order or close orders, which have similar morphological and ecological adaptations for living in the same environment. A typical example of life forms is the adaptive ecological groups of mammals: swimming, digging, running, jumping, flying, etc. Similar groups have been repeatedly described in birds, insects, fish, reptiles, ticks, and other animals, so we can talk about the universality of the phenomenon of adaptive parallelism in animals, a kind of "fourth rule" of adaptive evolution in animal ecology.

Other transformation strategies are also possible, such as the relationship of animals with the "microbial link" of the trophic chain, the development of "internal trophic chains" in ruminants, mollusks, coral polyps, and many other animals, which at the initial stage of trophic divergence is associated with the formation of life forms.

These and other changes observed in the isolation of life forms not only allow organisms to master new food resources, avoid adverse abiotic influences, and occupy an ecological space free of enemies and competitors, but also lead to a more complex structure of biogeocenoses and the biosphere as a whole.

The ecological importance of insects is reflected in the structure of their life forms. Thus, a life form is a complex of biological, physiological and morphological properties of a species that determine a certain reaction to the environment. Externally, a life form is characterized by general features of adaptation to the specifics of the habitat, similarity of basic morphological and behavioral features.

Terrestrial inhabitants have the following categories of life forms.

Geobionts - inhabitants of the soil, which are divided into:

- rhizobionts – animals associated with roots;
- saprobionts – inhabitants of decomposing organic matter;
- coprobiotics – invertebrates, inhabitants of manure;
- botrobionts – inhabitants of burrows;
- planophiles – animals characterized by frequent movement.

Epigeobionts are invertebrates that live in more or less open areas of the soil surface. In turn, depending on the soil on which the animals live, they are divided into:

- psammobionts – animals adapted to living on sandy substrates;
- petrobionts – inhabitants of rocky areas;
- halobionts – inhabitants of saline soil areas.

Herpetobionts are invertebrate animals that inhabit plant and other organic residues on the soil surface.

Forest floor inhabitants are usually called stratobionts.

Chortobionts are inhabitants of the grass cover. Depending on their habitat, they are divided into:

- ectobionts – animals that live on the surface of plants;
- endobionts – inhabitants of the thickness of leaves, stems, buds, galls.

Tamnobionts are inhabitants of shrubs.

Dendrobionts are inhabitants of trees. Tamno- and dendrobionts are often combined into one life form called dendrobionts.

Xylobionts are inhabitants of dead wood.

Living organisms exist in a relatively small layer of the Earth's surface shell called the biosphere. The biosphere includes part of the atmosphere, the hydrosphere, and the upper part of the lithosphere. Each part of the biosphere has different species of animals due to its specific environmental conditions.

The animal kingdom is divided into several types, which in turn are divided into classes, classes into orders, orders into families, families into genera, and genera into species.

The name of an animal species consists of two words – the so-called binary nomenclature. The first word is also the name of the genus. The second word, the species epithet, refers to a specific representative of the genus.

Each species also has an international Latin name consisting of two words. The foundations of modern taxonomy were proposed by Carl Linnaeus.

Modern species diversity is represented by about three million species, of which two million are animals, which are grouped into 35 major classification groups, or types. The most numerous of these are the protozoa, or unicellular (currently, there are 5 to 7 types) – over 30 thousand, sponges – 5, intestinal ciliates – 9, flatworms, primary ciliates, and ringworms – over 40, molluscs – 130 thousand, arthropods – over 1.6 million (including about 1 million insects, or 70% of the total number of known animals), and chordates – over 40 thousand.

1.5 Nutrition and ecological niches of entomological biodiversity

1.5.1 Insect adaptations to humidity and precipitation

The body of insects, like all living organisms, contains a large amount of water, which serves as a solvent for digestion, circulation of nutrients and excretion of excrement, and regulation of osmotic pressure. Water is also needed to regulate heat exchange. The percentage of water in the body of insects ranges from 46–48% (in the adult of the collar weevil (*Calandra granaria* L.) to 90–92% (in the caterpillars of *Telea polyphemus* Cram.), to the total body weight.

Under conditions of moisture deficit entering the insect body from the outside, the use of metabolic water formed as a result of oxidation of fats and some other substances is important for ensuring water exchange with the environment in some insects. Water ingested with food is retained in the insect's body the more it is deficient in the insect's body. In insects where the percentage of water is 80–92% of body weight and which feed on moist food, only 3–9% of water is bound by colloids.

The behavior and mobility of insects are largely determined by environmental humidity and precipitation. Hygrotaxis forces insects living on the soil surface to move to places with more favorable humidity.

Air humidity in burrows is always higher than on the soil surface. According to Shelford's research, the larvae of the horse beetle (Cicindelidae) in dry areas dig deeper burrows than in places with higher humidity. In desert and semi-desert areas, rodent burrows have a fairly rich insect fauna. The red forest ant (*Formica rufa* L.) adapts to the amount of precipitation by building anthills of different heights.

Precipitation and humidity affect mortality rates, fecundity, ontogeny of insects, their mobility, distribution in habitats, community formation, and geographical distribution. Heavy rains often kill a very large number of insects. Winter precipitation in the form of rain, as a rule, in cold and temperate climates, increases the mortality of many insects. On the contrary, precipitation in the form of snow increases the survival rate of many insect species.

Air humidity and precipitation significantly affect the development of fungal and bacterial diseases of insects, which has an indirect effect on the number of the latter. For many insects, the effect of environmental humidity on fertility is known. In *Psophus stridulus* L. and some other species of *Siberian locusts*, environmental humidity increases fertility. The bean beetle (*Acanthoscelides obtectus* Say.) does not reproduce at all at relative humidity below 26%.

For each phase of each insect species, there is a more or less specific optimum humidity of the environment, which largely depends on the percentage of water in their body, which ensures the best metabolic conditions. If the water content in the insect's body is higher than the optimum under certain conditions, dry air, by increasing evaporation, promotes insect viability, while moist air, on the contrary, inhibits it.

The effect of humidity on insects is closely related to other factors, especially temperature. Thus, when the temperature deviates from the optimal one for a given species and a given phase of insect development, humidity usually has a negative effect. Many small flat-bodied insects, such as the flea *Xenopsylla cheopsis* Rothsch. or the adult bug *Oxycarenus hyalinipennis* Costa. hardly react to changes in humidity at high temperatures, while large insects react more sharply.

1.5.2 Adaptations of insects to abiotic environmental factors

It is known that all environmental factors act on insects in combination. For example, the evening flight of the marbled beetle begins at a certain temperature. The poplar glass beetle (*Sesia apiformis* Cler.) is distributed in poplar plantations at different times of the day at different distances from the outskirts, according to the intensity of tree illumination.

In addition, it was found that the temperature preferred by the insect in the light and in the dark can differ by several degrees. Thus, in the caterpillars of the Chinese oak silkworm, catalase activity is higher during short daylight hours, while cytochrome oxidase activity, like succinic acidase, on the contrary, increases during long daylight hours.

In addition to different daily activity, many insects with a complete transformation have a strictly defined time of hatching from pupae, which is also largely due to lighting conditions.

Light can affect fertility, development of sexual products, fertilization of eggs and oviposition of insects.

The photoperiodic reaction of insects is manifested even in very low light of 1–3 lux. The range of temperatures at which the effect of daylight hours on insect diapause is manifested varies from species to species. Light conditions play a greater role the wider this range is.

In addition to affecting the range, the length of daylight hours can affect the speed of larval development, the color and body size of some insect species, and the migration of many aphid species.

Wind plays a significant role in the life of insects. There are numerous data in the literature on the impact of wind on insect dispersal. A massive arrival of *Brachycauda helichrysi* Kltnb. and several other aphid species within one day from a distance of 20 km from the mainland to the island of Memmert in the North Sea, where these aphids were completely absent the day before, was observed. Strong winds can carry not only small and light insects, but also large and heavy ones over long distances.

Wind in many cases determines the direction of insect flight. Some insects are characterized by positive anemotaxis (i.e., they often fly upwind), while others are characterized by negative anemotaxis (they fly in the direction of the wind). The plum weevil (*Contrachelus nenupar* Hbst.) flies upwind, while the meadow butterfly (*Loxostege sticticalis* L.) flies downwind; the desert locust (*Schistocerca gregaria* Forsk.) makes long-distance migrations in the direction of monsoon winds.

1.6 Main drivers of biodiversity threats and changes (direct and indirect)

Threats to biodiversity are related to habitat degradation. Natural ecosystems have been preserved on at most 25% of Ukraine's territory, but their transformation continues. An unbalanced land use structure, excessive plowing, and low forest cover are also factors of vulnerability to climate change. The steppes, which in the historical past occupied about 40% of Ukraine's land area, are now left on 3% of their original distribution and are divided into 10,000 plots. They are being affected by climate change: alkalization in the north and desertification in the south. Despite the preservation of the total area of forests in Ukraine, degradation of natural forest habitats continues. The area of clear-cut deforestation is growing, reaching a maximum in 2016. Reforestation in clearcuts cannot compensate for habitat degradation and destruction, as clearcuts occur, among other things, in areas of particular biodiversity value (virgin forests and other old-growth forests).

The canyons of the Dniester and Southern Bug rivers, which are the centers of endemism, are threatened by flooding due to new hydropower plants. Biodiversity is also threatened by the development of small hydropower in the Carpathians, where there are rivers with the best water quality, the lowest anthropogenic pressure, and, accordingly, a high level of biodiversity. The coastal ecosystems of the Black and Azov Seas are vulnerable due to construction in the coastal zone and high recreational pressure. Climate change is a risk factor for biodiversity, as it leads to a shift in natural zones, frequent natural disasters, and the spread of invasive species and infections new to the region. In the Black and Azov Seas, there has been a significant impact of invasive species that have entered the region with tanker ballast water: the invasion of the ribworm (Mnemiopsis leidy) has led to a decline in the number of pelagic fish, and the invasion of rapana has worsened the condition of benthic ecosystems. Poaching, largely driven by socio-economic circumstances, is responsible for the decline of both commercial species and some rare species, in particular as a result of accidental deaths in fishing gear. Measures aimed at strengthening the implementation of the Convention. Implementation of the NBSAP

Ukraine presented the Law of Ukraine "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period up to 2020" adopted in 2010 as an officially approved National Biodiversity Strategy. The Law contains "Section 3. Strategic goals and objectives" and defines seven national goals that directly or indirectly cover all biodiversity targets: each of the Ukrainian goals is linked to several targets (and vice versa). To implement the Strategy, the National Environmental Protection Plan was approved in 2011, which included measures, including financial ones. This plan expired in 2015. In the same year, the National Program for the Formation of the National Ecological Network of Ukraine was completed.

Currently, the implementation of the Strategy is directly linked to the Annual National Programs under the auspices of the NATO-Ukraine Commission, as well as a number of bylaws. However, the implementation of the NBS is indirectly supported by the existing legislation of Ukraine and the development and adoption of a number of national regulatory documents important for biodiversity conservation and achievement of the 120 targets.

Among them: The Laws of Ukraine "On Environmental Impact Assessment" (2017), "On Strategic Environmental Assessment" (2018), "National Action Plan to Combat Land Degradation and Desertification" (2016), "National Waste Management Strategy in Ukraine until 2030" (2017), "Concepts for the Implementation of State Policy in the Field of Climate Change for the Period up to 2030" (2016), "Sanitary Rules in the Forests of Ukraine" (2016), State Strategy for Regional Development of Ukraine until 2020 (2014), etc. Implementation of EU directives is important. Actions to achieve the 2020 biodiversity targets. As of January 1, 2018, the area of the nature reserve fund of Ukraine amounted to 43.9 thousand km^2, of which 15.2 thousand km^2 belong to IUCN categories 1 and 2. Today, legally protected areas of the nature reserve fund cover 6.6% of Ukraine's land area and 4,025 km^2 in the exclusive economic zone in the Black Sea. In total, there are 663 territories and objects of the nature reserve fund (NRF) of national importance and 7633 territories and objects of local importance in Ukraine. Of these, the most important are nature reserves (5.2% of the total area of protected areas), biosphere reserves (12%), and national nature parks (32.9%). In 2017. The Standing Committee of the Bern Convention approved 271 Emerald Network sites (all of which correspond to the IUCN protected areas classification) with a total area of 10% of Ukraine's territory, including all wetlands of international importance (39 sites). Experts of Ukrainian non-governmental organizations continue to work on supplementing the list of the Emerald Network (currently about 150 additional territories). A draft law "On the Emerald Network Territories" has been developed, prepared by experts from NGOs and the Ministry of Ecology and Natural Resources of Ukraine. It is important that these areas include most of the natural ecosystems of the northern Black Sea region, which is an important area for migration and wintering of wading, waterfowl and birds of prey from central and northern Europe. In total, the area of protected areas and the Emerald Network within Ukraine covers about 12% of the country's territory. In 2013–2017, 268 protected areas with a total area of 3342 km^2 (8.4% of the total protected areas as of January 1, 2018) were created in Ukraine. The Chornobyl Radiation and Ecological Biosphere Reserve with an area of 2,270 km^2 was declared within the zone affected by radioactive contamination as a result of the Chornobyl disaster (at the same time, the arch of the new safe confinement over Chornobyl NPP Unit 4 was installed). The Nizhnedniprovsky National Nature Park (with an area of over 800 km^2) was also created. New Ukrainian sites in the national nature parks Synevyr, Zacharovanyi Krai and Podilski Tovtry, and the nature reserves Gorgany and Roztochia were included in the UNESCO World Heritage Site "Primeval Beech Forests and Ancient Forests of the Carpathians and Other Regions of Europe". The network of Important Bird Areas in Ukraine currently consists of 166 separate areas with a total area of 25,000 km^2 (including those designated in 2018). In the reporting period, 12 new locations of key underground bat habitats were identified, the database of which (List of internationally important underground sites) is being filled in pursuance of the EUROBATS Agreement (currently the list includes 47 sites). In addition, under the Convention on Biological Diversity, 5 ecologically or biologically important areas (EBSAs) in the Black Sea have been designated in Ukrainian waters, one of which is primarily for cetaceans. Measures to identify and protect virgin and old-growth forests are ongoing. Ukraine has significantly increased the area of forests certified by the Forest Stewardship Council (FSC). According to FSC standards, 39% of forests are certified (most of them in recent years), and the share of protected areas in forests is 16.3%. A black stork monitoring program is in place. Winter and August waterfowl censuses are conducted in the Azov-Black Sea region of Ukraine, as well as assessments of bat, cetacean and sturgeon populations. The biota of the open part of the Black Sea was assessed. In 2018. The Ministry of Ecology and Natural Resources of Ukraine supported research to summarize the available data on species of the Red Data Book of Ukraine, as well as on plants, animals and habitats identified as priorities under the Bern Convention. The strategic task of preventing the destabilizing impact of fishing in the Dnipro River basin, one of the largest river basins in Europe, is being implemented. Measures are being taken to conserve and restore sterlet in the Dniester basin. The activity of the expert community allowed us to summarize scientific data on the state of populations of 121 commercial fish species and some invertebrates in the Black Sea. Two botanical reserves of national importance are in place to protect the Black Sea coastal area. Collections of rare species of wild plants and fungi have been created and maintained in a number of arboretums and botanical gardens. The National Genetic Bank of Plants of Ukraine operates, which includes repositories and field collections and includes 149 thousand samples belonging to 440 crops and 1770 plant species. The Bank of Animal Genetic Resources stores sperm samples (160 thousand samples), embryos, eggs, and somatic cell samples. Ukraine has entered data on 239 breeds into the European Farm Animal Biodiversity Information System. An inter-sectoral coordination center, a working group and a partnership network for the development of education for sustainable development have been established. Regional environmental passports were introduced. The creation of environmental education centers is mainly related to the objects of the nature reserve fund. Mechanisms to support national implementation (e.g. legislation, financing, capacity building, coordination, focusing. Ukraine has an extensive system of national environmental legislation, including in the field of biodiversity. In addition, Ukraine is a party to international treaties such as CITES, the Berne and Bonn Conventions, AEWA, EUROBATS, ACCOBAMS, the Ramsar Convention, the Espoo Convention, the UN Convention to Combat Desertification, the UN Framework Convention on Climate Change, etc. Ukraine participates in the development and adoption of resolutions and decisions of conferences of the parties to international treaties. A significant number of species protected by these agreements have also been included in the Red Data Book of Ukraine, which has strengthened their protection in the country. In 2013–2017, the main legal act with a direct reference to the Convention on Biological Diversity was the Association Agreement between Ukraine and the European Union, which entered into force on September 1, 2017 and paved the way for the implementation of European legislation on biodiversity protection in Ukraine and the expansion of the European legal space in Eastern Europe. It is the basis for all new legislation, which is complementary to the European one and takes into account modern environmental principles, including biodiversity conservation. The State Water Cadastre was created to record surface water bodies. The list of Emerald Network sites, the basis for biodiversity protection areas, was approved. Significant progress has been made in implementing environmental impact assessment procedures. The relevant law "On Environmental Impact Assessment" was adopted, enacted and supported by a number of regulatory acts. Under this law, mandatory public discussions of business projects that may have a significant impact on the environment are held on a regular basis, the number of which has reached 2,000. In 2013–2018, amendments were made to the Laws of Ukraine "On Fauna", "On Flora", "On the Red Book of Ukraine", "On Hunting and Fishing", etc.: in particular, uncontrolled burning of dry vegetation, use of a number of fishing gear in hunting and fishing, plowing of wildlife habitats are prohibited; a "silence season" was introduced in the farming sector. The use of the pesticide zinc phosphide was banned. The protected status was granted to elk. During the reporting period, there was a gradual increase in expenditures under the budget program on ecology and natural resources. The number of budget programs for environmental protection expenditures in the reporting period shows an upward trend, and the number of individual budget programs directly related to the protection and study of biodiversity has increased.

The State Fund for Environmental Protection of Ukraine is in place. However, the allocated resources are not enough to achieve certain goals and objectives. Ukraine is a recipient country for grant assistance and credit support from donor countries to mobilize financial resources. According to available data, the amount of financial assistance from international donors in the form of grant revenues in 2013–2016 ranged from USD 5–23 million in different years. Programs for the development of environmental laws and strengthening the institutional capacity of stakeholders are ongoing with the help of grants and loans from various sources, including the European Commission, UNDP GEF, and individual partner countries. The efforts of stakeholders and the public sector have resulted in a huge array of environmental initiatives, but the adoption and approval of relevant regulations and their implementation are slow and complicated. Species assessment and monitoring programs are largely funded by international grants and carried out on a voluntary basis. Ukraine has a strong expert and institutional scientific base for biodiversity research. Scientists are actively involved in the collection, accumulation and dissemination of biodiversity knowledge, are involved in expert and public councils under government authorities, and participate in assessments of the status of IUCN Red List species, international scientific and environmental projects on biodiversity. The results of scientific research are made public in the form of scientific publications. The National Commission on the Red Data Book of Ukraine operates. Since 2017, the public Internet portal Data Center "Biodiversity of

Ukraine" has been operating; the only open network for the accumulation and exchange of biodiversity data UkrBIN (Ukrainian Biodiversity Information Network) has been created. UkrBIN actively interacts with the public, disseminates knowledge on biodiversity, and engages society in observations of alien and invasive species. UkrBIN taxonomic data are part of the Catalogue of Life, and observations of alien and invasive species are transmitted to the European Alien Species Information Network (EASIN). The UkrBIN team plans to integrate Ukraine's biodiversity data into the Global Biodiversity Information Facility (GBIF). Mechanisms for monitoring and reviewing implementation Monitoring of most implementation tasks is partial. The Cabinet of Ministers of Ukraine and a number of non-governmental organizations monitor the legislative reform, in particular, its approximation to EU norms. State supervision (control) over the implementation of environmental legislation is carried out by the State Environmental Inspectorate of Ukraine. Forestry monitoring is partially carried out by the FSC office in Ukraine. In 2018, the Procedure for State Water Monitoring was approved. The fisheries monitoring system covers the Dnipro reservoirs. Environmental pollution is monitored by the National Hydrometeorological Service of Ukraine. Monitoring of species and habitats is limited to individual initiatives. The weakness of monitoring mechanisms is one of the main obstacles to an objective assessment of the progress of actions in all areas related to biodiversity conservation.

1.6.1 Reduction in the number of species

Changes in the environment and an increase in anthropogenic pressure have led to the extinction of many species of fauna. These species include the mammoth, woolly rhinoceros, giant deer, and the giant moa bird.

In 1627, the last rook was killed near Warsaw, in 1681 on the island of Mauritius, in 1768 a sea cow was killed, and in 1899 the last wandering pigeon was killed in the United States. The longest-lived wild horse in Ukraine was the tarpan, which lived until 1918 at a stud farm in the village of Dubravka near Myrhorod in Poltava Oblast (Fig. 2).

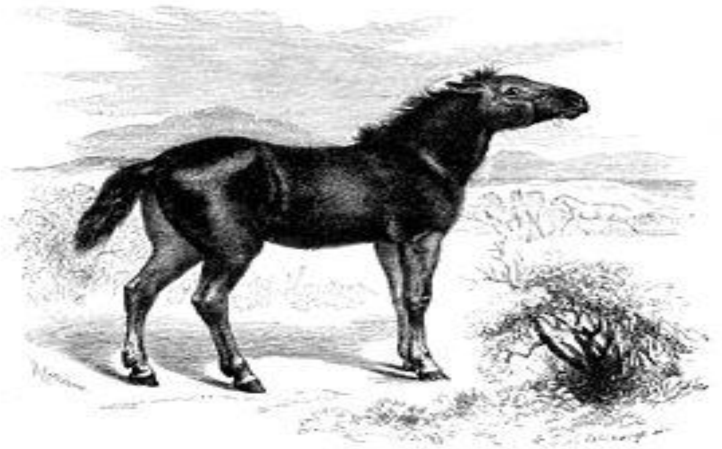


Fig. 2 **Wild horse or tarpan (*Equus ferus ferus* Boddaert, 1785)**

Intensive fishing causes great damage to the numbers of many species. The gray whale, white belly seal, Cape zebra and others have almost disappeared. Poaching also causes great damage. It is the main reason for the sharp decline in the number of elephants, rhinos, tigers, lions, antelopes, monkeys, saigas, etc.

In Ukraine, there is illegal hunting of elk, roe deer, deer, wild pigs, muskrats, grouse, birds of prey, etc.

However, the biggest threat to animals is the deterioration of environmental conditions due to deforestation, draining of swamps, construction of dams and reservoirs, construction of factories, development of the chemical industry, laying of power lines, roads, stubble burning, air and water pollution, etc. The research conducted by a group of scientists on the current state of entomological biodiversity in the agricultural landscapes of the Forest-Steppe of Ukraine showed rather negative results (Annexes 1–4). The analysis of the structure of entomological biodiversity showed that the number of entomofauna decreased from 1604 species to 780 species. The impoverishment is 824 species (51.3%) (see Annexes 1–4).

The data obtained indicate that 50% of insect species of agricultural landscapes, which in the past had the status of constant and dominant, have become scarce due to unfavorable environmental factors, which is the first step towards their actual extinction. Under the influence of climate change and anthropogenic pressure on the environment, the entomofauna of the Forest-Steppe agrolandscapes is undergoing significant changes. Against the background of the restructuring of the taxonomic structure of the entomocomplex, its species biodiversity has significantly decreased.

Many birds die as a result of collisions with power lines (almost 50% of white storks die in Ukraine). Globally, 600 species of birds, 120 species of mammals and other animals are threatened with extinction.

The fauna of Ukraine is characterized by great diversity, with an estimated 44,800 species. In Ukraine, 382 species of animals (listed in the Red Data Book of Ukraine) are threatened with extinction, the main ones being:

- ✓ **Hydroid polyps** (jellyfish) – (2 species). These are *Olyndas unexpected* and *Terezia azovii*, which are occasionally found on the coasts of the Black and Azov Seas; Roundworms (2 species) – *Axonolight castle*, *Chrotadorina bicornis* in the Dnipro-Bug estuary;
- ✓ **Ringworms** (7 species) – *Medical leech* (all over Ukraine), Gogolev's worm (Alma Crimea) and others;
- ✓ **Crustaceans** (26 species) – Branhinecta (3 species), Rylov's hemidiaptom, 3 species of tisila, broad-toed crayfish, stone crab, marble crab, etc;
- ✓ **Arachnids** (2 species) – *Crimean scorpion*, *Common solputa* (southern coast of Crimea);
- ✓ **Millipedes** (3 species) – Ukrainian mountain millipede, Semenkevich's, common flytrap;
- ✓ **leptolith Insects** (173 species) – emperor sentinel (Fig. 3), fragrant beauty, sacred scarab, hermit beetle, deer beetle, mahogany (Fig. 4), Polixena, Apollo, reddish bumblebee, etc;
- ✓ **Mollusks** (12 species) – edible oyster, mace-like pond sculpin, grain granaria, etc;
- ✓ **Roundworms** (2 species) – *Hungarian lamprey* (Tisza, Uzh, Latorytsia river basins), Ukrainian lamprey (Dnipro, Siverskyi Donets, Dniester river basins);

Fig. 3 **Emperor's watchman (*Anax imperator* Leach, 1815)**

Fig. 4 **Machaon killer whale (*Papilio machaon* Linnaeus, 1758)**

- ✓ **Fish** (32 species) – thornyhead (Black Sea coast), sterlet (Danube, Dniester, etc.), Black Sea salmon (Crimean peninsula), brown and gray gudgeon, sea devil, etc;
- ✓ **Amphibians** (5 species) – frog (Zakarpattia), reed frog (Volyn and Small Polissia), spotted salamander (Carpathians), Carpathian and mountain newts (Carpathians);
- ✓ **Reptiles** (8 species) – copperhead (Fig. 5) (all over Ukraine), eastern steppe viper (steppe), yellow-bellied, leopard (Fig. 6), forest, four-banded, Crimean gecko, yellow-bellied;

Fig. 5 **Common copperhead (*Coronella austriaca* Laurenti, 1768)**
Fig. 6 **Leopard's skid (*Zamenis situla* Linnaeus, 1758)**

✓ **Birds** (67 species) – pink (Fig. 7) and *Dalmatian pelicans*, lesser cormorant, yellow heron, black stork, egret, red-breasted vulture, golden eagle, white-tailed eagle, wood grouse (Fig. 8), gray crane, and owl;

Fig. 7 **Pink pelican (*Pelecanus onocrotalus* Linnaeus, 1758)**

Fig. 8 **Grouse (*Tetrao urogallus* Linnaeus, 1758)**

✓ **Mammals** (41 species) – eared hedgehog, lesser corneas (Fig. 9), white hare, azovka, ermine, steppe ferret, badger, river otter, forest cat, lynx, bison.

Fig. 9 **Lesser cutthroat trout (*Neomys anomalus* Cabrera, 1907)**
Fig. 10 **Bison (*Bison bonasus* Linnaeus, 1758)**

Ukraine has species of animals listed in the European Red List of Threatened Animals and Plants (1991): wolf, brown bear, bison (Fig. 10), lynx and others.

Vertebrate species that have disappeared on the territory of Ukraine in historical times (Black List):

- Steppe eagle (*Aquila rapax* Temminck, 1828). In the last century, it was found throughout the steppe zone. In the 60s and 80s of the XX century (until 1982), it nested only in the Askania Nova Biosphere Reserve. Now it is not found there either.
- Vulture (*Neophron percnopterus* Linnaeus, 1758). It nested in the Dniester valley and in Crimea. On the Dniester, it disappeared in the 30s–50s of the 20th century, and in the Crimea it was last observed nesting in 1958 (single pairs were observed until 1965). Now it is possible to see vultures from neighboring territories.White partridge (*Lagopus lagopus* Linnaeus, 1758). In the XVIII–XIX centuries. met in Polissia and Forest Steppe to their western borders. Until 1950, it was observed in the Glukhiv district of the Sumy region. Nowadays, the nearest nesting places of the white partridge are located on the territory of Belarus.The slender-billed kestrel (*Numenius tenuirostris* Vieillot, 1817). It disappeared from the territory of Ukraine after 1900. Now it is a rare migratory and passage bird.
- Monk seal (*Monachus monachus* Hermann, 1779). It was found in the Black Sea at Cape Tarkhankut, Zmeinyi Island (1940) and in the Danube Delta (until 1950). The species is almost extinct on Earth.
- Kulan (Asinus hemionus hemionus Pallas, 1775). Bone remains of this species of the XII-XIII centuries were found near Kyiv. Now the kulan is preserved in the south of Turkmenistan.
- Saiga (*Saiga tatarica* Linnaeus, 1766). It was found in the Steppe and Forest-Steppe in the interfluve of the Southern Bug, Dnipro, and Don rivers. It disappeared at the beginning of the XIX century. In the former USSR, it was preserved in Kazakhstan and Kalyashkia.
- Sable (*Martes zilellina* Linnaeus, 1758). In the times of Kievan Rus, it was a game animal. In the 18th century it was found in the Mogilev province. Now it is distributed mainly in the taiga of Siberia. In the middle of the

eighteenth century, it was hunted in Polissia near the town of Smotrych, and in 1880 – in the Kaniv district.

- Lesser pika (*Ochotona pusilla* Pallas, 1769). At the end of the XVIII century it lived in the Steppe between the Dniester and Bug rivers. Now it is found in the Volga steppes and Kazakhstan.

1.7 Adaptive mechanisms of biodiversity

Animals have evolved to adapt to the environmental conditions of their habitat. If the external conditions remain relatively constant for a long time, the vital activity of the animal organism stabilizes at a level adapted to this typical state of the environment. If the environmental conditions deviate from the average conditions, then functional adaptations come into play in animals, which are labile and responsible for the deviations and are aimed at ensuring maximum efficiency of the organism's functioning within this stable state.

The adaptive mechanisms of biodiversity that help it to adapt to changed environmental conditions are divided into two groups:

1) mechanisms that ensure the adaptive nature of the overall level of stabilization of individual functional systems and the organism as a whole in relation to the most general and stable environmental parameters;

2) labile reactions that maintain the relative constancy of the overall level of stability by including adaptive functional reactions when specific environmental conditions deviate from the average characteristic.

These two levels of adaptation work together, and their interaction leads to the sustainable existence of a species in a complex and dynamic environment. This concept is known in science as the rule of two levels of adaptation and is of general biological importance, as it specifically describes the patterns of the adaptive process at different levels of living organization, from the functioning of suborganizational systems to biocenoses inclusive.

The most general form of the considered scheme of aromorphoses of adaptation pathways to the processes of evolutionary transformation of large taxa is the concept of aromorphoses and idioadaptations.

Aromorphosis is a significant morphophysiological progressive change in organisms that leads to a complication of their structure, an increase in the overall level of organization and adaptability to new conditions of existence in the course of the evolutionary process. Aromorphosis provides range expansion and qualitatively new opportunities for habitat development, the concept of aromorphosis. Examples of aromorphosis include the emergence of chloroplasts, the vascular system, the development of warm-bloodedness in birds and mammals, and a qualitative leap in the transition from reptilian ancestors to mammals.

Idioadaptation – individual adaptive changes that are useful in certain environmental conditions; occur without increasing the overall level of organization. In animals, an example of idioadaptation is protective coloration, which is an adaptation that is not associated with an increase in organization.

Adaptations to environmental factors based on structural features of the organism are called morphological. Adaptations based on specific forms of functional response to external influences are called physiological. In higher animals, the higher nervous system plays a significant role in adaptation, on the basis of which adaptive forms of behavior – ethological adaptations – are formed.

When studying adaptation at the level of an animal organism, physiological methods are widely used in ecology. Physiological indicators are a criterion for the organism's response to external conditions, and physiological processes are considered primarily as a mechanism that ensures the sustainable implementation of the fundamental functions of the organism in a complex and dynamic environment.

Water as a living environment for aquatic organisms. Water plays a huge role in the life of animals. Animals that live in water are called aquatic animals. They are divided into two main groups: marine and freshwater:

According to their habitat, aquatic animals are divided into:

1) planktonic – live in the water column and move passively;

2) nektonic – live in the water column and actively move around;

3) benthic – live on or in the soil;

4) Pleistocene – associated with the surface water film.

Animals can be classified according to their origin and type of respiration:

1. primordial animals – evolved from aquatic ancestors and breathe with gills. Many invertebrate fish belong to this group;

2. Secondary amphibians – evolved from aquatic animals, adapted to a terrestrial lifestyle, but in the course of evolution again switched to an aquatic lifestyle, the way of breathing is pulmonary.

This group includes mammals such as pinnipeds (killer whales, walruses, eared seals, etc.) whales, dugong sirens, manatees); reptiles – turtles and snakes, insects – some beetles, cnidarians – some lungfish, and others.

Deep-sea animals are inhabitants of sea depths from 500 to 10,000 meters and more. There are different types of fauna:

- bathyal – up to 2 thousand meters;
- abyssal – at a depth of 2–3 thousand meters;
- ultra-abyssal, or walking, below 3 thousand meters.

The deep sea animals are dominated by needlefish, crustaceans and fish. However, ten-legged crayfish disappear at a depth of 5 thousand meters; sponges, ophiuchus and starfish – at a depth of 7 thousand meters; corals, barnacles and equipeds – at a depth of 8–9 thousand meters; at a depth of 10 thousand meters, several species of polychaetes, echiurites, holothurians and pogonophores are found. A characteristic feature of deep-sea animals is their adaptation to life in low temperatures.

Deep-sea animals have a special appearance. Most of them are almost black or purple, red or blue in color, some animals lack pigment. Eyes are either absent or highly developed, with a telescopic structure. Many deep-sea animals have light organs. Most of them do not have limestone skeletons or they have very thin skeletons. Special adaptations (a system of water-filled lacunae, long limbs, flattened bodies, elongated rays and stems, etc.) prevent deep-sea animals from sinking into soft soil. There are many predators among deep-sea animals.

Limnophilic animals are animals that have adapted to life in stagnant waters, with a lack of oxygen, temperature changes, etc.

Among limnophilic animals are distinguished:

1. limnobenthos – living on the bottom (mollusks, insects, small bristlecone);

2. limnoplankton – live in the water column – species of branchiopods and paddle-footed crustaceans, rotifers and protozoa;

3. nekton – actively moving in all zones of the reservoir – certain species of fish.

Rheophilic animals (pheophiles, reobionts) are animals that live in flowing waters. Most of them have adapted to passively staying in a strong current (they have special attachment organs, bury themselves in the soil), or they swim well and can move against the current. Rheophilic animals include sponges, bryozoans, larvae of some insects, many species of mollusks, crustaceans, and other animals.

Aquatic environment factors shape the living conditions of aquatic organisms, their conditions of fixation and movement in space. They determine the swimming conditions of pegahygous organisms (organisms that live in the water column: most fish and jellyfish), their ability to stay suspended in the water column.

Benthic organisms can bury themselves in silt, become fixed in it, and move around. Water movement helps to move organisms, remove metabolites, transfer sexual products, and equalize various gradients – temperature, salinity, gas content, etc. The density and viscosity of water determine the conditions for the movement of aquatic organisms. The higher the water density, the easier it is for organisms to stay in it. With depth, the pressure on organisms increases, which is expressed in hundreds of atmospheres. At lower viscosity, organisms can swim faster. As the temperature rises, the viscosity of water decreases, and as the salinity increases, it slightly increases.

Plankton is retained in the water column by special devices, such as siphonophore bells, pyrosome floats, air vacuoles in the cytoplasm of radiolarians, and many others. Reducing the specific body weight is achieved by reducing the size of these organisms or by the disappearance of calcareous formations (shells in cnidarians and naked gill shells in planktonic crustaceans); by increasing fat bubbles in the protoplasm even in such a large animal as the moonfish; by high water content in tissues (more than 95% in jellyfish). Increased bearing surface also contributes to buoyancy. This is achieved by the presence of lateral leg outgrowths in winged mollusks, umbrellas in jellyfish, and leaf-like parapodia in some polychaetes.

Fish have acquired relative weightlessness in water by equalizing their body densities with their environment. The buoyancy index (the ratio of the fish's body density to the water density) is zero in many sharks, sturgeons, and many other nektonic fish. In some inhabitants, it becomes negative, which allows them to stay on the bottom without expending muscle effort. This coefficient reaches 0.06 in flounder, 0.07 in stingrays, and even 0.12 in some deep-sea fish.

Organisms that can exist in a wide range of temperatures are called eurythermal, and in a narrow range – stenothermal. For example, corals live in the range of 20–30 ^{o}C.

Thus, the study of life forms is of great importance for solving a number of theoretical and practical issues related to the conservation of species biodiversity, in particular, the peculiarities of environmental impact and directions of adaptive changes in organisms during introduction and acclimatization.

SECTION 2. THREATS TO BIOLOGICAL DIVERSITY

A healthy environment has enormous economic, aesthetic and ethical value. Maintaining environmental health means keeping all its components in good condition: ecosystems, communities, species and genetic diversity. Initial small disturbances in each of these components can eventually lead to its complete destruction. In this case, communities degrade and shrink spatially, lose their importance in the ecosystem and eventually collapse completely, but as long as all the original species of the community are preserved, it can still recover. When the number of species decreases, intraspecific variability decreases, which can lead to genetic changes from which the species will not be able to recover. Potentially, after timely and successful rescue efforts, the species can restore its genetic variability through mutations, natural selection and recombination. But in the case of an endangered species, the uniqueness contained in its DNA, genetic information and combinations of traits it possesses are lost forever.

2.1 Rates of species extinction

The term "endangered" or "extinct" has many nuances and its meaning can vary depending on the context. A species is considered to be completely endangered (extinct) when there are no living individuals of that species anywhere in the world. If only a few individuals in captivity remain alive, or if they have somehow survived only under direct human control, then the species is said to have disappeared from natural ecosystems, for example, the Franklin tree has disappeared from nature but is growing well in nurseries. In both cases, the species is considered globally extinct. A species is considered locally extinct if it is no longer found throughout its original range, but is still found in some areas. In addition, ecologically endangered species are defined if the species remains at such a low number that its impact on other species in the community is very small.

The most fundamental question for conservation biology is how long can a given species survive before it becomes extinct, following extreme population decline, habitat degradation, or fragmentation? When a population declines to a certain critical level, the probability of extinction becomes very high. In some populations, the remaining individuals can survive for years or decades and even reproduce, but their fate is still extinction unless decisive measures are taken to preserve them. In particular, among woody vegetation, the last isolated nonreproductive specimens of a species can survive for hundreds of years. Such species are called potentially endangered: even if the species is not formally extinct yet, the population is no longer able to reproduce, and the future of the species is limited by its lifespan.

In the geological history of the Earth, species have constantly appeared and disappeared in the biosphere – all species have a finite lifespan. Extinction was compensated by the emergence of new species, and as a result, the total number of species in the biosphere increased. Species extinction is a natural process of evolution that occurs without human intervention.

The number of species that make up the current organic world represents only a tiny fraction of the total number of species that existed on our planet from ancient times to our era. More than 99% of all species that have ever appeared on earth have become extinct.

Species extinction is a gradual, natural or sudden evolutionary process characterized by slow reproduction and increased mortality. It leads to a reduction in the number and then to the complete disappearance of individuals of any systematic group of animals, including humans, as well as the disappearance of any taxon from the species level upwards, as a result of the indirect impact of humans and their economic activities, including the destruction of habitats. In the evolutionary sense, an extinct group is considered to be a group that has disappeared and left no descendants (even modified ones).

It has been shown that not all species have the same probability of extinction; certain categories of species are particularly susceptible to it and need careful protection and control:

Species with narrow ranges. Some species are found in only one or a few geographically limited areas, and if the entire range is exposed to human activity, these species may disappear. Numerous examples of this are the extinct species of birds that lived on oceanic islands. Many fish species that lived in a single lake or river basin have also disappeared;

Species formed by one or more populations. Any population of species can become locally extinct as a result of earthquakes, fires, disease outbreaks and human activity. Therefore, species with large populations are less susceptible to global extinction than species that are represented by only one or more populations;

Species with small population sizes, or the "small population paradigm". Small populations are more likely to become extinct than large populations because they are more susceptible to demographic and environmental changes, as well as loss of genetic diversity. Species characterized by small population sizes and highly specialized species are more likely to become extinct than those characterized by large populations;

Species in which the population size is gradually decreasing, the so-called "population decline paradigm". In normal cases, populations tend to be self-regenerating, so a population showing steady signs of decline is likely to disappear if the cause of the decline is not identified and addressed;

Species with low population density. Species with an overall low population density, if the integrity of their habitat has been disturbed by human activity, will be represented by low numbers in each fragment. The population size within each fragment may be too small for the species to survive. It begins to disappear within its entire range;

Species that require large ranges. Species in which individuals or social groups forage over large areas are susceptible to extinction if part of their range is destroyed or fragmented by human activity;

Large species. Compared to small animals, large animals usually have larger individual territories. They need more food and are more often hunted by humans.

Large carnivores are often exterminated because they compete with humans for game, sometimes attack pets and people, and are also the object of sport hunting. In each species guild, the largest species are the most likely to become extinct;

Species incapable of dispersal. In the natural course of natural processes, changes in the environment force species to physiologically adapt to new conditions, or to adapt by changing their behavior. Species that are unable to adapt to environmental changes must either migrate to more suitable habitats or face the threat of extinction. The rapid pace of human-induced change often outpaces adaptation, leaving migration as the only alternative. Species that are unable to cross roads, fields, and other human-altered habitats are doomed to extinction as their "native" habitats are transformed by pollution, invasive species, or global climate change. This low ability to disperse explains why 68% of mollusc species in North America are extinct or threatened with extinction, unlike dragonfly species, which can lay eggs by flying from one body of water to another, so the figure for them is 20%;

Species are seasonal migrants. Seasonally migratory species are associated with two or more habitats that are far from each other. If one of the habitats is disturbed, the species cannot exist. The survival and reproduction of billions of songbirds of 120 species that migrate between Canada and South America each year depends on the availability of suitable habitat in both areas. Roads, fences, or dams create barriers between essential habitats that some species need to complete their entire life cycle;

Species with low genetic diversity. Intrapopulation genetic diversity sometimes allows species to successfully adapt to a changing environment. When a new disease, a new predator, or other changes occur, species with low genetic diversity are more likely to become extinct;

Species with highly specialized ecological niche requirements. Some species are adapted only to unusual types of rare, scattered habitats. If the habitat is disturbed by humans, the probability of survival of such a species is catastrophically low.

Species with highly specialized food requirements are also at particular risk. A striking example of this is the species of ticks that feed only on the feathers of a certain species of bird. If the bird species goes extinct, the feather mite species goes extinct as well;

Species living in stable environments. Many species are adapted to environments whose parameters change very little. Often, such species are slow-growing, low-reproductive, and produce offspring only a few times in their lives. When the habitats of these species are rapidly altered by humans, they are unable to survive in the new conditions that arise: changes in microclimate (increased light, decreased humidity, temperature fluctuations), and competition with successional and invasive species.

Species that form permanent or temporary aggregations. Species that form aggregations in certain places are very susceptible to local extinction. For example, bats feed over a large area at night, but usually spend the day in a specific cave. Herds of bison, flocks of wandering pigeons, and schools of fish are aggregations that have been actively used by humans, up to the point of complete depletion of the species or even extinction, as happened with the wandering pigeon. Some species of social animals cannot exist when their population size falls below a certain level, as they can no longer forage, mate, or defend themselves.

Species hunted or collected by humans. A prerequisite for species extinction has always been their utilization. Overexploitation can rapidly reduce the population size of species of economic value to humans. If hunting or gathering is not regulated by law or local traditions, species may disappear.

Abiotic and biotic factors leading to species extinction are interrelated. The density of populations, forms of struggle for existence, the degree of competition between populations, and the immediate course of extinction depend in one way or another on the general geographical situation.

2.2 Main threats to biodiversity caused by anthropogenic activities

The main threats to biodiversity stemming from human activities are: habitat destruction, habitat fragmentation, habitat degradation (including pollution), global climate change, overexploitation of species by humans, invasion of exotic species, invasive species, and the growing spread of diseases.

Destruction of habitats. The main threat to biodiversity is habitat destruction, and therefore, the most important thing to preserve biodiversity is to protect it. Habitat loss is associated with both direct destruction and damage in the form of pollution and fragmentation. For most plants and animals on the verge of extinction, habitat loss is the primary threat. Other important factors include the negative impact of introduced species and overexploitation.

Many highly valuable wild species have lost most of their original range, and only a few of their remaining habitats are protected.

The plight of the tropical rainforest is probably the most widely known case of habitat destruction, but other habitats are also in grave danger. These include:

Wetlands and aquatic habitats. Wetlands are habitats for fish, aquatic invertebrates and birds. They regulate flood levels and serve as sources of drinking water and energy. Wetlands are often filled in, drained, or transformed by restricting the flow of water through artificial channels, dams, or chemical pollution;

Temperate prairies. Another type of ecosystem almost completely destroyed by human activity. It is enough to turn large areas of steppes into arable or pasture land;

Coral reefs. Tropical coral reefs occupy only 0.2% of the ocean area, but they are home to one third of all known species of ocean fish. Already, 10% of all coral reefs have been destroyed, and up to 50% may be destroyed in the coming decades;

Desertification. Many biological communities characteristic of areas with seasonally arid climates have been degraded by human activity to become artificial deserts, a process known as desertification. These communities include tropical and shrubby savannas, deciduous forests, and in temperate climates, shrub and herb communities in the Mediterranean, South Africa, and Chile. These areas were originally suitable for agriculture, but their intensive cultivation led to soil erosion and loss of the last water-holding capacity. Shrubs and trees were cut down and the land was trampled by cattle, sheep and goats. As a result, there is a progressive and largely irreversible degradation of the soil cover, which brings it to a point where the region looks like a desert;

Fragmentation of habitats. In addition to complete destruction, habitats that used to cover large areas are often crushed into small pieces by roads, fields, cities, and other structures. Habitat fragmentation is a process in which a continuous area of habitat is simultaneously reduced and broken up into two or more fragments. These fragments are often separated from each other by altered or degraded landforms. Fragmentation occurs with virtually any major reduction in habitat area, but it can also occur with relatively minor reductions, such as when original habitat is cut through by roads, railways, canals, power lines, fences, oil pipelines, fire trails, and other barriers that prevent species from moving freely.

Habitat fragmentation can also accelerate the disappearance of populations, as a widespread population splits into two or more isolated subpopulations. These small populations are subject to inbreeding and gene drift, which are characteristic of them. While a large area of habitat can normally support a single, coherent large population, often none of its fragments can support a subpopulation large enough to sustain itself for a long time;

Habitat fragmentation makes it inevitable that wild animals and plants will come into contact with domestic animals and plants. As a result, diseases of domestic animals spread rapidly among wild species that lack appropriate immunity. It should be borne in mind that such contact also ensures the transmission of diseases from wild plant and animal species to domesticated ones, and even to humans.

Even though the habitat has not been explicitly destroyed or fragmented, the communities that inhabit it can be profoundly affected by human activities. External factors that do not change the dominant vegetation structure of the community can nevertheless lead to disturbances in biological communities and ultimately to the extinction of species, although these disturbances are not immediately noticeable;

Habitat pollution. Environmental pollution is the most universal and insidious form of environmental destruction. It is most commonly caused by pesticides, fertilizers and chemicals, industrial and municipal wastewater, gas emissions from factories and cars, and sediments washed down from uplands. Visually, these types of pollution are often not very noticeable, even though they happen all around us every day in almost every part of the world. The global impact of pollution on water quality, air quality, and even the planet's climate is in the spotlight not only because of the threat to biodiversity, but also because of the impact on human health. Sometimes, however, environmental pollution is very visible and frightening, such as in the case of massive oil spills. Hidden forms of pollution are the most threatening, mainly because their effects are not immediately apparent.

Water pollution has negative consequences for human populations: foodstuffs such as fish and shellfish disappear, and drinking water is poisoned. More broadly, water pollution seriously disrupts aquatic communities.

Unlike land-based pollution, where waste is stored relatively locally, in aquatic environments, toxic substances are carried by currents over large areas. Thus, even very small concentrations of toxic substances can accumulate in aquatic organisms to lethal concentrations, as they filter large volumes of water while feeding. Birds and mammals that eat these animals are thus exposed to concentrated toxicants.

Even mineral elements necessary for plants and animals can become harmful pollutants in high concentrations. Wastewater, fertilizers for fields and lawns, detergents and industrial discharges supply water systems with so many nitrogen and phosphorus compounds that they cause a process called eutrophication. Small amounts of these substances stimulate the growth of plants and animals, and high concentrations often lead to abundant algal blooms. These accumulations of algae can be so dense that they crowd out other types of plankton and prevent light from reaching the plant species attached to the bottom. As the algae carpet becomes thicker, its lower parts sink to the bottom and die. The bacteria and fungi that decompose the dead algae actively multiply in response to the additional influx of algae and, consequently, absorb all the oxygen in the water. Due to the lack of oxygen, most animals begin to die, sometimes visible by the mass of dead fish floating on the surface. As a result, poor, simple communities are formed, composed only of species resistant to water pollution and low oxygen content. Large marine systems, especially their coastal areas and relatively enclosed waters, such as the Gulf of Mexico, the North and Baltic Seas in Europe, and the seas surrounding Japan, are also subject to eutrophication.

Acid rain lowers the pH of groundwater and water bodies such as ponds and lakes. Acids themselves are harmful to many species of plants and animals. As the acidity of water bodies increases, many fish stop spawning or die completely. In industrialized areas, many ponds and lakes have lost a significant portion of their animal communities due to acid rain.

Cars, power plants and various industrial facilities emit hydrocarbons and nitrogen oxides as waste. When exposed to sunlight, these compounds react in the atmosphere to form ozone and other secondary compounds collectively known as photochemical smog. While ozone in the upper atmosphere is necessary to trap harmful ultraviolet radiation, high concentrations in the lower atmosphere damage plant tissue, harm biological communities, and reduce crop productivity.

High-octane fuels, mining, metallurgy and other industrial production are accompanied by the release of large amounts of lead, zinc and other toxic metals into the atmosphere. Their compounds are toxic to plant and animal organisms. The impact of these toxic metals is especially noticeable around large metallurgical enterprises, where nature is destroyed for many kilometers around;

Climate change. Carbon dioxide (carbon dioxide), methane and other gases in the atmosphere are transparent to sunlight, they transmit light energy through the atmosphere, heating the Earth's surface. However, these gases, along with water vapor (visible as clouds), absorb energy radiated from the Earth's surface as heat, slowing the rate at which heat leaves the Earth and returns to space. These gases are called greenhouse gases because they act like glass in a greenhouse that lets in sunlight but traps energy inside the greenhouse after it has been converted to heat. The greater the concentration of these gases, the more heat is trapped around the Earth, and the higher the temperature on the planet. This phenomenon is called the greenhouse effect.

The current problem is that, as a result of human activity, the concentration of greenhouse gases has increased to such an extent that, according to scientists, it has begun to affect the Earth's climate. The term "global warming" is used to describe the greenhouse effect caused by human activity.

It is likely that many species will not be able to adapt quickly enough to these global anthropogenic changes, which are happening much faster than all previous natural climate changes.

In order to survive, humans have always hunted, gathered fruits, and used natural resources. As long as the population was small and their technology was primitive, people could use the environment sustainably, hunt and harvest without driving the necessary species to extinction. However, as the population grew, the pressure on the environment increased. Cultivation methods have become incomparably more extensive and efficient, and have led to the almost complete displacement of large mammals from many biological communities, resulting in surprisingly "empty" habitats. In the rainforests and savannas, hunting rifles have replaced bows, darts and arrows. In all the oceans of the world, powerful fishing motor vessels and fish processing "floating bases" are used for fishing.

The loss of biodiversity is one of the global problems of our time that cannot be postponed. Biodiversity is not only the basis of a significant part of natural resources that provide humans with food, various raw materials, medicines, etc., but it is also intrinsically valuable regardless of the material value determined by socioeconomic relations. This intrinsic value is inherent in the evolutionary history of life and the unique ecological functions performed by each species in the global ecosystem.

The greatest threat to biodiversity is primarily associated with the risk of extinction of rare species. The decline in biodiversity is due to a number of reasons. The most important of them are:

Habitat loss (Figure 11) is caused by the results of human intervention in the habitat on a global scale. Analysis of statistical data shows a significant impact of human activity on global ecosystems.

Intact areas: characterized by the largest amount of primary vegetation and very low population density.

Partially disturbed areas: characterized by changes in structure due to extensive agriculture; the presence of naturally regenerating secondary vegetation (secondary succession); increased density of domestic animals; and other signs of human intervention.

Areas with dense human settlement are characterized by the presence of permanent agriculture or a high level of urbanization; primary vegetation has been removed; current vegetation differs from potential vegetation; high levels of desertification or other permanent degradation.

Spread of an exotic species. Sometimes this happens by accident, as is the case with noxious weeds and pests. But in most cases, it's the other way around. For example, foxes, rabbits, and cats that arrived in Australia from Europe and replaced local species. The use of exotic fish for sport or food purposes has caused the extinction of 18 species of fish in North American rivers.

Problems of invasive insect species in Ukraine. More than 20 species of moths have been found in green spaces of settlements and agricultural cenoses in Ukraine. In recent years (2004–2022), the number of species of this group of phytophages has increased. These are mainly adventive species: *Lhyllonorycter platini* Staudinger, 1870, *Phyllonorycter issikii* Kumata, 1963, *Cameraria ohridella* Deschka & Dimic, 1986, *Acrocercops phaespora* Meyer, *Phtorimea operculella* Zell, *Tuta absoluta* Meyrick, etc.

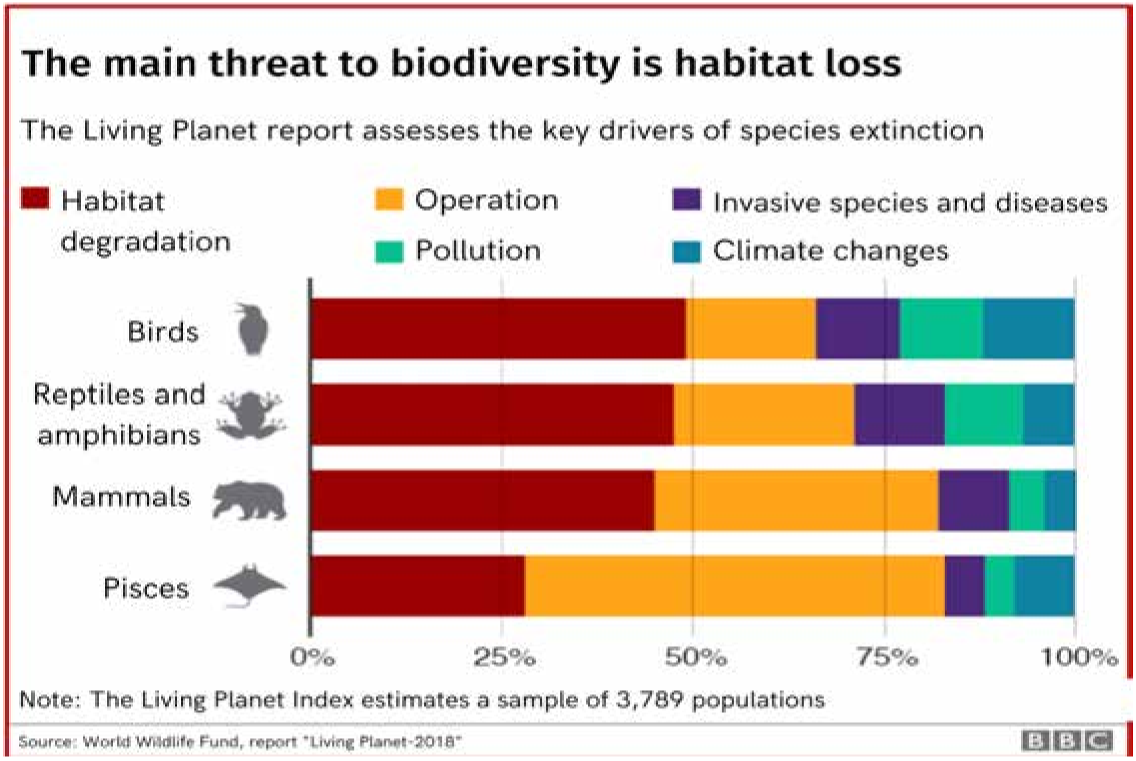


Fig. 11 **Main threats to biodiversity**

Studies on trophic specialization have shown that 6 species of insect phytophages are polyphages, in particular: *Gracillaria syringella, Phyllocnistis labyrinthella, Phyllonorycter emberizaepennella, Phyllonorycter salicicolella, Phyllonorycter sorbi, Phyllocnistis labyrinthella*, oligophages (14 species) – *Caloptilia semifascia, Caloptilia rufipennella, Parectopa robiniella, Phyllonorycter acerifoliella, Phyllonorycter apparella, Phyllonorycter blancardella, Phyllonorycter cerasicolella, Phyllonorycter coryli, Phyllonorycter guercifoliella, Phyllonorycter issikii, Phyllonorycter populifoliella, Phyllonorycter strigulatella, Phyllonorycter tenerella, Phyllonorycter ulmifoliella* and monophages (3 species) – *Cameraria ohridella, Phyllonorycter faginella and Phyllonorycter platani.*

For the first time in Kyiv, three species of moths were found: *Phyllonorycter issikii, Phyllonorycter platani* and *Phyllonorycter emberizaepennella*. It becomes obvious that the entomofauna of Ukraine is constantly being replenished with new immigrant species, which can have unpredictable consequences, for example, the chestnut moth, potato moth, etc. It has been established that adventitious species that have entered a new territory under conditions favorable for their development and reproduction, in the presence of sufficient food resources and the absence of natural enemies, expand their range extremely quickly. Therefore, to prevent the massive spread of such species, it is necessary to conduct regular monitoring in order to detect insect infestations in a timely manner.

Global climate change as a threat to the planet's biological resources is one of the most pressing environmental issues of our time. Scientific data presented in 2007 by the UN Panel on Climate Change finally confirm the reality of global warming caused by human activity. During the twentieth century, the average temperature on the planet rose by 0.6°C. Climate warming is evident in changes in surface and atmospheric temperatures, as well as in the ocean to a depth of several hundred meters, which is more significant in northern latitudes.

According to the international scientific community, the main cause of climate warming is anthropogenic impact. Global greenhouse gas emissions due to human activity increased by 70% between 1970 and 2004. Industry and agriculture emit four long-lived greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and carbohydrates containing fluorine, chlorine, and bromine. In 2005, the concentrations of CO_2 and CH_4 were significantly higher than the natural range over the past 650000 years. The main source of the increase in global CO_2 concentrations is the use of fossil fuels. The growth of CH_4 and N_2O concentrations is mainly due to agriculture. The dynamics of actual warming values is closely consistent with mathematical models that take into account natural and anthropogenic impacts on the atmosphere.

Numerous disruptions of abio- and biotic systems are recorded on the planet, the frequency of which is higher in the northern hemisphere, which coincides with the latitudinal distribution of the warming phenomenon. The impact of climate change on terrestrial ecosystems is manifested through:

- changes in habitats; the distribution of plant and animal species is directed towards the poles;
- earlier onset of spring phenomena, such as leaf blooming, bird migration, and egg-laying timing;
- an increase in the growing season of plants;
- in agriculture in the high latitudes of the northern hemisphere, earlier spring sowing is observed;
- in the forestry sector of the northern hemisphere, the frequency of fires and mass reproduction of harmful insects is increasing;
- changes in the distribution of vectors of infectious diseases, earlier appearance of allergenic plant pollen.

According to UN experts, an average temperature increase of 1–3°C will lead to the extinction of 30% of biota, while a warming of 2–4°C will affect 15 to 40% of the planet's ecosystems. In the agricultural sector, rising temperatures will lead to significant changes in crop productivity and an increase in the number of pest populations.

In the context of threats to bioresources caused by global warming, systematic studies of environmental disturbances in Ukrainian biocenoses are extremely relevant for environmental justification and development of a set of measures to prevent them.

Illegal hunting and systematic logging for energy or charcoal production are also causes of biodiversity loss. The use of medicinal plants can illustrate this statement to some extent.

Less well understood are cases of "interdependent" effects. A species that develops in conjunction with another (for example, plants that spread with the help of special insect pollinators) will go extinct if the other species of the pair is endangered.

When the last wandering pigeon died in early 1990, two of its parasites, a type of louse, disappeared.

Thus, according to the International Union for Conservation of Nature (IUCN) Red List, one in four species is threatened with extinction, which is a critical indicator of our impact on nature (Figure 12*)*.

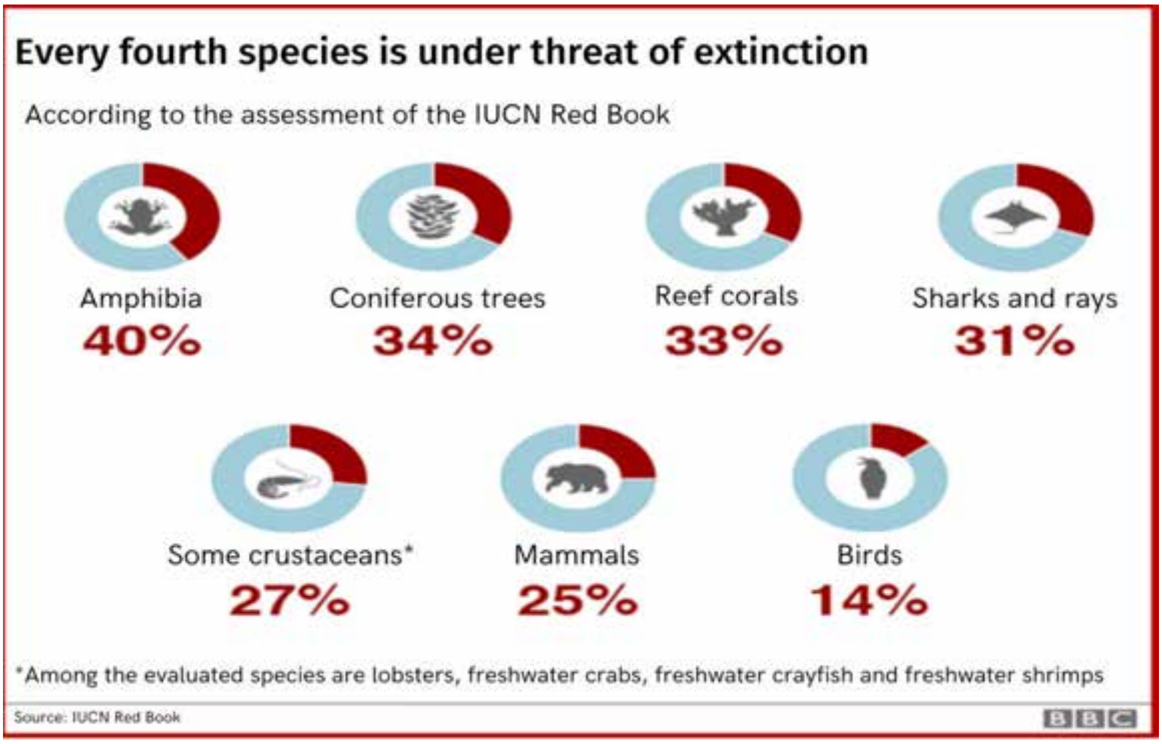


Fig. 12 **Statistical data on the disappearance of biodiversity species**

Pollution and global environmental change also threaten global biodiversity.

All these causes have one thing in common: they are caused by human activity. This makes human activity one of the most serious causes of modern biodiversity degradation. Therefore, many aspects of human impact on biodiversity, along with the direct causes of its deterioration, are important for prioritizing and counteracting existing negative trends.

Population growth. The relationship between biodiversity loss and population size, growth rates, and sustainability is complex. Population growth leads to increased consumption of resources and their degradation, expansion and intensification of land use, causes poverty and disruption of traditional environmental management systems. At the local level, population growth is often the result of urbanization, settlement and migration. Local population growth also has a direct impact on resource use and degradation, often leading to habitat conversion in areas important for biodiversity conservation.

Production structure and overconsumption. Increased production and energy consumption leads to habitat conversion and overuse of ecosystems. Reducing resource and energy consumption at various levels will reduce pollution and resource extraction that degrade biodiversity. There is a correlation between biodiversity decline and the level of environmental culture, education and well-being of the population.

Exploitation of natural resources. Traditional societies often impose restrictions on the overexploitation of natural resources: the rights to use agricultural land are strictly controlled; hunting is prohibited in certain areas; there are prohibitions on the destruction of females, young animals and animals with low numbers, no fruit collection is allowed in certain seasons and times of the day, or barbaric methods of collection are prohibited. These types of restrictions allow traditional societies to use natural resources on a long-term sustainable basis, as is the case with the strict fishing restrictions developed and imposed on the fishing industry in many industrialized countries.

In many cases, the mechanism of overexploitation is notorious. A resource is discovered, a market is identified, and then the local population is mobilized to extract and sell it. The resource is consumed so widely that it becomes rare or even disappears, and the market brings another species, resource, or opens up a new region for exploitation. This is the pattern of commercial fishing, where one species is successively harvested until it is depleted.

For many exploited species, the only hope of getting a chance to recover is when they become so rare that they no longer have commercial value. Unfortunately, the population size of many species, such as rhinos or some wild cats, has already been reduced so severely that these animals are unlikely to recover. One of the most heated controversies concerning the exploitation of wild species has arisen around whale hunting;

Infections and diseases. Infections caused by pathogens are common in both wild and captive species. Diseases can be caused by microparasites, such as viruses, bacteria, fungi, and protozoa, or by macroparasites, such as helminths or parasitic arthropods. For some rare species, such diseases can be the most serious threat. Three basic principles of epidemiology have obvious practical applications in captive breeding and management of rare species.

First, both wild and captive animals in dense populations are at greater risk of infection. In fragmented protected areas, animal populations can temporarily reach unnaturally high densities, which ensure a high rate of pathogen transmission. Under normal natural conditions, the risk of infection is usually lower because animals have less contact with excrement, saliva, shed skin, and other sources of infection. In artificially created situations, animals are in closer contact with these potential sources of infection and the risk of disease transmission increases.

Second, an organism's susceptibility to disease can be an indirect result of habitat destruction. When habitat destruction causes a host population to be concentrated in a small area, it often leads to a deterioration in the quality of the environment and a decrease in the amount of food, which leads to malnutrition, weakening of the animals and, consequently, their greater susceptibility to disease.

Thirdly, in many protected areas, zoos, national parks and new agricultural areas, wild animals come into contact with new species, including humans and pets, which they rarely or never encounter in nature and, accordingly, exchange pathogens with them.

SECTION 3. METHODOLOGICAL APPROACHES TO BIODIVERSITY CONSERVATION

3.1 Biodiversity conservation measures

Species richness of both animals and plants is rapidly decreasing as a result of negative processes occurring in the environment and human activity itself. To live and survive in nature, humans have learned to use the beneficial properties of biodiversity components to obtain food, raw materials for clothing, tools, housing, and energy. Anthropogenic activity, primarily related to agriculture, mining, expansion of settlements and transport and communication, leads to transformation and degradation of ecosystems and their components, fragmentation and reduction of areas occupied by natural complexes, desertification, dehumidification, and intensification of erosion processes. Reduction of the areas occupied by natural ecosystems, loss of primary plant communities and faunal complexes, changes in the structural and functional characteristics of ecosystems, landscapes and biomes, and is ultimately associated with the loss of biotic and landscape diversity, "natural capital", and "ecological fund".

The loss of biodiversity is one of the global problems of our time that cannot be postponed. Biodiversity is not only the basis of a significant part of natural resources that provide humans with food, various raw materials, medicines, etc., but it is also intrinsically valuable regardless of the material value determined by socioeconomic relations. Such intrinsic value is inherent in the evolutionary history of life and the unique ecological functions performed by each species in the global ecosystem.

Nature is an interdependent hierarchy of ecosystems. The conservation of biological diversity is inextricably linked to the conservation of landscape diversity (diversity of habitats, econonichs, trophic chains). Among the most effective measures to preserve biodiversity is the creation of protected areas, nature and biosphere reserves, national parks and forest plantations (forest reclamation). These measures provide the conditions necessary to reduce the harmful anthropogenic impact on biological objects, and help preserve the integrity of ecological systems, where natural mechanisms of relations between biological species necessary for the system's existence can be maintained.

Today, it is widely recognized that forests play a crucial role in maintaining the stability of the biosphere through biodiversity conservation and global climate change. Forests play an important role at the regional and local levels as key elements of landscapes that ensure their stability and as sources of biodiversity. In addition, the forest landscape is a crucial element in the concept of biodiversity conservation and development.

The nature reserve network of Ukraine includes 6939 such territories and objects, which make up more than 4% of the country's area. The highest categories of conservation include four biosphere reserves, 16 nature reserves, and 12 national nature parks. The status of natural national heritage corresponds to 2,507 nature reserves, 3,016 natural monuments, 35 dendrological parks, 527 parks-monuments of landscape art, 22 botanical gardens, 12 zoological parks, 35 regional landscape parks, and 754 protected tracts. It should be noted that, unlike the national classification, the international classification distinguishes between the functions of national and natural parks. Natural parks are primarily created for recreation, i.e., rest. The main task of national parks is to preserve natural diversity, while recreation and tourism play a subordinate and limited role.

Forest plantations are one of the main types of vegetation, consisting of a combination of woody plants, shrubs, herbaceous plants, mosses and lichens, including animals and microorganisms that are biologically interconnected in their development and influence each other and the environment. Forests are one of the leading components of the living environment. They have a positive impact on many other components of natural complexes and ensure their conservation as a whole. The state of forest plantations largely determines the sustainability of natural territorial complexes, the nature and intensity of the processes that take place in them. All of this determines the enormous environmental protection role of forest plantations.

Forest belts are strip forest plantations of artificial origin (forest crops) located in flat areas and on slopes, on agricultural land along field boundaries, to increase crop yields, improve the microclimate in adjacent fields, retain snow, combat deflation, and preserve and improve soil fertility. They also play an important environmental role.

Field forest belts are a kind of "oasis" for many groups and species of biota in agricultural landscapes. They are home to a large number of organisms due to a greater diversity of food sources, a milder and more stable climate, etc. In forest belts and their herbaceous plumes, species that do not tolerate soil plowing find refuge. They contain a large number of dendrobiont and eurybiont species.

Formation and functioning of varieties of phytowalls. At the present stage in Ukraine, due to land parceling, the agro-industrial complex is being reformed, in some cases contrary to scientific justification, especially in the area of organizational and technological methodology. This leads to a deterioration of the economic situation and the state of the environment, including a decrease in soil fertility, pollution with synthetic technological materials, a decrease in the yield and quality of raw materials and plant products, etc.

One of the important ways to solve this problem at the state, regional and local levels is to create the prerequisites for harmonizing the development of phytocoenoses based on the effective formation and functioning of field and other varieties of phytobands, especially in the production of high-quality and safe products in the conditions of natural (organic) management, as one of the most promising areas of development of the agro-industrial complex.

The purpose of phytobands is to harmonize the formation and functioning of ecosystems, their phytocoenoses and associated biota, to produce a wide range and optimal quality and safe phytoproducts for various sectors of the economic complex through effectively created phytobands, taking into account the principles of their phytodesign, respectively, aesthetic pleasure, recreation, environmental protection, obtaining beekeeping products, medicinal and other raw materials, cleaning the environment from adverse factors due to the phytoncidal properties of plants, harmonizing:

Wind breaker activities. Harmonization of snow retention in natural, anthropogenic and cultural ecosystems. Reducing soil evaporation. Resistance to air and soil droughts, windstorms to prevent water balance disruption, moisture deficit in plants, weakening of plant growth and development, reduction of yields and quality of raw materials and products, or plant death. Preventing dust storms that blow away the top humus layer, sown seeds, plant seedlings, etc. Preventing the decline in soil erosion and fertility. Territorial delimitation and inadmissibility of transferring a number of specific drugs and products from fields, growing raw materials using synthetic technological materials based on extensive and intensive agriculture, to agrophytocenoses for the production of phytoproducts without the use of synthetic technological materials based on biodynamic and natural (organic) agriculture. Creation of favorable conditions for the development of profitable biodiversity (entomophages, pollinating insects, birds and other fauna). Reducing the risks of unprofitable (harmful) biodiversity through the role of natural regulatory mechanisms and the negative impact of abiotic factors such as temperature, air and soil humidity, and changes in the microclimate in general. Reducing global climate change, improving the microclimate and snow deposits to counteract their blowing away, harmonizing the oxygen-carbon balance and the daily temperature and relative humidity.

Varieties of phytowalls: field; road; railroad; street; estate; anti-erosion, snow retention, phytowalls; around settlements, outbuildings, industrial facilities, water bodies, on slopes, etc.

Anti-erosion phytobars. Soil erosion occurs as a result of wind and water, usually on slopes of varying degrees, which should be taken into account when selecting a range of tree, shrub and herbaceous plants. Damage from soil erosion is a decrease in soil productivity, an increase in unproductive areas for growing crops, deterioration of water bodies, waterlogging, deterioration of roads and soil, etc.

This approach in the current conditions of harmonious formation and functioning of varieties of phytobands should be structured on the basis of scientific substantiation, special research and support when introduced into production at the state, zonal and economic levels.

Along with this, a variety of concepts have recently emerged that relate to the principles of biodiversity management, including the integrity, health, resilience, and resilience (ability to withstand stress and shocks) of an ecosystem.

One of the most productive ideas of modern ecology is the idea of an ecological network. It is integral to the organization of biodiversity and landscape conservation, on the one hand, and the prospect of sustainable use of natural resources, on the other. The general trend in the approach to the ecological network is to try to create a universal socio-natural structure that would solve not only the problems of conservation of animals, plants, fungi and their habitats, but also constantly provide social and economic benefits to the population and, by improving their living conditions, thereby laying the foundations for ecologically balanced development of the territory as one of its basic elements. The scientific literature discusses aspects and problematic aspects of the practical implementation of the ecological network idea.

Biodiversity conservation measures have become an important component of the state environmental policy, specifying and developing the ideology of traditional nature protection. The formation of an ecological network will help improve the ecological state of the environment by regulating the hydrological regime, reducing soil erosion, mitigating microclimate, stabilizing the small-scale cycle of substances, preserving renewable resources, and maintaining the natural balance. The ecological network is the first active form of nature protection, the main goal of which is to restore the natural territorial and functional integrity of ecosystems in combination with their balanced use.

3.2 Conservation of insect species diversity in agrobiocenoses

Under the current system of on-farm land management, which combines plots with quite different soil and microclimatic conditions, significant differences in the supply of heat, moisture and mineral nutrients to plants, the timing of phenological phases, the degree of damage to crops by pests, diseases and weeds, and, as a result, high variability in crop yields are inevitable between crop rotation fields and even within the same field. In other words, a system of large-scale leveling land management that does not adequately take into account the uneven distribution of soil and microclimatic factors does not allow for the most important agrobiological tasks of crop rotation, i.e., ensuring the most rational use of local natural resources, the adaptive potential of plant varieties and man-made factors of agricultural intensification.

It is obvious that the practice of "equalizing" land use, which has been established throughout the country, requires, first of all, a radical revision of the on-farm land management system. It should be based on economically justified, but more differentiated use of natural and anthropogenic resources through the allocation of ecologically similar territories (EOT) combining relatively homogeneous basic surfaces (morphological elements), soil characteristics, microclimate, and natural processes.

Man has come to understand the need to preserve the diversity of the environment through conservation or other types of protection of natural areas. But when carrying out environmental protection measures, it is necessary to remember, especially at the economic level, about groves, ravines, borders, beams, glades, shrubs, and so on, because these are the sources from which both natural and artificial biocenoses are constantly "fed" by species. Such semi-natural stations of agricultural landscapes are called "entomological refugia" in the ecological literature. A "refugium" is an ecological refuge – an area of the earth's surface where one or many species of fauna experience unfavorable periods during which these life forms have disappeared over large areas.

If the diversity of habitats in agricultural landscapes is preserved, there will be fewer problems with biodiversity conservation.

Non-interference by humans in these small centers of biotic complexes will facilitate their close to natural succession processes, i.e., self-regulation of internal relationships will prevail there. For example, there is no need to treat forest strips (and all other "islands"), including their roadsides (against weeds), with pesticides, or to burn them. There will be no practical benefit from the use of chemical plant protection in such conditions, but the succession processes will be greatly damaged. It is advisable to fight weeds and phytophages directly in cultivated phytocoenoses, but with scientifically based protective systems that minimize the impact on beneficial entomofauna (toxicity of seeds of cultivated plants, especially row crops, night chemical treatments, etc.)

At the same time, as with economic activities in agro-landscapes in general, it is necessary to pay maximum attention to the conservation of beneficial entomofauna. As for wild plant pollinators, the preservation of their species diversity (there are up to 700 species in Ukraine) also depends on the preservation of their habitats (forest edges, lawns, roadsides, slopes of beams, ravines, fallow land, etc.) Moreover, all these habitats should be granted the status of micro-reserves. This does not require large expenditures, but brings many benefits. Therefore, the conservation of wild pollinator species diversity should be given the same attention as that of Red Data Book insect species.

Nowadays, little attention is paid to the fact that the biodiversity of insect faunal complexes can be a guarantee against degradation of the entomofauna in natural, partially modified ecosystems. Long-term studies have shown that the species diversity and abundance of beetles of different families living in the soil of virgin plots can be 1.5 to 5.0 times higher than in agrocenoses, depending on the type of soil and crop. The biodiversity of lepidopterans (butterflies), whose caterpillars live mostly in the open on plants and are therefore more vulnerable to physical and chemical impacts, varies even more significantly. Therefore, it can be said that entomological shelters or refugia have now become the last stronghold of insect biodiversity in agricultural landscapes. For example, as a result of studies of the peculiarities of entomocomplexes formation in the agrobiocenoses of the Central Forest-Steppe of Ukraine, it was found that species diversity varied from sugar beet field to field (H=2,45±0,10 bit/person), sowing peas (H=2,52±0,17 bit/person), winter wheat (H=2,97±0,13 bit/person) to corn (H=3,01±0,13 біт/особину) and forest belts (H=3,65±0,17 bit/person). Semi-natural habitats, cereal and legume fields were characterized by a greater diversity and abundance of beetles and hoppers compared to row crops, as conditions in these habitats are favorable for most species of native fauna. The dominant species in the crops were *Pterostichus cupreus* L., *P. melanarius* L., *Bembidion properans* Steph., *Ophonus rufipes* Deg. In winter wheat fields bordering on shelterbelts, roadsides, and sown areas of other crops, the number of beetle species (especially zoophagous), their diversity, and population density increased in places of contact with forest belts. Larger areas of meadow habitats, field protection plantations and ecotones in the field system contributed to the accumulation of epigeon entomophages, and thus to the natural regulation of phytophagous numbers. The impact of field protection forest belts on the entomocomplex in a particular agrocenosis was manifested in a decrease in the total diversity of insect chortobionts and the number of entomophages with distance from tree plantations. semi-natural ecosystems (hayfield, recreational, pasture and hydromelioration) were characterized by the highest species diversity of insects. Various complexes of arthropods were formed on fallow lands, but with a numerical predominance of harmful phytophages – lepidopterans, bedbugs, and cicadas. Agrocenoses were characterized by a lower diversity of insects, but a higher population density of individual representatives.

Entomological refugia on non-agricultural land are a natural part of agricultural landscapes. Therefore, they should be treated as if they were arable land. Overgrazing, steppe fires, dumping of household waste, barbaric collection of medicinal herbs, unreasonable plowing of areas with poor soils that subsequently turn into contaminated deposits – all this impoverishes the biodiversity of insects within each particular farm. But the most dangerous are pesticides that, as a result of washing or wearing off from fields, poison natural ecosystems, gradually depleting the species composition of insects.

It is advisable to occupy agricultural land directly bordering entomological refugia with alfalfa and other forage legumes, regularly placing outbreak fields of grain crop rotations on them. In addition, it is advisable to use insecticides with the shortest half-lives in the soil on these fields, using only ground spraying equipment. Aerosol generators of insecticide sprays should not be used near entomological refugia, nor should intensive fruit orchards be established, as all existing systems of chemical protection of orchards involve the use of larger volumes of insecticides, several times higher than their consumption on field crops.

3.3 Determining the algorithm of impoverishment of the agroecosystem of Ukraine

Ukraine's richest land fund in Europe, combined with favorable climatic conditions, should ensure a high level of agricultural production. At the same time, the productivity of Ukraine's agroecosystems is 2–3 times lower than that of the EU, and this trend has been observed for many years despite the course of socio-economic formations, land use structure, development of scientific support for the agricultural sector, etc. What is the reason for the insufficient productivity of domestic agrocenoses?

At the end of the twentieth century, the world scientific community came to the conclusion that the development of the global environmental crisis of the biosphere and its components, in particular agroecosystems, is due to a catastrophic decline in the planet's biodiversity as a result of excessive anthropogenic pressure. Today, understanding of the importance of biodiversity and the need to preserve it for sustainable development is at the forefront of the global environmental agenda.

The ecological and economic importance of biodiversity is formalized as follows. The main characteristic of the biosphere is the level of diversity of life in all its manifestations, the diversity of biota, which reflects the diversity of environmental conditions on the planet. As a result of the interaction of biota with abiotic and biotic environmental factors, the space of environmental factors in the biosphere forms a network of ecological niches in which elementary ecosystems carry out a continuous cycle of matter, energy and information. As a result of biota activity, each life cycle of the biosphere is replenished with drinking water and clean air, and soil fertility is restored. In this way, biodiversity supports the ecological sustainability of ecosystems and reproduces the conditions for the further existence of life on the planet.

What happens as a result of anthropogenic transformation of landscapes in the course of agricultural activities? The impoverishment of the diversity of ecological niches, which results in the impoverishment of biodiversity. "Holes" are formed in the network of ecological niches, where natural resources fall out of the cycle of matter, energy and information, which leads to the development of such environmental phenomena as soil degradation, deterioration of water quality, etc. The rate of development of the global environmental crisis is steadily increasing.

In our opinion, one of the aspects of the problem of increasing the productivity of domestic agroecosystems while maintaining the ecological stability of the environment is the conservation and reproduction of agrobiodiversity.

The study of the algorithm of impoverishment of the agroecosystem of Ukraine (Fig. 13) will allow us to substantiate the connection between impoverished agrobiodiversity and environmental and socio-economic factors of agricultural production.

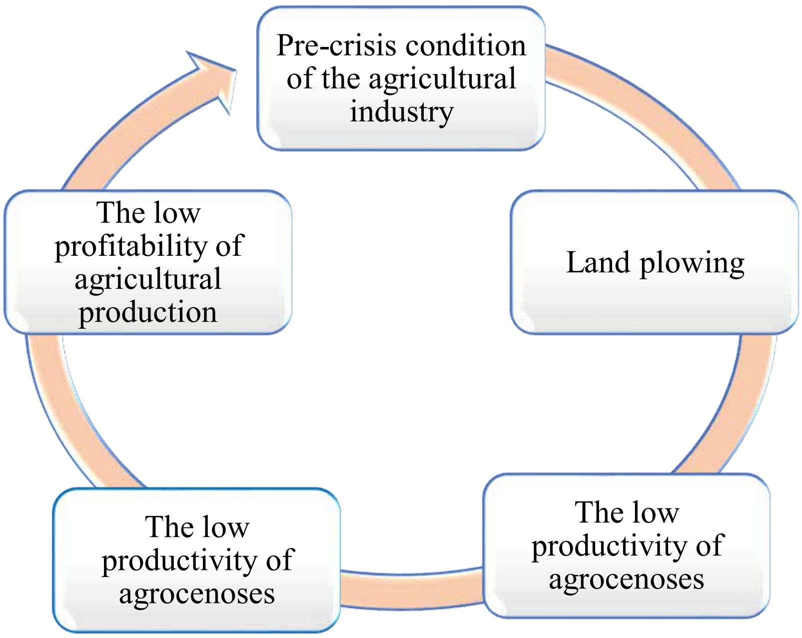


Fig. 13 **Algorithm of impoverishment of the agroecosystem of Ukraine**

Thus, the pre-crisis state of the agricultural sector primarily depends on the land fund of Ukraine. It is known that in order to form highly productive, environmentally sustainable agricultural landscapes, the level of plowed land should not exceed 40–50%. The plowed land in Ukraine exceeds the ecologically sound norm. For example, in France, 36% of the land is plowed, in Germany – 32%, in England – 18.5%, and in the United States – 20%. In Ukraine, agricultural land occupies 41 million hectares, or approximately 70% of the land, of which 79.3% is arable.

Today, a major problem for the land fund is the degradation of agricultural soils due to the lack of innovation. Thus, according to the National Research Centers "A.N. Sokolovsky Institute of Soil Science and Agrochemistry" and "Institute of Agriculture of the National Academy of Sciences of Ukraine", up to 600 million tons of soil, up to 15 million tons of humus, 0.3–0.9 million tons of nitrogen, 700–900 thousand tons of phosphorus, 6–12 million tons of potassium are lost annually due to erosion, which is much more than is applied with fertilizers. Crop yields on eroded soils are 20–60% lower than on non-eroded soils. Losses of agricultural products due to erosion exceed 9–12 million tons of grain units, and environmental and economic losses amount to $10 billion annually. The area of agricultural land subject to water erosion is 13.3 million hectares (32% of the total area), including 10.6 million hectares of arable land.

Among the eroded lands, 4.5 million hectares are heavily and moderately washed away, and 68 thousand hectares have lost their humus horizon. More than 6 million hectares are systematically exposed to wind erosion, and up to 20 million hectares in years with dust storms. The dust storm of 2007 covered 125 thousand km2, up to 20% of Ukraine's area, and 50% of the steppe zone.

The level of land erosion due to feedbacks suppresses both the ecological sustainability of agroecosystems and their productivity.

The ecologically unjustified level of plowing of the land fund causes a catastrophic impoverishment of agrobiodiversity. Thus, according to the National Academy of Sciences of Ukraine, there are crisis phenomena in the state of wild and associated agrobiodiversity. It has been determined that the greatest impact on agrobiodiversity is caused by: changes in land use (37%), poor environmental management (16%), habitat fragmentation (7%), exploitation of natural resources (9%), toxicity (7%), disturbance (6%), etc. The calculation of indicative indicators shows that the natural capital index for agriculture in 2001 was 52% compared to 1994.

The next stage is the insufficient ecological sustainability of agroecosystems. It is known that the high sustainability of more diverse ecological systems is due to the close packing of ecological niches, the mechanisms of which, primarily various types of competition, determine the mutual regulation of the number of populations and their access to ecosystem resources. Insufficient ecological sustainability of agricultural landscapes as a result of the impoverishment of agrobiodiversity is clearly manifested in the constant deterioration of the phytosanitary condition of agrocenoses, which has been occurring for many years even with the stabilization of plant protection measures. For example, in some years, the country loses almost 50% of the harvest of its main grain crop, winter wheat, due to pests.

As a result, we observe low productivity of agrocenoses. Insufficient ecological sustainability of agricultural landscapes and poor phytosanitary conditions determine the current level of productivity of agroecosystems, which does not correspond to the quality of the land fund of Ukraine. For example, according to the European Economic Commission, the average long-term yields of winter and spring wheat in Ukraine are 2.3 vs. 5.8 t/ha in the EU, potatoes, respectively, 11.9 vs. 33.9, and sugar beet 18.3 vs. 51.2 t/ha.

Insufficient profitability of agricultural production exacerbates social problems in rural areas, which, in turn, negatively affect the productivity of agroecosystems through feedback loops. At the same time, social problems in rural areas determine the current level of plowed land as a factor of extensive production growth.

It is worth remembering that the pre-crisis state of the environment determines the level of public health. Thus, constant monitoring of public health indicators shows that it is deteriorating due to the spread of certain classes of diseases. This is primarily evidenced by an increase in the overall morbidity rate. In the regions, there have been significant changes in the prevalence of endocrine system diseases, digestive disorders, metabolic disorders, a 1.8–fold increase in the number of endocrine system diseases, the prevalence of circulatory system diseases (by 10.6%), blood and hematopoietic diseases (by 7.4%), and neoplasms (by 3%) compared to previous years.

According to the developed algorithm for the pre-crisis state of Ukraine's agroecosystems, it can be concluded that the main factor in the ecological state of the system is the excessive plowing of the land fund of Ukraine, which causes the impoverishment of agrobiodiversity.

SECTION 4. ECOLOGICAL AND ECONOMIC IMPORTANCE OF BIODIVERSITY

4.1 Ecological role of biodiversity in nature

There is a problem in understanding the ecological role of biodiversity in science - there is no full agreement on the importance of biodiversity for ecosystem sustainability and functioning. In addition, most ecological studies of the ecological role of biodiversity are theoretical in nature, or they are the results of field studies that were designed to study other ecological problems.

There are three classes of hypotheses regarding the ecological role of biodiversity:

1. The "*redundancy hypothesis*". Biodiversity is redundant, all species are approximately equally important for the ecosystem, and the removal of any species from the ecosystem is compensated by other species.

2. The "*basic biodiversity hypothesis*". The functioning of an ecosystem is regulated by the dominant or base biodiversity.

3. "*Contextual dependence hypothesis*". The level of biodiversity of an ecosystem is context-dependent, i.e., the ecological consequences of species losses or additions depend on certain conditions: the composition of the biotic community, the abundance of stations, etc.

Biodiversity experts believe that insects and their relatives dominate terrestrial and freshwater ecosystems. Thus, insects provide a significant part of the biotic cycle of matter, energy and information in the biosphere, which ensures the maintenance of ecological balance. Humanity considers only 1% of insect species to be harmful insects and has been waging a devastating chemical war against them since the beginning of the twentieth century.

Insects are the most diverse group of animals. Currently, about 750 thousand species of insects have been identified, but it is estimated that there are about 1.5 million species in nature. According to other estimates, the world's fauna includes more than 1.5 million species, which is 5 times more than plants. Insects make up 75% of the total number of animals.

Insects have mastered the main areas of the planet and participate in various natural processes. Natural ecosystems cannot function normally without insects and other arthropods, so the level of their diversity is a reliable indicator of the ecological state of ecosystems. High insect diversity provides the potential and reliability to detect relatively small, but nevertheless important changes in the ecological state of natural systems at early stages. Despite a solid history of entomology, insects have been studied insufficiently in the face of this level of biodiversity. For example, only about 34–67 thousand species of insects and their relatives are known in Canada, and about 100–181 thousand species in North America as a whole. In some parts of Europe, the state of knowledge of the entomological community is much better: for example, more than 93% of the predicted 24 thousand species of insects have been identified in the UK. However, in most tropical areas, and thus globally, knowledge of the number of insect species is not complete – no more than 10% of existing species are believed to have been identified.

Insects are most diverse in the tropics, where the combination of high plant diversity and warm climate makes it possible for many species to exist. In the United States and Canada, 91 thousand species are known and probably about 67 thousand species have not yet been identified.

Recently, the importance of insect biodiversity has been assessed. An ecological and economic analysis of the four main functions performed by insects in nature (1) processing of organic residues; 2) control of the number of harmful insects of cultivated plants; 3) pollination; 4) food source for other animals) shows that the annual economic effect of insect activity in the United States is US $ 57 billion. At the same time, insects provide US $ 50 billion of this amount as a source of food for other animals, as well as acting as reducers, US $ 4.5 billion of profit is generated by controlling the number of harmful insects of cultivated plants, and US $ 3 billion is generated by pollinators. The authors use the example of dung beetles to analyze the ecological role of insects: "reducing the number of livestock parasites and insects that pester them; manure processing, which makes nitrogen more available for crops." The authors of the study conclude that the reduction of insect biodiversity brings tangible economic benefits, so multibillion-dollar investments in biodiversity conservation programs are economically justified. According to other estimates, the economic contribution of pollinating insects in the United States is about US $ 9 billion. Humanity uses more than 1000 species of insects as food. At the same time, insects contain many trace elements and vitamins, and so much protein that they provide 5–10% of the protein requirement for the population groups that use them as food. Estimates of the global economic value of insect pollination of agricultural plants range from US $ 112–200 billion annually.

The following are examples of the ecological role of insects for the environment:

- many species of ants are responsible for the cycling of nutrients and ventilation in the soil;
- termites in the forest decompose organic matter accumulated in the respective biogeocenosis;
- wasps control the number of many species of harmful insects on which they parasitize;
- insects are important as a food source not only for other insects, but also for birds, reptiles and mammals, including humans;
- insects pollinate many species of higher plants;
- insect phytophages form the ecological structure of plant communities;
- pollinators and entomophages provide important services to agriculture by increasing crop productivity and regulating the number of harmful insects.

The preservation of the biosphere and its continued existence largely depends on understanding the role and mechanisms of biodiversity. It is now known that insects are one of some of the key groups of organisms that determine the complex nature of biodiversity and are a reliable indicator of ecosystem resilience. Cataloging the species that inhabit an ecosystem is the foundation of understanding biodiversity.

The survival of humanity depends on the functioning of ecosystems, including agroecosystems. At its simplest level, ecological condition is determined by the number and diversity of species. At a deeper level, it is determined by genetic diversity, which contributes to the dynamics of species populations and ensures the survival of populations, their numbers and interdependence. Biodiversity affects such fundamental ecological processes as the carbon cycle, atmospheric and energy exchanges.

Biodiversity conservation issues such as global warming, ozone depletion, desertification, surface and groundwater pollution, and food security are rapidly approaching crisis status. Despite the fact that many ecological processes in the biosphere are beyond human control, understanding the functioning of biodiversity can help maintain the health of the planet and make informed management decisions.

More than half of all multicellular animal species are insects. Therefore, they play a dominant role in the functioning of ecosystems. Insects are one of the few classes of organisms that define the complex nature of biodiversity and can serve as a reliable indicator of its viability.

The use of pesticides is still the main means of controlling the sanitary condition of agro- and forest biogeocenoses. Chemical suppression of pests, along with a positive economic effect, leads to a decrease in the entomological diversity of ecosystems, which in turn causes degradation of the agricultural sector.

Biodiversity is important for humanity both in terms of utilitarian use and spiritual values. Our own health, as well as the health of the economy and society as a whole, depends on the continuous receipt of various ecosystem services, which will be either very expensive or simply impossible to replace.

For people, biodiversity has economic, recreational, cultural, ecological, and other values.

1. *Economic value*. Biodiversity is an incredible wealth from a "utilitarian" point of view. Biological resources are the foundation on which civilization is built. They are the basis for most human activities, such as agriculture, pharmaceuticals, pulp and paper, horticulture, construction and waste management, and the production of cosmetics. Biological resources provide people with all kinds of products: food, fibers for clothing, building materials, dyes, synthetic substances, medicines, etc.

In agriculture, the genetic diversity of a particular crop is of great importance. It is a powerful weapon for fighting pests and diseases of plants and animals. In the past, genetically different types of crops were always planted together to avoid possible crop losses: it is more difficult for one crop to resist the effects of insects and diseases than for several crops to be planted together. Farmers are increasingly interested in the genetic diversity of crops and animals to increase their productivity and adaptability to changing environmental conditions.

2. *Health benefits*. For centuries, plant and animal extracts have been used to treat people. This type of treatment remains the mainstream to this day. For example, about 80% of the world's population trusts only traditional medicine that uses plants and animals. Modern medicine is showing interest in biological resources, hoping to find new treatments. It is believed that the greater the diversity of living beings, the more opportunities there will be to discover new medicines and accelerate economic development. Potentially, any species can have commercial value or be used in medicine. According to this point of view, all species of living organisms should be preserved.

3. *Recreational value*. Biodiversity is of great importance for recreation. It is also the most important condition for the development of tourism. A type of recreational activity that provides pleasure without destroying nature is becoming increasingly popular. We are talking about hiking, photography, bird watching, etc. This type of activity is now rapidly expanding and is often the main source of income for the local population. For example, 84% of Canadians go on outdoor recreation,

which generates US $ 800 million annually. The global eco-tourism industry is growing rapidly and includes up to 200 million people annually.

4. *Ecological value.* Biodiversity is a prerequisite for the survival and stable functioning of many ecosystems. Ecosystems that contain millions of species that exist today contribute to the preservation of environmental conditions necessary for human survival. The existence of many species that have direct consumer value for humans depends on wild species that have no direct value for humans. Therefore, the disappearance of the latter can lead to the disappearance of species that are cultivated and important to the economy.

Ecosystems provide a range of ecosystem services. They contribute to soil formation processes. The accumulation and transfer of essential nutrients ensures soil fertility. Ecosystems assimilate waste, absorb and destroy pollutants. They purify water and stabilize the hydrological regime by retaining groundwater. Wetlands, for example, regulate the flow of flood waters, reduce salinity due to the recharge of aquifers with fresh water, and increase the minimum flow of rivers during dry periods. Ecosystems contribute to the preservation of atmospheric quality by maintaining the required level of oxygen through photosynthesis. Plants – the "green lungs" of our planet – produce oxygen, which is used by all living things.

The functioning of the planet as a whole and its climate balance largely depend on the normal cycle of water, carbon, nitrogen, phosphorus and other substances, which is ensured by the diversity of ecosystems. The ecological value of plants at the global level is related to the ability of plants to bind carbon compounds, which helps to avoid the greenhouse effect that leads to an increase in global temperatures.

5. *Educational and scientific value*. Many books, magazines, television programs, and movies use nature-related subjects. More and more materials about nature are being included in educational programs. A large number of professional scientists and educators, together with interested nature lovers, are involved in conducting environmental observations and preparing educational materials. Such activities are useful for the areas where they are carried out. But its special value lies

in expanding knowledge and enriching human experience. Biodiversity is of great importance for science, as it helps to unlock the mystery of the origin of life. If the closest relatives of humans - chimpanzees, baboons, gorillas and orangutans – disappear, we will lose important keys to understanding human evolution.

6. *Indicative value*. Species that are particularly sensitive to toxic substances can serve as "early warning systems" to monitor the state of the environment. The best known living indicators are lichens, which grow on rocks and absorb chemicals in rainwater and air. Each lichen has a certain level of resistance to air pollution. High levels of toxic substances kill lichens. The composition of the lichen community at any given location can be used as a biological indicator of air pollution. Mollusks, which pass large volumes of water through themselves and concentrate toxic substances, such as poisonous metals and pesticides, in their tissues, are also used to monitor environmental pollution.

7. *Optional value* (potential value, the value of the right to choose actions). This value is that species can bring economic benefits to humans at some point in the future. Often, solutions to new problems involve animals or plants that have not been used in any way before. Entomologists, for example, are looking for insects that can be used as biological pest control. Some plants can accumulate quite significant amounts of gold, which could lead to the cultivation of these plants in old precious metal mines. Pharmacists research plants and other species to create new drugs that can treat people.

8. *Aesthetic value*. The beauty embodied in biodiversity is a great source of pleasure. Although this aesthetic value cannot be quantified, it is no less fundamental than other values. People have a need for a variety of natural environments. The aesthetic aspect of biodiversity is not just about enjoying the beauty of certain places, but rather an organic need inherent in every human being, as diversity of life forms improves the quality of life.

9. *Intrinsic value.* The beauty of biodiversity is what makes it valuable. Biodiversity is valuable in itself, regardless of the value of its use by people.

10. *Cultural value.* Landscapes reflect the diversity of cultures. We value this diversity because it strengthens our sense of belonging. It is the source of our diverse perception of reality. Landscapes are connected to our history. Throughout history, religious thinkers, poets, writers, artists, and musicians have drawn inspiration for their work from observing nature. For thousands of years, landscapes have inspired the imagination of entire peoples.

11. Economic benefits. The U.S. Agency for International Development estimates the total global profit from biodiversity at at least 16 trillion hryvnias. This is almost 11% of the world's gross national product. The loss of biodiversity and the related ecosystem functions that depend on it can entail significant economic costs. For example, polluted air and water increase disease and reduce productivity. If an ecosystem loses its pollinators, it can be extremely costly for society to bring them back or not to bring them back. Disrupted ecosystems lose their ability to clean and store water and ensure nutrient cycling. This forces cities to build expensive water treatment plants and farmers to import expensive fertilizers or accept lower crop yields.

A very important benefit of biodiversity is its "potential future value". Specific benefits from agrobiodiversity are: genetic diversity, wild plant diversity, livestock diversity, aquatic diversity, soil diversity, arthropod diversity, and associated biodiversity.

Literature data indicate a close relationship between invertebrates and plants in agrocenoses. Different types of weeds serve as a source of food for different types of phytophagous insects, and the vital activity of both endangered and rare species and harmful insects is closely related to them. Regular use of herbicides for weed control affects the fauna and flora of agrocenoses. The significant impact of pesticides on the biodiversity of agrocenoses requires the search for more sustainable methods of agricultural production.

In Germany, it is estimated that, compared to the first half of the twentieth century, 75% of agrobiodiversity has disappeared; in some sectors of agricultural production, "genetic erosion" is over 90%. Thus, according to some estimates, 63 species of mammals and 74 species of birds completely disappeared between 1600 and 1875. Nowadays, from 1 to 10 species of animals and about 1 species of plant disappear annually. In recent years, 600 species of vertebrates and many species of flowering plants have been threatened with extinction. Many other species on the planet are in constant decline, and many of them are threatened with extinction at the national level.

The geological record shows that the average life expectancy of an insect species does not exceed 10 million years. An analysis of the state of insect species diversity allows us to conclude that the current rate of biodiversity decline is 1 species per hour or even minute, which is significantly higher than the rate of extinction during geological disasters.

What determines the low or relatively low number of endangered species, as opposed to all others in a given place or region? By the fact that their ecological niches have special axes of measurement in the niche hyperspace, or need special combinations of them. In other words, the "bottleneck" of rare species is not related to the characteristic conditions of the region, which form many axes of the ecological niche hyperspace. It is related to the special features of these species (narrow food specialization, the need for larger spaces, and so on).

4.2 Ecological and economic services of ecosystem services on the example of pollinating insects

Biodiversity is vital for maintaining ecological processes and is currently considered the main parameter characterizing the state of ecological systems. The destruction of ecosystems poses a threat not only to the animals and plants that make up them, but also to humans.

Insects make up about two-thirds of all biota species and are important for maintaining ecosystem stability and providing ecosystem services.

Ecosystem services are all the useful resources and benefits that humans can obtain from nature. The classification of ecosystem services is based on dividing them into groups according to the following functions:

- supply – includes food, raw materials, fresh water, soils and other resources that can be priced in monetary terms;
- regulation – the whole variety of processes in ecosystems that form the habitat of biota, including humans. These include climate regulation, weather conditions, air quality, freshwater quality and quantity, soil formation, plant pollination, and other processes that support the sustainability of ecological systems;
- maintaining ecosystems – global processes of atmospheric formation, climatic zones, and the cycle of substances in nature. Maintenance of biodiversity, global processes of biochemical cycles, and accumulation of organic matter;
- cultural and social services include intangible benefits and benefits that people receive from nature: opportunities for recreation, spiritual enrichment, inspiration for creativity, scientific knowledge, and the formation of the identity of social and ethnic groups.

Unlike many other ecosystem services, pollination can be monetized relatively accurately, as the value of products derived from insect-pollinated plants is known. For example*, the economic value of pollination of entomophilous plants by honeybees for global crop production is estimated at US $ 518 billion per year*. The work of pollinators in Europe is estimated at about 22 billion euros per year.

In many countries, there is a shortage of pollinators. From 1960 to 2008, the average number of bee colonies per hectare of insect-pollinated crops decreased from 0.23 to 0.16 globally, and from 0.25 to 0.05 in the United States (with the minimum number required for these crops, taking into account their diversity, being 1.2–6.2 bee colonies). In Europe, the demand for pollination services sometimes exceeds the capacity of the available number of honey bees by almost five times.

For example, the United Kingdom has only 34% of the bee colonies needed for the country's agricultural needs.

Loss of ecosystems interrupts the supply of regulating and supply services. All forms of life on Earth are connected by complex relationships, and the disappearance of any component makes the entire system less stable. For example, the disappearance of pollinating insects will lead to the disappearance of many plant species with their fruits, seeds, and the functions they performed. The disappearance of each plant species will lead to the disappearance of several insect species, which will also reduce the number of insectivorous birds; fungi that are in symbiosis with plants also disappear. Thus, the disappearance of one species from the natural ecosystem will lead to the destruction of a large complex structure, the stability of which depends on each component.

All pollinating insects are conventionally divided into specialized and minor ones. Those species of insects whose larvae consume nectar and pollen are the main specialized pollinators Specialized pollinators primarily include Hymenoptera, namely bees and some wasps.

In Ukraine, research on the ecological and economic valuation of ecosystem services is not sufficiently conducted, mainly focusing on the substantiation of methodological approaches to valuation. This state of affairs determines the relevance of our work. Knowledge of the value of ecosystem services is essential for making decisions on biodiversity conservation and maintaining natural processes in the environment.

The importance of beekeeping as a branch of agricultural production is determined primarily by the great importance of bees for pollination of crops, as well as by various types of valuable products produced by bees (honey, wax, propolis, etc.). The increase in yield from pollinating insects is shown in Table 4.1.

Table 4.1

Ecological and economic efficiency of pollination of entomophilous crops

Entomophilous plant, name	**Average yield on the farm, kg/ha**	**Yield increase from pollination*,%.**	**Product price, UAH/kg****
Buckwheat	2000	60	16,8
Winter rape	1500	50	17,3
Sunflower	1800	50	21
Cucumbers in the open field	25000	30	22

* according to (A. Meged, V. Polishchuk, 1986)
** product price as of 05.2016-19 (https://agropolit.com/news/16770-za-rik-tsini-na-grechku-zrosli-na-150; https://landlord.ua/news/zakupivelni-tsiny-na-soniashnyk-v-ukraini-perevyshchyly-21-tys-hrn-t/; https://tripoli.land› raps; https://www.ukrinform.ua/rubric-economy/3048772-gorodni-perspektivi-comu-ne-vsi-ovoci-pospisaut-desevsati.html)

The results of observations of honey bee and other pollinating insects visiting the experimental plots are shown in Table 4.2.

Using alfalfa pollinators as an example, it was found that the daily activity of pollinating insects (bees) is characterized by two flight peaks: the first one – 10 specimens/100 b.p. – occurs at twelve o'clock, the second – 18 specimens/100 b.p. – at six o'clock in the evening. Thus, the period of insect population counts we have given overlaps with the period of pollinator activity in nature.

As can be seen from the above data, honey bees dominated in the structure of the insect pollinator community of the studied entomophilous crops, the highest degree of dominance was noted in buckwheat crops – 83.1%.

Using the average yields of the studied entomophilous crops on the farm, the total yield increase from pollination (see Table 4.1), and the composition of the pollinator community (see Table 4.2), we calculated the actual yield increase from pollination of different crops and differentiated it by the contribution of domestic bees and wild pollinators. The results of the study are shown in Table 4.3.

Table 4.2

Intensity of visits and composition of the pollinator community of different entomophilous crops

Culture	Pollinating insects, units	Dynamics of visiting the crop (1 m2 per 15 minutes)					Composition grouping of insects pollinators
		9 o'clock	10 o'clock	16 o'clock	17 o'clock	18 o'clock	
Rapeseed winter	Domestic bee,	7 ± 0,8	7 ± 0,5	10 ± 1,2	12 ± 1,4	10 ± 1,0	80,7 %
	Wild pollinators	3 ± 0,5	2 ± 1,2	1 ± 0,9	3 ± 0,5	2 ± 0,8	19,3 %
Buckwheat	Domestic bee,	9 ± 0,1	12 ± 1,4	15 ± 1,8	15 ± 2,0	13 ± 1,6	83,1 %
	Wild pollinators	1 ± 1,2	3 ± 1,6	3 ± 1,9	2 ± 1,8	4 ± 1,8	16,9 %
Sunflower	A domestic bee,	2 ± 0,9	5 ± 0,7	4 ± 0,6	2 ± 0,5	2 ± 0,7	78,9 %
	Wild pollinators	0	1 ± 0,9	2 ± 0,5	0	1 ± 0,9	21,1 %
Cucumber	A domestic bee,	4 ± 0,8	5 ± 0,7	5 ± 0,9	4 ± 0,5	3 ± 0,6	72,4 %
	Wild pollinators	2 ± 0,7	1 ± 0,9	2 ± 0,6	2 ± 0,9	1 ± 0,9	27,6 %

Taking into account the current price of the products of the studied entomophilous crops (Table 4.1) and the actual increase in yield from pollinators on the farm, we calculated the income from the increase in yield of each crop. The data obtained are presented in Table 4.4.

Table 4.3

Yield increase from pollination of entomophilous crops by honey bee and other pollinating insects, kg/ha

Name of the crop	Yield increase from pollination, kg/ha	Yield increase from honey bee pollination, kg/ha	Yield increase from pollination by wild pollinating insects, kg/ha
Edible buckwheat	1200	997	203
Winter rape	750	606	144
Sunflower	900	710	190
Cucumbers in the open field	7500	5430	2070

Table 4.4

Income from additional yield from pollination of entomophilous crops, UAH/ha

Name of the crop	Revenue from pollination of entomophilous crops by insects, UAH/ha	Income from pollination of entomophilous crops by honey bee, UAH/ha	Income from pollination of entomophilous crops by other insect pollinators, UAH/ha
Common buckwheat	20160,00	16269,12	3890,88
Winter rape	12975,00	10470,83	2504,17
Sunflower	18900,00	14912,10	3987,90
Cucumbers in the open field	165000,00	119460,00	45540,00
Total	217035	161112,05	55922,95

As can be seen from the above results, the cost of the ecological service of pollination of the studied entomophilous crops in the farm is 217035 UAH/ha, of which 161112.05 UAH/ha is accounted for by pollination by honey bees.

The total area of the studied entomophilic crops in Ukraine is: sunflower – 6.37 million hectares; rapeseed – 1.1 million hectares; buckwheat – 60 thousand hectares; open field cucumber – 80 thousand hectares.

In terms of the total area of the studied crops in Ukraine, the value of the ecosystem service is estimated as follows:

sunflower pollination – 18900.00 UAH/ha × 6370000 ha = 120393000000 UAH = 120.4 billion UAH

pollination of winter rape – 12975.00 UAH/ha × 1100000 ha = 14272500000 UAH = 14.3 billion UAH;

buckwheat pollination – 20160 UAH/ha × 60,000 ha = 1209600000 UAH = 1.21 billion UAH;

pollination of open field cucumber – 165000.00 UAH/ha × 80,000 ha = 13200000000 UAH = 13.2 billion UAH.

In total, it amounts to UAH 149.11 billion.

Thus, the total value of the ecosystem service of pollination of only four studied entomophilous crops in Ukraine convincingly demonstrates the economic relevance of preserving insect pollinator biodiversity.

SECTION 5. HARMONIZATION OF NATIONAL AND EUROPEAN LEGISLATION IN THE FIELD OF BIODIVERSITY CONSERVATION

5.1 Convention on Biological Diversity

The scientific literature states irreversible processes of global biodiversity depletion. Today, biodiversity is being lost in the course of construction, land plowing, land reclamation, construction of reservoirs, creation of transport infrastructure networks, and other economic activities. The areas occupied by natural vegetation are shrinking, leading to the threat of loss of the gene and price pool. Biological diversity is the result of centuries of evolution, so it must be passed on to future generations in the most preserved condition.

The diversity of biological structures and processes is the basis for the organization of the biosphere in all its global manifestations. One of the most commonly used definitions of biodiversity by ecologists is "The totality of genes, species, and ecosystems in a region." This definition allows for a unified approach to different levels of biota organization. Biodiversity is the basis for the structural and functional organization of the living matter of the biosphere and its ecosystem components, which determines the stability and resilience of the latter to external influences.

The phrase "biodiversity" was first used by G. Bates in his famous work "A Naturalist in the Amazon" when he described his impressions of meeting about 700 different species of butterflies during an hour-long excursion.

The estimates of the degree of biodiversity of the Earth were first introduced by biogeographers who, in the XVIII–XIX centuries, developed schemes of botanical, geographical and zoogeographical division of the surface of our planet according to the degree of originality of flora and fauna. In the twentieth century, the same schemes were drawn up not only for flora and fauna, but also for ecological communities of plants and animals, and biogeocenoses.

The United Nations Environment Programme (UNEP) organized an Ad Hoc Working Group of Experts in November 1988 to study the need to develop an international convention on biodiversity. In February 1991, the Ad Hoc Working Group was transformed into the Intergovernmental Negotiating Committee. The result of its work was the Conference on the Adoption of the Agreed Text of the Convention on Biological Diversity held in Nairobi on May 22, 1992. The Convention was opened for signature on June 5, 1992, at the United Nations Conference on Environment and Development in Rio de Janeiro (Earth Summit). One of the main outcomes of the Rio Conference was the Framework Convention on Biodiversity.

The Verkhovna Rada of Ukraine ratified the Framework Convention on November 29, 1994 (the Ratification Law), and adopted a number of laws on ratification, accession and implementation of other binding and non-binding international treaties regulating the conservation and use of biological and landscape diversity. At the national level, the National Commission on Biodiversity Conservation and the Ministry of Environmental Protection of Ukraine coordinate the implementation of the laws and relevant programs.

The Cabinet of Ministers of Ukraine approved the Concept of the National Biodiversity Conservation Program for 2005–2025 by its Resolution No. 675-r of September 22, 2004.

As an officially approved national action plan to implement the global Strategic Plan and Targets for Biodiversity, Ukraine presented the Law of Ukraine of 2010 "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period up to 2020" (http://zakon.rada.gov.ua/laws/show/2818-17). This document defines seven national goals.

National target 1 (NT1). Increase the level of public environmental awareness.

Rationale: the need to raise public awareness and education on environmental conservation and protection, dissemination of information; professional development of civil servants in charge of environmental protection; the need to support and promote public associations and communities involved in environmental protection; creation of information, experimental and demonstration and training centers to support measures to implement and disseminate models of non-polluting environmental practices. The Goal and Objectives are also directly in line with the obligations under the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters; they are also in line with the implementation of many other international environmental treaties signed and ratified by Ukraine and/or their respective resolutions and decisions.

The objective is directly or indirectly facilitated by the provisions of the current regulatory legal acts, in particular: the Laws of Ukraine "On Access to Public Information", "On the Ecological Network of Ukraine", "On the National Program for the Formation of the National Ecological Network of Ukraine for 2000–2015", "On Environmental Protection", "On Environmental Impact Assessment", "On Flora", "On Strategic Environmental Assessment", "On the Red Book of Ukraine"; "Regulation on the Green Book of Ukraine" and others, "Concept of the National Program for Biodiversity Conservation for 2005–2025".

National goal 2 (NG2). Improving the environmental situation and increasing the level of environmental safety.

Rationale: the need to improve environmental safety by introducing an integrated approach to risk assessment, prevention and minimization of the consequences of natural disasters in accordance with the Johannesburg Plan of Action, reducing emissions of common pollutants, implementing and/or intensifying measures to protect water resources and reduce their pollution, protecting land and soil and managing them on the basis of sustainable development; the need to increase the area of forests; introduction of safe technologies and NC 2 corresponds to the implementation of the provisions of signed and ratified international treaties, in particular: Convention on the Protection of the Black Sea against Pollution, Convention on the Protection and Use of Transboundary Watercourses and International Lakes, Convention on Environmental Impact Assessment in a Transboundary Context, Convention on Long-range Transboundary Air Pollution, Convention to Combat Desertification, etc.

This goal is directly or indirectly facilitated by the provisions of the following legal acts, in particular:

- Land, Water, and Forest Codes of Ukraine, as well as the Subsoil Code;
- The Laws of Ukraine "On Waste", "On the State Land Cadastre", "On the Ecological Network of Ukraine", "On the General Principles of Further Operation and Decommissioning of the Chornobyl Nuclear Power Plant and Transformation of the Destroyed Unit 4 of this NPP into an Environmentally Safe System", "On the National Program for the Formation of the National Ecological Network of Ukraine for 2000-2015", "On Land Management", "On Atmospheric Air Protection", "On Environmental Protection", "On Environmental Impact Assessment", "On Strategic Environmental Assessment", "On Radioactive Waste Management", "On the Nature Reserve Fund of Ukraine", "On Fisheries, Commercial Fishing and Protection of Aquatic Bioresources", "On Wildlife";
- "National Action Plan to Combat Land Degradation and Desertification", "National Waste Management Strategy in Ukraine until 2030", "Action Plan for the Implementation of the Stockholm Convention on Persistent Organic Pollutants", "National Transport Strategy of Ukraine until 2030", "Concept of the National Program for Biodiversity Conservation for 2005–2025", etc.

National target 3 (NT3). Achieving a safe environment for human health. *Rationale:* the need to ensure the biosafety of the population, in particular through: prevention of violations and compliance with sanitary and hygienic requirements for air quality in settlements, surface water quality in places of intensive water use by the population, water quality used for drinking water supply and cooking by the rural population; preparation of a targeted program for assessing and preventing risks to the health of the population of Ukraine from environmental factors; Identification of environmental risk zones and preparation of a state target program to reduce man-made pressure on the health of the population in environmental risk zones; strengthening state environmental control over compliance with legislation in the process of siting, construction, and operation of new man-made facilities; creation of institutional frameworks for informing the public about environmental risks; development of the state environmental monitoring system by modernizing it, strengthening coordination of monitoring entities and improving data management systems as a basis for making management decisions.

- ✓ The achievement of the goal is directly or indirectly facilitated by the provisions of the current regulatory legal acts, in particular:
- ✓ Water Code;
- ✓ Laws of Ukraine "On Waste", "On the National Program for the Formation of the National Ecological Network of Ukraine for 2000-2015", "On Atmospheric Air Protection", "On Environmental Protection", "On Environmental Impact Assessment", "On Drinking Water and Drinking Water Supply", "On the Nature Reserve Fund", "On Flora", "On Strategic Environmental Assessment", "On Fauna", etc;
- ✓ "National Transport Strategy of Ukraine for the period up to 2030", "Concept of the National Program for Biodiversity Conservation for 2005–2025".

National target 4 (NT4). Integration of environmental policy and improvement of the integrated environmental management system.

Rationale: the need to develop and implement a regulatory framework for the mandatory integration of environmental policy into other documents; institutional development and strengthening of the effectiveness of public administration in the environmental sector; development of partnerships between sectors of society in order to involve all stakeholders in the planning and implementation of environmental policy; implementation of environmental management systems and preparation of state targeted programs for the greening of certain sectors of the national economy; introduction of new standards for the purpose of greening the industrial and energy sectors, transport, housing and communal services and construction, and agriculture; development and implementation of a system of incentives for business entities that implement an environmental management system; etc.

The goal and defined tasks are related, directly or indirectly, to the norms and provisions of Ukrainian legislation, in particular:

- Land and Water Codes of Ukraine;
- Laws of Ukraine "On the National Program for the Formation of the National Ecological Network of Ukraine for 2000-2015", "On Environmental Protection", "On Air Protection", "On Environmental Impact Assessment", "On Strategic Environmental Assessment", etc;
- "National Action Plan to Combat Land Degradation and Desertification", "Action Plan for the Implementation of the Concept of State Policy in the Field of Climate Change for the Period up to 2030", "Concept of the National Program for Biodiversity Conservation for 2005–2025", etc.

National target 5 (NT5). Halt the loss of biological and landscape diversity and create an ecological network.

Rationale: the need to create a system of prevention and control over invasive species; control over trade in endangered species of wild flora and fauna; education on the value of ecosystem services and further application of ecosystem services valuation; increase in the area of the national ecological network, introduction of a system of environmental measures to preserve biodiversity and landscape diversity and expansion of the area of the nature reserve fund; implementation of the ecosystem approach in management activities and adaptation of Ukrainian legislation in the field of environmental protection to the requirements of the EU directives; creation of a network of centers for artificial breeding and reacclimatization of rare and endangered species of plants and animals; creation of a system of economic levers that would contribute to the conservation of biodiversity and landscape diversity and the formation of an ecological network; taking measures to stop the catastrophic decline in aquatic life resources. Complies with the provisions of international treaties to which Ukraine is a party, in particular: Berne Convention on the Conservation of European Wildlife and Natural Habitats, Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the EUROBATS, ACCOBAMS, AEWA agreements; Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); Ramsar Convention on Wetlands of International Importance, especially as Waterfowl Habitat; Convention on the Protection of the Black Sea against Pollution; UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage; Framework Convention on the Protection and Sustainable Development of the Carpathians; European Landscape Convention.

- ✓ The objective is directly or indirectly facilitated by the provisions of the following legal acts, in particular:
- ✓ The Laws of Ukraine "On the Ecological Network of Ukraine", "The National Program for the Formation of the National Ecological Network of Ukraine for 2000-2015", "On Environmental Protection", "On Environmental Impact Assessment", "On the Nature Reserve Fund of Ukraine", "On Fisheries, Commercial Fishing and Protection of Aquatic Bioresources", "On Flora", "On Fauna", "On Strategic Environmental Assessment", "On the Red Book of Ukraine", etc.
- ✓ "Regulations on the Green Book of Ukraine", "Concept of the National Program for Biodiversity Conservation for 2005–2025", etc.

National target 6 (NT6). Ensure environmentally balanced use of natural resources.

Rationale: The need to ensure sustainable use of natural resources, further development of the national system of natural resource cadastres, state statistical reporting on the use of natural resources and environmental pollution, preparation of the Concept of Sustainable Consumption and Production, introduction of a system of mechanisms to encourage producers to use natural resources sustainably and renewably and to protect the environment, and introduction of new cleaner technologies, innovations in the field of natural resources management, increasing energy efficiency of production, increasing the use of renewable and alternative energy sources, increasing the share of land used in organic agriculture, creating an environmentally and economically sound system of payments for special use of natural resources and environmental pollution charges to encourage business entities to use natural resources rationally, reforming the current system of environmental protection funds. Complies with the provisions of international treaties signed and ratified by Ukraine, in particular: UN Convention on Climate Change, UN Convention to Combat Desertification.

- ✓ The achievement of the goal is directly or indirectly facilitated by the provisions of the following legal acts, in particular:
- ✓ The Laws of Ukraine "On the Ecological Network of Ukraine", "On Atmospheric Air Protection", "On Environmental Protection", "On Environmental Impact Assessment", "On Fisheries, Commercial Fishing and Protection of Aquatic Bioresources", "On Flora", "On Strategic Environmental Assessment", "On Fauna";
- ✓ "Energy Strategy of Ukraine for the period up to 2035 "Security, Energy Efficiency, Competitiveness", "National Action Plan to Combat Land Degradation and Desertification", "Action Plan for the Implementation of the Concept of the State Policy in the Field of Climate Change for the

period up to 2030", "Concept of the National Program 16 for Biodiversity Conservation for 2005–2025".

National target 7 (NT7). Improvement of regional environmental policy.

Rationale: the need to improve regional policy with regard to the environmental component, including the development and implementation of regional environmental action plans, including the development of methodology and preparation of local action plans for the implementation of the environmental component in strategic documents for the development of cities and regions, the development of a regulatory framework for environmental and economic macro-regions, and the classification of regions by levels of technogenic and environmental risks, creation of appropriate geoinformation data banks and maps, implementation of a pilot project to combine the territorial planning system with long-term forecasting procedures, environmental, social and economic planning and strategic environmental assessment, development of public-public-power-business partnerships at the regional level, and reduction of the negative impact of urbanization on the environment. It corresponds to the implementation of the provisions of the Framework Convention on the Protection and Sustainable Development of the Carpathians and the Convention concerning the Protection of the World Cultural and Natural Heritage signed and ratified by Ukraine.

The implementation of the national goal is directly or indirectly facilitated by the provisions of the current regulatory legal acts, in particular the Laws of Ukraine "On the Ecological Network of Ukraine", "On the National Program for the Formation of the National Ecological Network of Ukraine for 2000–2015", "On Air Protection", "On Environmental Protection", "On Environmental Impact Assessment", "On Strategic Environmental Assessment", etc., as well as the provisions of the State Strategy for Regional Development of Ukraine for the period up to 2020 , "Concept of the National Program for Biodiversity Conservation for 2005–2025" and others.

5.2 Implementation of the Association Agreement between Ukraine and the European Union in the field of biodiversity conservation

A set of legal and regulatory measures aimed at Ukraine's accession to the European legal area. European integration is the main driver for the modernization of Ukraine's biodiversity conservation legislation. The legal basis for European integration processes in the environmental sector is Title V, Chapter 6 of the EU–Ukraine Association Agreement. Annex XXX to the Association Agreement provides for the approximation of national legislation to EU legislation in the environmental sector. Since 2017, the Action Plan for the Implementation of the Association Agreement between Ukraine and the European Union has been in place, and it provides for the improvement of waste management, protection of migratory wild bird species, implementation of the Birds and Habitats Directives, development of the Emerald Network, promotion of environmental education, implementation of legislation on the Azov and Black Seas, improvement of basin water management and prevention of water pollution, etc. The plan implementation is related to: "The Procedure for Developing a River Basin Management Plan", the Laws of Ukraine "On Amendments to the Law of Ukraine "On Drinking Water and Drinking Water Supply", "On Ratification of the Agreement between the Cabinet of Ministers of Ukraine and the Government of the Republic of Moldova on Cooperation in the Field of Protection and Sustainable Development of the Dniester River Basin", "On Ratification of the Agreement on Financing the Danube Transnational Program". The Ministry of Ecology and Natural Resources of Ukraine submitted for public discussion the draft Law of Ukraine "On the Emerald Network Territories". In order to reduce environmental pollution, the Action Plan for the implementation of the Agreement provides for the transposition of the requirements of the relevant directives into the national legislation of Ukraine. The development of environmental draft laws and enhancement of the institutional capacity of stakeholders is supported by the European Commission, UNDP GEF, individual partner countries, etc. The projects involve companies (e.g., EPTISA) and NGOs (e.g., EPL). APENA is the EU project "Support to Ukraine in Approximating EU Environmental Legislation" (since 2015) to assist in the development of draft laws and regulations, increase the institutional capacity of the Ministry of Ecology and Natural Resources of Ukraine and other stakeholders, and raise public awareness. The development of Ukraine's Emerald Network includes a number of public initiatives aimed at collecting data and substantiating the status of potential Emerald Network sites.

EU–funded projects and the activity of civil society organizations play a key role in the development and promotion of draft laws. The book "Involvement of the Public and Scientists in the Design of the Emerald Network in Ukraine" contains the first version of the "shadow list" (78 territories), proposals for future work, and expert recommendations on the principles for the development of the network. The provisions of the Birds and Habitats Directives, which are key for biodiversity protection, are not yet fully implemented in the national legislation of Ukraine. The draft laws on the implementation of the directives and on the Emerald Network sites are currently under development. A large number of environmental initiatives have been created through the efforts of stakeholders and the public sector, but the adoption and approval of relevant regulations and their implementation are slow and complicated.

5.3 Integrate biodiversity conservation plans into strategic and sectoral development programs

A set of legal and regulatory measures that includes the approval of relevant regulatory acts. "The State Strategy for Regional Development of Ukraine for the period up to 2020 (2014) contains the task of "rational use of recreational resources of territories and objects of the nature reserve fund for the formation of the economic environment and development of employment in the regions". "The Strategy for Overcoming Poverty (2016) includes the restoration, preservation and sustainable use of ecosystems, in particular, as a result of the introduction of a mechanism of economic incentives for the use and protection of land and improvement of soil fertility. "The Strategy for the Development of Tourism and Resorts for the Period up to 2026 (2017) stipulates the need to ensure the balanced use of natural therapeutic and recreational resources, preserve the ability of natural complexes to reproduce themselves, and create an interactive database containing information on the tourism and recreational resources of Ukraine, including cultural heritage sites and nature reserves. "The Action Plan for the Implementation of the Concept for the Implementation of the State Policy in the Field of Climate Change for the Period up to 2030 (2017) provides for the identification and implementation of approaches and technologies that provide for the balanced management of natural ecosystems. "The National Transport Strategy of Ukraine for the period up to 2030 (2018) envisages the development of safe, environmentally friendly and energy-efficient transport for society. It includes the fulfillment of obligations under the Convention on the International Maritime Organization, the Convention on Biological Diversity and the Convention to Combat Desertification, requires the use of technologies that minimize the impact on wildlife and land, contribute to the conservation of marine biodiversity, and take into account the needs of environmental protection, conservation of land, water bodies, and biodiversity in the development of transport infrastructure. The purpose of the approved Energy Strategy of Ukraine for the period up to 2035 (2017) is to meet the needs of society and the economy in fuel and energy resources in a technically reliable, safe, cost-effective and environmentally acceptable manner to ensure the improvement of the living conditions of society and provides for the implementation of measures to achieve strategic goals in the field of environmental protection, including: approval of the National Plan for Reducing Emissions from Large Combustion Plants and reconstruction and modernization of thermal power plants and One of the goals of the Strategy for Development of the Agricultural Sector of the Economy for the period up to 2020 (2013) is the rational use of agricultural land and reduction of the anthropogenic impact of the agricultural sector on the environment.

5.4 Creation and status of eco-grid implementation in Ukraine

The model of an ecological network as a specific conservation measure has been developed in Europe for more than 10 years. The reason for this was the need to address the problems associated with the restoration of large herbivores within their historical ranges in Europe, namely, to ensure their long-distance movement and migration routes by creating a network of connected areas of natural areas.

Further developments in this area have shown that the ecological network is a key element in the practical implementation of the ecological paradigm of nature management and conservation of the natural framework of national territories and the most effective mechanism for fulfilling the objectives of the Convention on Biological Diversity.

In fact, every sufficiently large area where ecosystems with all their components have been preserved in their natural state is a natural ecological network, i.e., there is a continuum of natural ecosystems in such an area and all living organisms have the necessary conditions for existence, reproduction and migration. The higher the degree of fragmentation of ecosystems in a given area, the more difficult it is to restore their natural continuum. The territory of Ukraine is very heterogeneous in terms of disturbance of natural complexes. The Carpathians are the least fragmented. Large, intact natural areas have been preserved in the Ukrainian Polissya. The territory of the Forest-Steppe is more fragmented and the Steppe is the most disturbed.

The basic structural elements of Ukraine's ecological network are defined in the Law of Ukraine "On the Ecological Network of Ukraine" in accordance with the principles of territorial structuring of the European Ecological Network. They differ in their functions and are divided into key (cores), connecting (eco-corridors), buffer and restoration areas.

Core areas ensure the conservation of the most valuable and typical components of landscape and biological diversity in the region. Connecting areas (eco-corridors) connect key areas and ensure animal migration, plant and animal dispersal, and the exchange of genetic material. Buffer areas include natural and anthropogenically modified areas, protecting key and connecting areas from external impacts. Restoration areas, represented by anthropogenically altered landscapes, ensure the formation of the spatial integrity of the ecological network.

There are biosphere, continental, national, regional (oblast), and local (local) levels of ecological networks. The key level is the regional level, as it ensures the formation of a real territorial ecological network system.

According to the Law "On the Ecological Network of Ukraine," ecological network design at the regional level is carried out through the development of regional ecological network schemes of oblasts and the city of Kyiv, as well as local ecological network schemes of administrative districts. Regional ecological network schemes can also be developed for natural regions whose boundaries are determined by natural factors, such as river basins, mountain systems, coastal strips of the sea, etc. The main principles that the territorial structure of a regional ecological network should meet are as follows:

- Sufficiency (the total area of the ecological network's territories and objects is sufficient for biodiversity conservation);
- spatial integrity (the territories and objects of the ecological network are connected into an integral spatial system);
- representativeness (both typical and rare species of plants and animals, plant communities, ecosystems, and landscapes are represented on the territory of the ecological network).

The design territorial structure of the regional ecological network is developed based on the characteristics of its constituent structural elements.According to international standards, there are 3 stages of formation of national ecological networks:

- the first (pioneer) – the network as a prospective list of specific territories and their cartographic representation;

- second – the network as a basis for a national environmental plan;

- third – a network as part of an integration national or regional (local) plan.

Ukraine is at the first stage of forming a national ecological network. It is the only country in the entire post-Soviet space, and possibly in Europe, that has a legislative framework for creating an ecological network. These are the Laws of Ukraine "On the National Program for the Formation of the National Ecological Network of Ukraine for 2000–2015" (No. 1989-III of September 21, 2000) and "On the Ecological Network of Ukraine" (No. 1864-IV of June 24, 2004). The scientific and methodological foundations for the creation of the ecological network and perspective plans of varying degrees of detail have already been developed. However, there is still no complete prospective list of specific ecological network areas.

Thus, the creation of an ecological system (ecological network) is the formation of an interconnected set of protected areas that ensure ecological balance, landscape biodiversity, and the purity of the biosphere. The creation of a scientifically based ecological network involves ensuring favorable environmental conditions for the life of the organic world; reproduction and preservation of rare natural objects, resources or territorial complexes; satisfaction of scientific and cultural needs of society, creation of preconditions for the balanced use of land, water, forest resources and sustainable development of the territory; conservation of biodiversity, protection of vital ecological processes, ecosystems and landscapes.

5.4.1 Scientific criteria for selecting areas for inclusion in the structural elements of the ecological network and lists of territories and objects of the ecological network

According to the methodological recommendations for the development of regional and local ecological network schemes as the main measure for the conservation of agrobiodiversity, the use of the landscape principle in planning the ecological network of an administrative unit allows for the fullest representation of the floristic and coenotic diversity of the region within its boundaries. Each high-ranking key area should include different landscapes and natural-population complexes, which is a prerequisite for self-regulation of the biota of this key area, and therefore for creating conditions for the restoration of potential flora, vegetation and biota in general that existed in this area in the pre-agricultural period. It is advisable to analyze the territory of an agricultural enterprise using land management maps. This allows you to distinguish landscape elements of different groups within the meadow or steppe areas according to the degree of landscape change. In areas with a predominance of anthropogenic landscapes, the role of small areas of natural vegetation is increasing, provided that they are interconnected in a coherent network. Such a network should be considered as the territory of a structural element of the local ecological network.

Ecocorridors are spatial, elongated structures that connect key areas (cores) and include existing biodiversity of varying degrees of naturalness and habitat. Their main function is to ensure the maintenance of reproduction processes, gene pool exchange, species migration, spread of species to adjacent territories, survival of unfavorable conditions, hiding, and maintenance of ecological balance. The functional purpose of ecological corridors as pathways for migration, colonization and gene exchange through adverse conditions is to cover different geographical distances – from local to global, and for small and sedentary species – from local to regional, which determines the territorial status of ecological corridors.

The shape of the corridors can be either straight or winding. According to the territorial integrity, there are continuous and island eco-corridors. The former are a continuous strip with natural or semi-natural vegetation, while the latter are an elongated contour within which natural areas are located between which there is or is potentially possible exchange of genetic information. It is necessary that they include the maximum number of natural objects characteristic of the key areas they connect and are wide enough to create appropriate conditions for biodiversity. In general terms, the narrower the corridor, the worse it fulfills its purpose, and the wider it is, the better.

Most of the indicators used to identify eco-corridors are the same as those used to identify key areas. They should have optimal conditions for the survival of organisms, opportunities for their movement and migration, places suitable for resting and feeding for migratory animals, and opportunities for integration into a single continental system.

The basic criteria for the selection of connecting areas (eco-corridors) are the naturalness of the boundaries, the breadth and length of the area to ensure the migration of species, their reproduction, and survival of unfavorable conditions. This is due to the fact that the main function of eco-corridors is to ensure spatial connections between key areas. The main criterion for their allocation is migration. An eco-corridor is a territory or a set of territories along which genetic material can be exchanged and migration between key territories can take place. The main conditions for this are:

the length of the eco-corridor is no longer than the distance over which most species that exist in the key areas that the eco-corridor connects migrate;

the width of the eco-corridor allows populations to effectively use it as a migration and settlement channel;

the edaphic conditions of the eco-corridor are similar or close to the edaphic conditions of the key areas it connects;

there are no migration barriers or other factors that may hinder the migration and dispersal of species within the eco-corridor.

The components of the restoration areas of the ecological network include the following areas: long plowed, low-productive; re-salinized due to excessive irrigation; pasture failures, areas of livestock grazing and places of their permanent concentration; weededs with quarantine weed species, including those harmful to human health; quarries, rock dumps, etc. weeds, including those harmful to human health; quarries, rock dumps, etc.; arable land on slopes that are allocated for soil protection strips or permanent areas intended for breeding wild pollinating insects; embankment slopes and exclusion zones along roads, railways, oil and gas pipelines, power lines and other communications; areas of open soils where gully and landslide processes are occurring or may develop; places of permanent recreation and other recreational areas; areas subject to long-term conservation due to radiation, chemical or other pollution that poses a threat to human and animal health; rural areas subject to reclamation – estates, abandoned farms, etc.

5.5 Red Data Book of Ukraine – a way to preserve rare and endangered biodiversity

The Red Data Book is a list of flora and fauna species approved at the state level and the law that defines the procedure for their protection. The book itself is only a printed edition, with an updated version published once every 10 years. Each new edition of the book is a kind of starting point for the next decade (the so-called revision period). The International Red Data Book was first published by the International Union for Conservation of Nature in 1966 in France to protect flora and fauna from destruction. Work on the Red Data Book of Ukraine began in 1975.

The first Red Data Book of Ukraine contained 85 species of animals and 151 species of higher plants. And in April 2021, 1544 species were listed in the Red Data Book of Ukraine, including 687 animals and 857 representatives of the plant world. Only humans can preserve the diversity of nature and prevent the number of pages in the Red Data Books of the planet from increasing.

The Red Data Book of Ukraine is the main document that summarizes the materials on the current status of rare and endangered species of animals and plants, on the basis of which scientific and practical measures aimed at their protection, reproduction and rational use are developed.

The Red Data Book of Ukraine includes species of animals and plants that permanently or temporarily occur or grow in natural conditions on the territory of

Ukraine, within its territorial waters, continental shelf and exclusive (maritime) economic zone, and are endangered. Species of animals and plants listed in the Red Data Book of Ukraine are subject to special protection throughout Ukraine.

The book is an official state document on the current status of endangered species of the Ukrainian fauna and on measures for their conservation and scientifically based reproduction.

Depending on the status and degree of threat of extinction of species of flora and fauna listed in the Red Data Book of Ukraine, they are divided into the following categories:

endangered – species for which, after repeated searches conducted in typical areas or other known and possible habitats, there is no information on their presence in nature or specially created conditions;

endangered species – species that have disappeared in nature but have been preserved in specially created conditions;

endangered – species that are threatened with extinction in the wild and whose preservation is unlikely if the factors that adversely affect the state of their populations continue to exist;

Vulnerable – species that may be classified as endangered in the near future if the factors that adversely affect the state of their populations continue to exist;

Rare – species whose populations are small and are not currently classified as endangered or vulnerable, although they are threatened;

unassessed – species that are known to be endangered, vulnerable or rare, but not yet classified as such;

insufficiently known – species that cannot be assigned to any of the above categories due to the lack of necessary complete and reliable information.

As an example, here are 10 species of insects (!) listed in the Red Data Book of Ukraine: Sacred scarab (*Scarabaeus sacer* Linnaeus, 1758), Fragrant red beetle (*Calosoma sycophanta* Linnaeus, 1758), Dumpster beetle (desert beetle) (*Osmoderma eremita* Scopoli, 1763), Hairy staphylin (*Emus hirtus* Linnaeus, 1758), Fragrant bumblebee (*Bombus fragrans* Pallas, 1771), Hatchet moth (*Periphanes delphinii* Linnaeus, 1758), Cheerful moth (*Lygaena laeta* Hubner, 1790), Hungarian moth (*Carabus hungaricus* Fabricius, 1792), Giant moth (*Satanas gigas* Eversmann, 1855), Steppe moth (*Saga pedo* Pallas, 1771) (Appendix 5.). These insects are still found in the biocenoses of Ukraine, but rarely and in rather small numbers (!).

5.6 Key regulatory documents on biodiversity conservation in Ukraine

International agreements

Convention on Biological Diversity – Rio de Janeiro, 1992

Vienna Convention for the Protection of the Ozone Layer – Vienna, 1985

Pan-European Strategy for the Conservation of Biological and Landscape Diversity – Sofia, 1995.

The 1999 Gothenburg Protocol to the Convention on Long-range Transboundary Air Pollution of 1979 on the Control of Acidification, Eutrophication and Ground–level Ozone

European Landscape Convention – Florence, 2000.

Cartagena Protocol on Biosafety to the Convention on Biological Diversity – Montreal, 2000

Kyoto Protocol to the United Nations Framework Convention on Climate Change – Kyoto, 1997

UN Convention to Combat Desertification in Those Countries Suffering from Serious Drought and/or Desertification, Particularly in Africa, 1994

Convention on the Protection of the Black Sea against Pollution, 1992

Convention on the Conservation of Migratory Species of Wild Animals – Bonn, 1979

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1963

Convention concerning the Protection of the World Cultural and Natural Heritage – Paris, 1972

Convention on the Protection of Wild Flora and Fauna and Natural Habitats in Europe (Bern Convention) – Bern, 1979.

Convention on the Protection of the Danube River – Sofia, 1994.

Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia (requires consideration of the issue of implementing appropriate procedures at the national level to sign the Memorandum on behalf of Ukraine).

Memorandum of Understanding on Conservation Measures for the Swift Reed Warbler (Acrocephalus paludicola).

Memorandum of Understanding on the conservation and management of the Central European population of the blackbird (Otis tarda).

Memorandum of Understanding on Conservation Measures for the Thin-billed Curlew (Numenius tenuirostris).

Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity, 2010.

Program of work on protected areas of the Convention on Biological Diversity.

Protocol on the Conservation and Sustainable Use of Biological Diversity to the Framework Convention on the Protection and Sustainable Development of the Carpathian Mountains.

UN Framework Convention on Climate Change – Rio de Janeiro, 1992.

Framework Convention on the Protection and Sustainable Development of the Carpathians – Kyiv, 2003.

Ramsar Convention on the Protection and Conservation of Wetlands – Regina, 1987.

Agreement on the Conservation of African-Eurasian Migratory Waterbirds.

Agreement on the Conservation of Bats in Europe.

Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Adjacent Atlantic Ocean.

Laws of Ukraine

Law of Ukraine "On Environmental Protection" of June 25, 1991.

Law of Ukraine "On the Nature Reserve Fund" of June 16, 1992.

Law of Ukraine "On Protection of Atmospheric Air" of October 16, 1992.

The Law of Ukraine "On Pesticides and Agrochemicals" of March 2, 1995.

Law of Ukraine "On Flora" of April 9, 1999.

The Law of Ukraine "On Moratorium on Clear Felling on Mountain Slopes in Fir and Beech Forests of the Carpathian Region" of February 10, 2000.

The Law of Ukraine "On Hunting and Gaming" of February 22, 2000.

Law of Ukraine "On Ukraine's Accession to the Cartagena Protocol on Biosafety to the Convention on Biological Diversity" of September 12, 2000.

The Law of Ukraine "On Fauna" of December 13, 2001.

Law of Ukraine "On the Red Data Book of Ukraine" of February 7, 2002.

Law of Ukraine "On Land Protection" of June 19, 2003.

Law of Ukraine "On the Ecological Network of Ukraine" of June 24, 2004.

Law of Ukraine "On Environmental Audit" of June 24, 2004.

The Law of Ukraine "On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period up to 2020" of December 21, 2010.

Law of Ukraine "On Fisheries, Commercial Fishing and Protection of Aquatic Bioresources" of July 8, 2011.

Order of the Cabinet of Ministers of Ukraine "On Signing the Protocol on Conservation and Sustainable Use of Biological and Landscape Diversity to the Framework Convention on the Protection and Sustainable Development of the Carpathians" of June 11, 2008.

SECTION 6. METHODOLOGY, METHODS OF BIODIVERSITY ACCOUNTING AND DEFINITION

6.1 Methods of studying the current state of entomological biodiversity

It is convenient to study the state of entomological biodiversity of agricultural landscapes by the life forms of insects of constant and dominant species. During faunal studies, representative samples are obtained from populations, compared with registers of known species, and the actual state of biodiversity of agricultural landscapes is determined. The next step is to compile lists of species biodiversity of the constant and dominant species of the main ecological groups of insects known in Ukraine by life form: geophiles (geobionts, herpetobionts) and phytophiles (chortobionts, dendrobionts), which is the basis for determining the real state of the entomofauna of agricultural landscapes.

Based on the results of remote sensing data, the structure of agrolandscapes of Ukraine is analyzed (by natural zones: Steppe, Forest-Steppe, Polissya). Google Earth photos are used to analyze the components of the agricultural landscape. The survey sites are chosen to include areas of ecosystems of different nature: biocenoses, agrocenoses, trees and shrubs, herbaceous vegetation in semi-natural ecotones, and soil environment.

They use analytical and synthetic, ecological and statistical, and experimental methods that have been tested and recommended for field and laboratory research in entomology, plant protection, and ecology.

The entomofauna is collected according to generally accepted methods once every 7–10 days at stationary sites. The taxonomic affiliation of biological collections is determined using entomological determinants.

Indicators of entomological biodiversity are assessed by species richness and Shannon-Weaver index, which are calculated by M. Bigon.

Collections of insect hortobionts are carried out by mowing with an entomological net during the growing season using standard methods in the accounting plots, which are located in a matrix pattern (4 × 10) at a distance of 25 m from each other, and by catching on yellow glue traps.

6.2 Methods of accounting for herpetobiont insects

Barber traps (0.3–0.5 liter jars, glass or plastic) are buried in the soil so that their mouths are level with the soil surface. Alcohol, formalin, etc. are used to fix the caught insects.)

Trapping grooves 3–4 m long are dug to a depth of 7–10 cm from the soil surface. The walls are vertical and smooth. It is advisable to use catching grooves together with Barber traps, placing the latter at the ends or intersections of two grooves.

Barber traps and catching grooves are used to record insects that actively move on the soil surface. To complete the characterization of the herpetobiont entomofauna, additional surveys are conducted under stones, clods of soil, tree trunks, etc.

6.3 Methods of accounting for insect hortobionts

The entomofauna of any type of grass cover is counted by mowing with a net, using an exhauster, biocenometer, or by visual observation.

During the research, we used the method of mowing with an entomological net. To do this, choose a typical area for the area, mowing is directed against the sun. The net is held in the hands at a distance of 1 m from the ring. With vigorous movements, the net is dragged to the right and left over the surface of the plants with an amplitude of about 180o. With each new stroke, take a step forward. Such double strokes are made 25–50 (respectively, single 50 and 100), after the last stroke the net is moved closer to itself, in the air the collected insects are quickly shaken to the bottom of the net and poured into a prepared jar (stain) with ether or alcohol and closed. In the laboratory, the contents of the stain are poured onto a sheet of paper, and plant parts are selected, carefully examined. The insects are first sorted into systematic groups, counted, the results are recorded in a table, and the insects are placed on a mattress with a label.

To collect small insects, an exhauster is used. This is a test tube or a wide-mouth jar with a stopper. 2 thin (0.5 cm) glass tubes are inserted into the cork, and a rubber tube is pulled over one of them. The opening of the free tube is brought closer to the insect and air is drawn through the rubber tube. In this way, the insect is drawn in and transferred to the test tube (jar).

6.4 Methods of accounting for phyllophagous insects

1. Inspection of trees: small specimens of trees (shrubs) are selected for recording. The insects found are counted and the data are recorded in a diary. Determine the percentage of trees inhabited by a particular species, the average number of individuals found on a tree in the part accessible for inspection. Note the height at which the survey was conducted.

2. Tree shaking: shaking is carried out early in the morning or in cloudy weather when insects are inactive. Insects are shaken off on a tarpaulin placed under a tree or shrub.

3. Mowing with a net on the branches of a tree or shrubs: shake off insects in a net.

4. Accounting for damaged leaves: there are several categories of damage: solid – the insect eats the entire leaf, leaving the petiole; marginal – the leaf is eaten out from the edge; hole – insects eat through holes in the leaf; window – more or less small areas are eaten out on the leaf plane, the upper or lower skin remains intact; skeletonization – the flesh and skin of the leaf are eaten, the veins remain intact; mining – arthropods that have penetrated the epidermis in one place, eat away the parenchyma, leaving traces in the form of spots of various sizes and shapes,

winding lines; spotted – spots of brown, yellow, white, black color formed from sucking the leaf; galls – tumors of various sizes, on willows often collected in the form of a flower from the leaves; tubular – a leaf (leaves) rolled into a tube of various configurations; spider nests – insects fasten the leaves with a web while feeding. Leaf counts are carried out on 5–10 model branches; branches are not cut.

5. Accounting for damage by the degree of leaf eating. The method is used to directly determine the area of leaf surface removal (weight method, pallet method) and to determine the relative degree of removal. In this case, the nature of the damage is determined as follows: there are traces of damage, the leaves are eaten by 5% – 1 point; 2 points – weak damage, the leaves are eaten by 5–25%; 3 points – medium damage – the leaves are eaten by 25–50%, 4 points – severe damage, the leaves are eaten by 50–75%; 5 points – complete damage – the leaves are eaten by 75–100%.

When characterizing the damage to plants by aphids, the degree of plant population by these insects is taken into account on a 4 – point scale: 0 – no aphids, 1 – individual aphids, 2 – single specimens inhabit up to 50% of leaves (branches), 3 – colonies occupy more than 50% of leaves (branches).

6.5 Accounting for soil insects (geobionts)

It is carried out in different ways depending on whether they live in the soil or in the soil litter on the soil surface.

6.5.1 Excavation method. The number and condition of insects in the soil is determined by excavation. Samples during excavation are taken in three types: shallow, regular and deep. Shallow samples (up to 10 cm deep) are used to account for a relatively limited group of insects (cocoons of meadow butterflies, pea moths, young caterpillars, scoops, pupae of moths, etc.) Ordinary samples (up to 45 cm deep, more often 30–35 cm) were used to record most insects living in the soil. Deep soil samples (up to 65 cm, sometimes up to 1 m) are used to record some plate beetles (especially May beetle larvae), gray beet weevil larvae, some thrips and other phytophages living in deep soil layers.

The sites are placed evenly on the plot in order to examine the edges and the middle of the plot. Samples are placed diagonally or evenly across the site (staggered).

The size of soil samples depends on the method of extracting insects. Thus, when manually sampling insects from the soil, square samples of 0.25 m^2 (50X50 cm) are most often laid. The soil is removed from each sample in layers: the first layer is 5 cm deep, each subsequent layer is 10 cm deep. When using the wash method, all layers should be taken 5 cm deep. Insects are selected, counted and identified separately for each layer.

On narrow long sections (road edges, irrigation canals), the "snake" sampling method is used. In homogeneous areas of small area, soil samples are placed along two mutually intersecting diagonals.

6.5.2 Manual sampling method. An area of the required size is measured on the soil surface using the distributions applied to the shovel, and the edges of the area are dug. The soil removed from the sample is placed on a bedding (plywood, tarpaulin, film), and then insects are removed from it by hand. All live and dead insects are removed from the soil and put into a jar with a strong solution of salt. If the excavation is in layers, then as many jars are used for each section as there are layers.

6.5.3 The sieving method is suitable for dry and slightly moist soil. This method uses a set of soil sieves with different sized holes. The soil sieves are stacked in such a way that the largest mesh size is at the top and the sieves with gradually decreasing mesh sizes are below. The soil from the sample is passed through a set of these sieves in small portions. Larger insects remain on the top sieve, smaller insects on the intermediate sieve, and the smallest insects on the bottom sieve.

6.5.4 The washing method is the most accurate way to extract insects from soil. This method can remove almost all, even the smallest objects from a soil sample. Three metal basins are filled halfway with water, the soil sample is immersed in the first basin and stirred thoroughly with a stick. Then, the second sample is immersed in the second basin and stirred as well. A third sample is placed in the third basin and also mixed. Most of the insects in the basins float away. They are collected from the surface of the water in a test tube and the sample is mixed again.

PRACTICAL PART OF THE DISCIPLINE "BIODIVERSITY AND ITS CONSERVATION"

MODULE I. BIODIVERSITY AND ITS IMPORTANCE
Practical work № 1.
Biodiversity as an objective factor in assessing the state of the environment and ecosystem stability

Objective: to deepen knowledge about biodiversity, to explore the importance of biodiversity as a factor in disaster assessment and ecosystem stability.

Progress of work

1. Analyze the reference material "Biodiversity – an objective factor in assessing the state of the environment and ecosystem stability"
2. Complete the task
3. Answer the questions

In everyday life, we are already accustomed to such terms as "ecology", "environment", "natural environment", "environment" and know that in one way or another they are related to the protection of nature, its national wealth and man himself as an integral part of nature. Recently, a new term has emerged – "biological diversity" or "biodiversity" – which is closely related to the above-mentioned terms and is now becoming more and more common in our everyday life.

The term **"biological diversity"** as a legal category emerged as a result of the adoption of the Convention on Biological Diversity at the UN Conference on Environment and Development (the Convention was opened for signature by the Parties on June 5, 1992 and entered into force on December 29, 1993). In 1995, Ukraine ratified the Convention on Biological Diversity, assuming a number of obligations, including the obligation to develop a national strategy for biodiversity conservation.

The Convention defines biodiversity as the ability of different species of wildlife to exist: all species, not just those that, from the point of view of the States Parties to the Convention, have actual or potential benefits for humanity. The latter fall under the definition of "bioresources", which is much narrower than "biodiversity", since "bioresources" include genetic resources, organisms or parts thereof, populations or any other biotic components of ecosystems, as actual or potential benefits or value to humanity, expressed in money.

Biodiversity is of great ecological, genetic, social, scientific, cultural, recreational and aesthetic value; it is essential for the evolution and preservation of ecosystems and the biosphere as a whole. An important task today is to preserve it.

Biodiversity is the diversity of living organisms from all sources, including terrestrial and aquatic ecosystems and the ecological complexes of which they are a part. This concept encompasses diversity within a species, between species, and in ecosystems.

Biodiversity can be divided into three categories:

- genetic diversity
- species diversity;
- ecosystem diversity.

Genetic diversity is the diversity within a single species.

Species diversity is the diversity within one region.

Ecosystem diversity is the diversity of habitats, biotic communities and ecological processes in the biosphere.

All three levels of biodiversity form a single system. A decrease in the genetic diversity of a species, which occurs, for example, as a result of the division of a once unified area into parts (habitat fragmentation), can lead to the death of the species, and thus to a decrease in the biological diversity of the region. Biodiversity is directly related to the stability of ecosystems and the biosphere as a whole, and at the same time, it is subject to various changes, including those caused by human activity. Decreasing biodiversity leads to the destruction of existing ecological links and degradation of natural communities to the point of their inability to sustain themselves and, ultimately, to their destruction.

Biologists estimate that there are between 5 and 30 million species, with the most conservative estimate being about 10 million. Only 1.4 million species have been systematized. The greatest species diversity is observed among microorganisms, insects, and small ocean inhabitants. The areas characterized by the highest species diversity are the humid tropical forests of Southeast Asia, Central and West Africa, and Latin America. Ukraine has a rich biota, which includes more than 25 thousand species of plants and 45 thousand species of animals.

Problems of biodiversity loss.

Today, no one doubts the fact that the problem of wildlife conservation is linked to the problem of biodiversity.

National actions in the field of biodiversity conservation are based on the provisions of the Constitution of Ukraine adopted in 1996 and are carried out in accordance with environmental legislation, the requirements of international conventions to which Ukraine is a party, and the European Strategy for the Conservation of Biological and Landscape Diversity.

Thus, the Convention on Biological Diversity is considered by the international community to be the most important legal means of solving one of the global environmental problems and, at the same time, to a large extent a criterion for assessing the level of development and civilization of states. Therefore, Ukraine's active participation in international cooperation in this area and strict compliance with the requirements of the Convention are of particular importance to our country.

The main objectives of the Convention on Biological Diversity are the conservation of biodiversity, the sustainable use of its components and the fair and equitable sharing of benefits arising from the utilization of genetic resources through appropriate transfer of relevant technologies, taking into account all rights to such resources and technologies, and through adequate funding.

The content of the Convention demonstrates the intention of the Parties to unite their efforts to preserve wildlife as a common heritage of all mankind through contractual arrangements.

The Red Data Book of Ukraine is the main state document that contains generalized information on the current status of endangered species of animals and plants, as well as measures for their conservation and scientifically based reproduction. Species of animals and plants listed in the Red Data Book of Ukraine are subject to special protection throughout Ukraine. Depending on the status and degree of threat to the populations of animal or plant species, they are divided into the following categories: endangered, threatened, vulnerable, rare, uncertain, poorly known, and restored.

Biodiversity ensures ecosystem and biosphere functions of living organisms and shapes the human environment. Unfortunately, today we are losing this wealth as we build up, plow land, reclaim land, build reservoirs, create transport infrastructure networks, and carry out other economic activities. Over the past 350 years alone, about 60 species of animals and almost 100 species of birds have disappeared from the surface of our planet, one third of them in the past 50 years. Today, about 600 species of animals are on the verge of extinction.

Control over resource extraction is of great importance for the preservation of flora and fauna in our country. For example, many species of fish, mammals, and birds are disappearing due to overfishing, hunting, and poaching. As for plants, species with medicinal or ornamental properties that are harvested by harvesting organizations and local people are affected. The analysis of the dynamics of changes shows a general trend towards an increase in the loss of flora and fauna species under the influence of anthropogenic pressure on the environment. In order to create the preconditions for biodiversity conservation in Ukraine, it is necessary to provide an appropriate regulatory framework and develop a biodiversity monitoring program for Ukraine focused on ensuring the solution of such tasks:

- monitoring the state of biodiversity in Ukraine;
- restoration of anthropogenic landscapes and disturbed natural ecosystems; creation of conditions for the reproduction of endangered species populations and reintroduction of rare and endangered species;
- preventing the emergence of alien species that are dangerous to local flora and fauna;
- implementation of a number of measures aimed at balanced use of bioresources;
- implementation of measures to ensure compliance with the standards of pollutant

emissions into the environment;

 improvement of nature reserve management in Ukraine;

 organization of environmental activities with the participation of the local community.

Objectives:

 Show the importance of the legal framework for biodiversity conservation;

 Identify the problems of biodiversity loss.

 To get acquainted with the creation of preconditions for biodiversity conservation in Ukraine.

Answer the questions:

1. What do we understand by the term "biodiversity"?

   1) Only rare and vulnerable species of plants and animals;

   2) all flora and fauna;

   3) only the diversity of ecosystems;

   4) the diversity of life at all levels, from molecular genetic diversity to the biosphere.

2. What categories is biodiversity divided into?

3. What are the main measures to be taken to preserve biodiversity?

   1) Make the fullest use of available natural bioresources for the benefit of humans;

   2) the available natural bioresources should be fully protected from human impact;

   3) the current way of using natural bioresources should continue;

   4) balanced protection and rational use of natural bioresources.

4. Write the names of several "Red Book" species (no more than 10).

   - ____
   - ____
   - ____

5. What are the main threats to biodiversity?

6. What ways do you consider to be the most effective for biodiversity

conservation? (please, underline up to three main answers)

a) create new nature reserves; unite protected areas into an ecological network;

b) supplement the Red Book and Green Book of Ukraine, protect rare species;

c) ban hunting, and transfer the lands of hunting farms to the reserve fund of Ukraine;

d) reduce environmental pollution;

e) develop biological and environmental education;

f) to develop and start implementing a state program that provides for all of the above;

g) other.

Practical work №2.

Biological diversity of Ukraine and principles of its protection

Objective: To get acquainted with the current state of biodiversity in Ukraine.

Materials and equipment: ecological and environmental maps of Ukraine and its regions; Red Book of Ukraine, Green Book of Ukraine; herbaria and collection materials of rare species of biota.

Procedure:

1. Familiarize yourself with the theoretical material

2. Analyze the current state of the biota of Ukraine.

3. To complete the task.

Biota of Ukraine

The geographical location of Ukraine and its natural conditions have contributed to the formation of a rich flora and fauna consisting of more than 70,000 species. It is estimated that one third of the species, especially among insects and fungi, have not yet been described. However, the high intensity and scope of anthropogenic impact has had a significant impact on Ukraine's biodiversity.

There are more than 25,000 species of plants, fungi, mushrooms and lichens in Ukraine, including 5,100 species of vascular plants, and, including the most important cultivated species, including exotics grown in open ground in botanical gardens, more than 75,000 species. About 250 species of vascular plants are recognized by the state as medicinal, although almost 1,100 species contain biologically active substances, and their preparations are used in the world for the manufacture of medicines.

The most floristically rich regions of Ukraine are the Crimean Mountains and the Carpathian mountain systems (2220 and 2012 species, respectively). Crimea has a higher number of endemic species (240 to 300).

More than 29% of Ukraine's territory is covered by natural, secondary and semi-natural vegetation, including: forests –14.3%, meadows – 9.7%, swamps – 2%, steppes and salt marshes – 3%. Almost a quarter of Ukraine's flora species are concentrated in forests (15.5% in broadleaf forests) and about 20% in steppes. Vitamin (over 200 species), essential oil (300 species), tanning and dyeing plants (100 species each) are widely represented. Woody plants include more than 100 species.

The fauna of Ukraine includes more than 45,000 species, including more than 44,000 species of invertebrates (more than 35,000 species of insects). Vertebrates are represented by fish and amphibians (about 200 species), amphibians (17 species), reptiles (21 species), birds (about 400 species), mammals (108 species), and 12 vertebrate species are endemic. Up to 80% of the flora of the Ukrainian Polissya and Steppe is protected in nature reserves, and the flora of the Ukrainian Carpathians and the mountainous Crimea is almost completely protected. Animal species diversity is less well protected.

Nature conservation strategy

The idea of nature conservation was first expressed by J.J. Rousseau, but it gained general recognition after the First International Congress on Nature Conservation, held in 1913 in Switzerland. In 1980, the World Strategy for the Conservation of Nature and Natural Resources was proclaimed. In 1982, the UN plenary adopted the World Charter for Nature, which became a document of global importance. Nowadays, nature protection is understood as a system of scientific knowledge and practical approaches to the rational use of natural resources, protection of the environment from anthropogenic degradation and preservation of flora and fauna species from destruction. The protection of all natural systems and objects became especially important in the 80s and 90s of the last century. The nature conservation strategy includes:

a) preservation of biodiversity in natural biomes;

b) growing plants and breeding animals in botanical gardens and zoos;

c) reintroduction of plants and animals in their original habitats;

d) long-term storage of genetic information in the form of cryobanks - deeply frozen germ and somatic cells.

Rapid anthropogenic changes in the natural environment have necessitated the preservation of its "standards" that have not yet been subjected to such impacts. A new approach to nature conservation is the creation of so-called "species habitats". This is a rational method, as in many cases species become extinct not as a result of direct human destruction, but as a result of the destruction of their habitats. Protected areas should be large enough. Their dismemberment, the so-called insularization, leads to the loss of habitats necessary for living organisms. In small reserves, the natural environment is rapidly deteriorating, there are few ecotopes, and animal migration is not possible. The development of the conservation theory has led to the conclusion that it is not possible to protect habitats or individual species of living organisms from global pollution at the local level. Reserves and other protected areas, as well as those that are not, are sensitive to the effects of acid rain, soil and groundwater pollution.

Protection of the gene pool. The Red Book of Ukraine

One of the most important tasks of nature protection is to preserve biodiversity. Biodiversity protection begins with the preservation of the gene pool of living organisms on the planet. Such conservation should apply to all living things on the planet. By the way, the number of species has not yet been precisely established and ranges from 5 to 80 million, due to different interpretations of the number of viruses and bacteria species by experts. Ukraine is home to 45,000 species of animals, including 17 species of amphibians, 20 species of reptiles, about 400 species of birds, and 200 species of fish. The flora of higher plants includes 4997 species. According to V. Tikhomirov (1009), the leading role in the protection of general biological diversity is played by the preservation of vegetation, which carries out the primary synthesis of organic matter and is food for animals. Without preserving plants and vegetation, it is impossible to preserve the fauna.

The list of plant and animal species in need of protection is provided in the Red

Data Book. The first Red Data Book was created in 1966 at the initiative of the International Union for Conservation of Nature and Natural Resources. Red Data Books exist in many countries. The Red Data Book of Ukraine (II edition, 1994, 1966) includes 429 species of vascular plants, 28 species of mosses, 30 species of fungi, 27 species of lichens, 17 species of algae, and 382 species of animals.

The Green Book of Ukraine

The decline in biodiversity on the planet is associated with the degradation of binomials and, above all, plant communities - phytocoenoses. The degradation of natural systems is a common phenomenon, so communities need protection no less than individual species. And such protection is more relevant, since species cannot exist outside of the community. The work on the protection of plant communities went through three stages. At the first stage, we studied the peculiarities of rare coenoses. At the second stage, their passive protection began: the creation of nature reserves or national parks. And only at the third stage – active protection – the task was set to preserve the planet's phytocoenosis fund as a set of phytocoenotic taxa. Ukrainian botanists were the first in the world to emphasize the need to protect plant communities and develop a methodological basis for their registration in the form of a Green Book.

The first list of rare plant communities of the Carpathians in need of protection, as well as typical coenoses of different ranks. Among them: forest communities – 51, steppe – 26, meadow – 16, aquatic – 16, marsh – 12, and shrubs – 5. Rare coenoses can be protected only as part of the relevant ecosystems and areas of the biosphere.

Ecosystem protection

Ecosystems, together with all their living components, should be protected in so-called protected areas. According to J. Rowley, as of 1992, approximately 5% of the world's land area was protected. In the XXI century, this figure is planned to be doubled.

There is no clear classification of protected natural areas in the world. The Law of Ukraine "On the Nature Reserve Fund of Ukraine" (1992) developed a division into categories of protected natural objects and territories. These objects are divided into nature and biosphere reserves, national nature parks, reserves, protected tracts, natural monuments, etc.

A nature reserve is an area set aside for the protection of typical or unique natural complexes with all their components in their natural state. The status of a nature reserve implies a complete ban on economic activity on its territory. There are more than 2 thousand nature reserves in the world.

A biosphere reserve is an area of international importance intended to preserve areas of the biosphere in their natural state, conduct background monitoring and study the natural environment. As of 1990, there were about 300 biosphere reserves in 76 countries. Their area ranges from 300 hectares to 2 million hectares.

National nature parks are created for nature protection, recreation, cultural, educational and research purposes to protect and study natural complexes of special importance in places of natural, health, cultural and aesthetic value. Economic activity is also prohibited in such parks.

A national park is always a large territory where landscapes or their sections are protected, together with all natural components. In natural national parks, nature protection is combined with the organization of recreation and environmental education. Systems of special roads and trails are built here. By the beginning of the XX century, there were 19 national parks in six countries with a total area of 4.6 million hectares.

Regional landscape parks are created for environmental protection and recreational purposes in places with a unique or typical landscape. During the organization of parks, economic activity within their borders does not stop. The task of these objects is to preserve the landscape as a complex of ecosystems. Today, there are about 300 landscape parks in the world.

A nature reserve is a natural area or water area intended to preserve a separate natural complex or even a separate component of it. In reserves, economic activities are allowed that do not harm the protected object. Reserves serve to protect and restore the number of certain species of plants or animals. Depending on the object of protection, reserves are divided into landscape, geological, hydrological, botanical, zoological, and paleontological reserves.

Natural monuments are individual unique natural areas of special significance. Natural monuments can be objects of animate or inanimate nature: individual reservoirs, rocks, caves.

Protected tree tracts, etc. are areas of forest, swamp, meadow, steppe, and other vegetation that have scientific or aesthetic value and are protected to preserve their natural state.

Botanical gardens are organized for growing, acclimatizing and studying plants in specially created conditions.

In **dendrological parks**, tree and shrub vegetation is protected and studied in specially created conditions for the purpose of its scientific and aesthetic use.

A **zoological park** is a place where rare, foreign and local species of fauna are kept in order to protect their gene pool and organize scientific and educational activities.

Parks – monuments of landscape art are areas of natural, aesthetic or historical value. In Ukraine, examples of monuments of landscape art are Sofiyivka in Uman and Oleksandriia in Bila Tserkva.

Today, there are about 20 thousand different protected natural areas on the planet, including 1200 large protected areas.

Objectives:

1 . To analyze the regulatory and organizational support for the protection of biological diversity.

2. Analyze the current state of the biota of Ukraine and fill in the table 1.

Table 1.

Analyze the current state of the biota of Ukraine and fill

	Number of species	Listed in the Red Data Book	Categories					
			I	II	III	IV	V	VI
Biota								
Flora								
Vascular plants								
Mosses								
Lichens								
Algae								
Mushrooms and slime								
Fauna								
Chordates								
Mammals								
Birds								
Reptiles								
Amphibians								
Fish								
Invertebrates								
Echinoderms								
Tentacles								
Mollusks								
Arthropods (without								
Insects								
Ringworms								
Scrapers								
Roundworms								
Nematodes								
Flatworms								
Ribworms								
Gastropods								
Sponges								
Protozoa								

3. Analyze the current state of the selected area and draw graphs of the biota composition of your region.

Practical work № 3.
The main causes of biodiversity loss

Objective: to develop the ability to analyze and critically evaluate global and regional issues regarding the causes of biodiversity loss; to improve the ability to discuss and argue their opinion on this issue.

Key concepts and terms: natural resources, fragmentation, range, introduction, biodiversity, ecosystems, population explosion

Procedure:

1. Get acquainted with the theoretical material on the main causes of biodiversity loss and reduction.

2. Complete the task.

Biodiversity is rapidly declining due to factors such as land use change, climate change, invasive species, overexploitation and pollution. These natural, or more commonly human-induced factors, called catalysts, tend to interact and reinforce each other.

While changes in biodiversity patterns are more clearly linked to direct catalysts, such as habitat loss, they are also linked to indirect catalysts that underlie many changes in ecosystems. The main indirect catalysts are changes in the structure of human communities, the delocalization of economic activity, the aggressive onslaught of mechanization, and cultural globalization, which leads to the emergence of cultural surrogates detached from a specific territorial context.

Different direct catalysts have been critical in different ecosystems over the past 50 years. For example, in terrestrial ecosystems, the main catalyst has been land cover change, such as the conversion of forests to agriculture. Similarly, in marine systems, oil pollution and overfishing have been the main drivers of biodiversity loss.

For the most part, the main factors that directly lead to biodiversity loss are: habitat changes, such as forest fragmentation; invasive species that take root and spread outside their normal range; overexploitation of natural resources; and pollution, such as the excessive use of chemical fertilizers, which leads to excessive amounts of toxic waste products in soil and water.

Recent climate change has already had a significant impact on biodiversity and ecosystems in some regions. As climate change becomes more severe, the harmful impacts on ecosystem stability are expected to outweigh the economic benefits, such as longer growing seasons, in most regions of the world. Climate change is expected to increase the risk of species extinction, floods, droughts, and disease outbreaks. Many negative factors affect biodiversity today more than in the past, especially when taken together. Because of their vulnerability to one threat, species often become susceptible to others; multiple threats can have unexpectedly dramatic consequences for biodiversity. The catalysts for extinction vary from local to global scales, and from immediate to long-term effects. For example, species extinction due to habitat loss can be rapid for some species, but take hundreds of years for others.

Objectives:

1. After reviewing the additional material provided, prepare a report in the form of presentations on the topics.
2. Draw a conclusion and provide recommendations for reducing biodiversity loss.

Topics for the report:

1. Losses of biodiversity under the influence of world population growth.
2. Reduction of biodiversity due to the growth of "predatory" consumption of natural resources (flora, fauna, ecosystems).

Think about how indigenous peoples in poor countries are victims of the unfair distribution of natural resources by rich countries and how this affects the biodiversity of these countries?

3. Destruction of habitats, habitat fragmentation and other causes of biodiversity

loss?

4. What is the impact of international trade on biodiversity?
5. State policy in the field of natural resources use.
6. Introduction as one of the causes of biodiversity loss. Consider whether introduced species that have been transferred can lead to qualitative changes in ecosystems?

Practical work № 4.
Footprint and its evaluation

Objective: to learn how to determine the ecological footprint of humans on the planet; to improve the ability to critically assess the situation on planet Earth and make predictions for the future on this issue.

Equipment and materials: reference material, comparative table "Ecological footprint and biological capacity of some countries of the world".

Procedure:

1. Work through the reference material.
2. Analyze the comparative table "Ecological footprint and biological capacity of some countries"
3. Solve calculation problems and exercises

Reference material

Ecological footprint – is an estimate of the consumption of natural resources by the world's population. How carefully is natural capital used today? To do this, we need to measure how much we have and how much we spend. One of these indicators of sustainable development is the ecological footprint, or footprint, which is a "trace" that leaves an impact on the environment of an individual, a country, or humanity as a whole. The ecological footprint takes into account the extent to which the economy of a particular region corresponds to the capacity of natural ecosystems.

The calculation of this indicator takes into account the biologically productive area of land or sea that is necessary for the production of renewable resources for consumption by the population of a given territory (water area), as well as for the assimilation of waste. The area is measured in global hectares - conventional units of area with an average global productivity.

Thus, the ecological footprint takes into account the consumption of natural resources and the pollution resulting from this consumption, regardless of which continent or where in the world these processes occur. This feature of the footprint makes it a universal indicator of sustainable development that can be used to compare different countries and regions. The ecological footprint takes into account various types of anthropogenic load (growing plants for human consumption, fattening livestock; breeding animals for milk, meat, wool, leather production; deforestation for construction timber, fish and seafood; development and placement of infrastructure (housing, transport routes, industrial enterprises, etc.).

If we add up all the indicators and divide them by the world's population, we get the natural capacity of the biosphere, which is expressed in hectares per capita. For different regions characterized by different environmental conditions and living standards, the biological capacity per person and the ecological footprint of one inhabitant are different.

Reducing the ecological footprint.

The trend of economic growth, which is associated with an increase in the production and consumption of goods and services, according to the UN (even optimistic) forecasts, will lead to the fact that in 2050 we will need twice as many natural resources as the Earth can produce. This level of excess will lead to the risk of losing the resilience of natural ecosystems due to a sharp decline in biodiversity.

The alternative scenario should prevent the biosphere from exceeding its capacity by increasing bioproductivity. Obviously, this will require substantial expenditures from society. Long-term investments will be needed in many areas, including education, technology, nature conservation, family planning, and environmental certification. Between 2 and 10% of the global gross product should be allocated for these purposes.

The main goals of the environmental footprint reduction program are as follows:

1. Population growth should slow down. The three main factors that

influence families' choice to have fewer children are: women's access to education, income, and health care.

2. Reduction in per capita consumption of goods and services. People living at or below the poverty level may need to increase their consumption, but wealthier people can reduce their consumption while maintaining a reasonably high quality of life (for example, a reduction in fossil fuel consumption by cars can be offset by creating favorable conditions for walking in cities).

3. The amount of resources used in the production of goods and services should be significantly reduced - through increased energy efficiency in production and at home, switching to cars that consume less fuel, reducing the distance of transportation of goods (preference should be given to local producers), increasing recycling and reuse of waste.

4. Increasing the area of bioproductive areas, improving poor land. For this purpose, terracing and irrigation can be used. However, firstly, it should be borne in mind that economic efficiency may decrease, and secondly, it is necessary to prevent negative environmental effects, such as soil salinization and desertification.

5. Increase the bioproductivity of ecosystems. The amount of biota production per hectare depends on the type of ecosystem and the way it is managed. This can be achieved by: protecting soils from erosion; protecting wetlands and waterways to ensure fresh water supplies; sustainable forestry and fisheries; preventing climate change (droughts, hurricanes, floods, etc.); and avoiding the use of pesticides.

Why are ecological footprint calculations useful?

Positive aspects:

- they allow tracking the needs of states and regions for natural resources and comparing these needs with the capacities that are currently available;
- provide answers to more specific questions about the spatial distribution of these needs and opportunities, as well as the acceptable volumes of goods and services that maintain or improve the quality of life for the

population of the region;

- provide an opportunity to speak a common language when negotiating sustainable development issues with governments at various levels of government and with the public.

In addition, calculations of the ecological footprint allow governments to:

- increase the competitiveness of regions by tracking environmental deficits, as these deficits can cause social and economic problems over time;
- get an early warning tool to ensure long-term security, which will inform about global trends and warn of resource shortages;
- track the cumulative effect of various environmental impacts (e.g., climate change, fish stocks, loss of arable land, deforestation, urbanization) that are usually assessed separately.

Undoubtedly, the resource-based approach is not the only and exhaustive approach to determining the value of nature. At the same time, the ecological footprint is a system of comprehensive science-based accounting that compares the use of natural resources by people and the ability of nature to regenerate

Calculation tasks

Task №1

When determining the ecological footprint, different types of anthropogenic load are taken into account, in particular:

- cultivation of plants for human consumption, livestock feeding, fiber, oil, rubber production, etc. – 1.3 billion hectares of arable land;

- breeding animals for the production of meat, milk, wool, leather and fur requires pastures – 4.6 billion hectares;

- deforestation for construction wood, pulp, firewood – 3.3 billion hectares;

- fishing and seafood production – 3.2 billion hectares of water area;

- development, placement of infrastructure facilities (housing, transport, highways, industrial enterprises, water reservoirs) – 0.2 billion hectares;

- combustion of extracted fuel leads to carbon dioxide emissions (35% of emissions are absorbed by the ocean; to absorb the remaining 65%, the required area of forests and wetlands must be taken into account.

Task: Taking into account all these indicators, determine the natural capacity of the biosphere.

Task №2

Calculations show that an average Ukrainian citizen needs 3.2 hectares to provide him or her with natural resources. At the same time, the bioproductive area of our country per capita is 1.7.

The task is to determine the ecological deficit (or reserve).

Task №3

The average global demand for natural resources per person is 2.23 hectares. Currently, the bioproductive area of land and sea on our planet is 1.78 hectares per person.

Task: answer the following questions:

1. Does the available biologically productive land and sea area currently meet the needs of humanity?

2. What would happen if all the people of the world lived like in the United Arab Emirates?

Task № 4

The ratio of two factors – the level of consumption and the population size – determines the global trend of environmental deficit.

Today, environmental deficit is characteristic of both developed countries (3.12 hectares) and underdeveloped countries (0.09 hectares).

Question: What caused the environmental deficit in these countries? What do you see as the difference?

Task № 5

According to calculations, an average Russian citizen needs about 4.4 hectares to meet his or her own needs for natural resources. At the same time, the country's bioproductive area is 6.9 hectares, meaning that there is an available ecological reserve of 2.5 hectares (6.9 – 4.4 = 2.5 hectares). At the same time, at this level of natural resource consumption by the Japanese, there is an ecological deficit of the territory (3.7 hectares).

Note: ecological deficit values may not add up to the difference between ecological footprint and biological capacity values due to rounding

Do the exercises:

Identify resources for your needs using an ecological footprint.

If you want to find out what your personal ecological footprint is, answer the questions in the quiz.

In order to calculate your ecological footprint, you need to select the statement that applies to your lifestyle and add/subtract the number of points indicated on the right. Summing up the points, you will get the value of your ecological footprint.

1. *Housing.*

1.1. The area of your home allows you to keep a cat, but a normal-sized dog would be cramped +7

1.2. Large, spacious apartment +12

1.3. A cottage for two families +23

Divide the points you received for the first question by the number of people who live in your apartment or house.

Ecological footprint and biological capacity of some countries

Region	Population, million people	Ecological footprint, ha/person	Biological capacity, ha/person	Ecological deficit (-) or reserve (+), ha/person	Changes in the ecological footprint
The whole world	6 301,5	2,23	1,78	-0,45	14
Developed	955,6	6,4	3,3	-3,12	40
countries	3011,7	1,9	2,1	+0,18	14
Developing countries	2303,1	0,8	0,7	-0,09	8
Weakly	846,8	1,1	1,3	+0,24	-2
developed	71,9	1,4	0,5	-0,9	49
Africa	5,6	3,4	1,0	-2,4	13
Egypt	9,9	0,4	0,7	+0,3	-38
Libya	346,8	2,2	1,0	-1,2	-19
Somalia	8,4	1,7	1,2	0,5	-62
Middle East and	3,1	1,1	0,6	-0,5	-76
Azerbaijan	23,9	0,1	0,3	+0,2	-45
Armenia	5,1	0,8	1,2	+0,5	-83
Afghanistan	15,4	4,0	4,1	+0,1	-14
Georgia	5,1	1,3	1,4	+0,1	-73
Kazakhstan	3,0	11,9	0,8	-11,0	205
Kyrgyzstan	6,2	0,6	0,5	-0,1	-86
United	4,9	3,5	3,6	+0,1	-24
Arab	26,1	1,8	0,8	-1,1	-60
Emirates	3489,4	1,3	0,7	-0,6	38
Tajikistan	19,7	6,6	12,4	+5,9	-7
Turkmenistan	1065,5	0,8	0,4	-0,4	16
Uzbekistan	13117	1,6	0,8	-0,9	82
Asia and	62,8	1,4	1,0	-0,4	60
Pacific	127,7	4,4	0,7	-3,6	30

Continuation of the table "Ecological footprint and biodiversity capacity of some countries of the world"

Latin America	535,2	2,0	5	+3,4	21
	178,5	2,1	9,9	+7,8	30
and the Caribbean	44,2	1,3	1,5	+2,3	13
Brazil	11,3	1,5	0,9	-0,7	-2
Costa Rica	325,6	9,4	5,7	-3,7	35
Cuba	31,5	7,6	14,5	6,9	11
North	294,0	9,6	4,7	-4,8	38
America	454,4	4,8	2,2	-2,6	31
Canada	82,5	4,5	1,7	-2,8	6
UNITED STATES	5,2	7,6	12,0	4,4	57
Europe (EU)	8,9	6,1	9,6	-0,6	16
Germany	1,3	6,5	5,7	0,7	41
Finland	272,2	3,8	4,6	0,8	-11
Sweden	3,2	1,4	0,9	0,5	0
Estonia	9,9	3,3	3,2	-0,1	-28
Europe (non-EU)	4,3	1,3	0,8	-0,5	-72
Albania	143,2	4,4	6,9	+2,5	-4
Belarus	48,5	3,2	1,7	-1,5	-30
Moldova	7,2	5,1	1,5	-3,6	39

2. *Energy use.*

2.1. Is your home heated with oil, natural gas or coal +45

2.2. Water, solar or wind energy is used to heat your home +2

2.3. Most of us get our electricity from fossil fuels, so add +75

2.4 Your home heating is designed so that you can adjust it depending on the weather –10

2.5. At home you are warmly dressed, but at night you hide under two blankets -5

2.6. When leaving a room, you always turn off the light in it –10

2.7. You always turn off your household appliances without leaving them in standby mode –10

3. *Transportation.*

3.1. You go to work by public transport +25

3.2. Do you walk or ride a bicycle to work +3

3.3. You drive an ordinary passenger car +45

3.4. You use a large and powerful car with all-wheel drive +75

3.5. Last vacation you flew by airplane +85

3.6. You went on vacation by train, and the journey took up to 12 hours +10

3.7. Last vacation you traveled by train, and the journey took more than 12 hours +20

4. *Food.*

4.1 In a grocery store or market, you buy mostly fresh products (bread, fruit, vegetables, fish, meat) of local production, from which you prepare your own lunch +2

4.2 You prefer processed foods, semi-finished products, freshly frozen ready-to-eat meals that only require heating, and canned foods, and you do not look at where they are made +14

4.3. You mostly buy ready-to-eat or almost ready-to-eat foods, but try to have them made closer to home +5

4.4. You eat meat 2-3 times a week +50

4.5. You eat meat three times a day +85

4.6. You prefer vegetarian food +30

5. *Use of water and paper*.

5.1. Do you take a bath every day +14

5.2. You take a bath once or twice a week +2

5.3. Instead of taking a bath, you take a shower every day +4

5.4. From time to time you water your garden or wash your car with a hose +4

5.5. If you want to read a book, you always buy it +2

5.6. Sometimes you borrow books from the library or borrow them from friends -1

5.7. After reading a newspaper, you throw it away +10

5.8 Someone else reads the newspaper after you +5

6. *Household waste.*

6.1. We all create a lot of waste and garbage, so add +100

6.2. Over the past month, have you ever handed in bottles –15

6.3. When throwing away garbage, you put waste paper in a separate container –17

6.4. Do you hand in empty beverage and canned food cans –10

6.5. You throw away plastic packaging in a separate container – 8

6.6. You try to buy mostly weighted goods rather than packaged ones; you use the packaging received in the store at home –15

6.7. You make compost from household waste to fertilize your land – 5

If you live in a city with a population of half a million or more,

multiply your total by 2.

Summarize the results:

Divide the result by 100 and you will find out how many hectares of the earth's surface are needed to meet all your needs, and how many planets would be needed if all people lived like you!

To ensure that one planet is enough for all of us, there should be no more than 1.8 hectares of productive land per person.

For comparison: the average USA resident uses 12.2 hectares (5.3 planets!), the average European uses 5.7 hectares (2.8 planets), and the average Mozambican uses only 0.7 hectares (0.4 planets).

Practical work № 5.

Rare and endangered species of flora and fauna of Ukraine

Objective: to get acquainted with rare and endangered species of flora and fauna of Ukraine, as well as with the structure of the Red and Green Books.

Procedure:

1. Carefully read the background material on the conservation status of flora and fauna species.
2. Analyze the species of plants, animals and fungi that are listed in the Red Data Book in the selected area.
3. Complete the task

Background material

The problem of environmental protection and conservation of biodiversity has become particularly relevant in our time, in the era of scientific and technological progress, which has given humanity powerful levers of influence on nature. Taking into account the sad mistakes of the past, no one doubts that the disappearance of each new species is a real catastrophe and may result in irreplaceable losses in the future. The protection and restoration of rare and endangered species of plants and animals in developed countries is considered one of the most important tasks of national importance.

In 1948, the International Union for Conservation of Nature and Natural Resources (IUCN) was established. Its organizational structure provides for a special commission to assess the status and determine the danger to wildlife, primarily vertebrates and vascular plants. One of IUCN's objectives is to involve as many countries, their governments, scientific forces and public organizations as possible in solving complex and multifaceted environmental problems.

As a result of many years of hard work, the Red Data Book, or Red Data Book of Facts, was first published in 1963. Later, its name was simplified to the Red Data

Book.

The need to protect plants and animals is reflected in many documents of international cooperation.

A resolution of the Verkhovna Rada of Ukraine of October 29, 1992, approved the Regulation on the Red Data Book of Ukraine, which is the main state document on the protection of flora and fauna. It contains generalized information on the current status of endangered species of animals and plants in Ukraine and measures for their conservation and scientifically based reproduction.

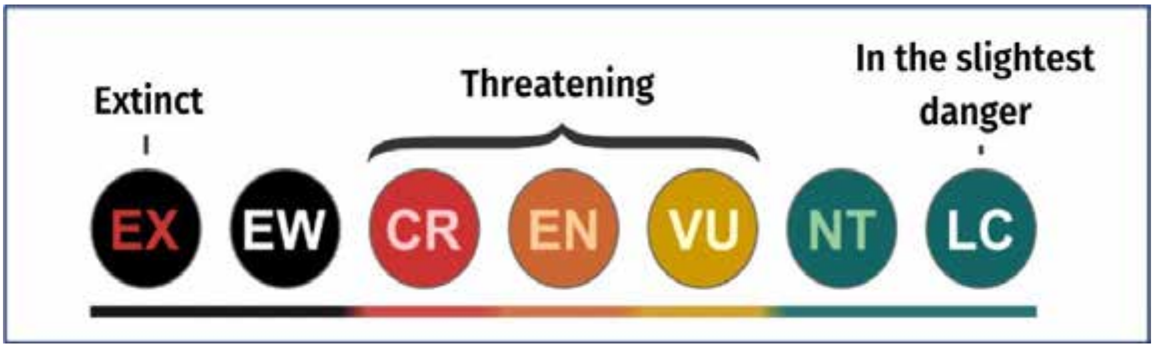
The conservation status of a species is an indicator of the likelihood that this species will continue to exist in the future. Many factors are taken into account when assigning conservation status categories: not only the number of existing representatives of the species, but also trends in population (declining or increasing), the degree of reproductive success, the normal number of the species in the ecosystems where it lives, known threats and/or factors that contribute to the survival of the species, etc.

The most comprehensive reference system on the conservation status of species on Earth is the IUCN Red List. It divides species into 9 categories, taking into account both the aforementioned general factors and individual characteristics specific to each species:

- Extinct (EX)
- Extinct in the Wild (EW)
- Critically Endangered (CR)
- Endangered (EN)
- Vulnerable (VU)
- Near Threatened (NT)
- Least Concern (LC)
- Data Deficient (DD)
- Not Evaluated (NE)

The list of endangered species includes those that disappeared after 1500.

Categories of environmental status:



Categories of saving status NatureServe:

Another system for classifying species under threat is the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) classification, which was developed to prevent international trade in species in a form that could threaten their existence.

To comply with CITES, the European Union has developed the EU Wildlife Trade Regulations with its own database, which is a form of classification of species based on vulnerability. In addition, there is the EU Habitats Directive and the EU Birds Directive.

Within Canada, the United States and Latin America, a system of classifying the conservation status of species called "NatureServe conservation status" has been developed. This system currently has a slightly different classification system than the IUCN Red List, but is becoming more and more closely aligned with the one adopted by the IUCN.

Objectives:

1. Look at the pictures and read the short list of species of plants, animals and fungi listed in the Red Data Book of Ukraine. Fill in the table 1.

A short list of species of plants, animals and fungi listed in the Red Data Book of Ukraine

Fig. 1. **Plants of the Red Data Book of Ukraine:**

1 – Cuckoo's slipper *Cypripedium calceolus* L. – a vulnerable species;

2 – Heuffel's saffron *Crocus heuffelianus* Herb. – an unappreciated species;

3 – Snowdrop *Galanthus nivalis* L. – unassessed species;

4 – Bear's onion *Allium ursinum* L., unassessed species;

5 – Forest lily *Lilium martagon* L., an unassessed species;

6 – Alpine aster *Aster alpinus* L., a rare species;

7 – *Lunaria* L. – an unappreciated species;

8 – Meadow dream *Pulsatilla pratensis* (L.) Mill;

9 – Berry yew *Taxus baccata* L. – vulnerable species.

Fig. 2. **Animals of the Red Data Book of Ukraine:**

1 – Deer beetle Lucanus cervus Linnaeus – a rare species;

2 – Papilio machaon Linnaeus – vulnerable species;

3 – Freshwater sterlet Acipenser ruthenus Linnaeus – endangered species;

4 – Spotted salamander Salamandra salamandra Shaw –Vulnerable species;

5 – Common copperhead *Coronella austriaca* Laurenti – vulnerable species;

6 – Black Stork *Ciconia nigra* Linnaeus – a rare species;

7 – Osprey *Bubo bubo* Duméril – a rare species;

8 – Eared hedgehog *Erinaceus auritus* Gmelin – endangered species;

9 – River otter *Lutra lutra* Linnaeus – an unappreciated species;

10 – Bison *Bison bonasus* Linnaeus – endangered in nature.

Fig. 3. **Mushrooms in the Red Data Book of Ukraine:**

1 – Edible truffle *Tuber aestivum* Vittad is an endangered species;

2 – Steppe wrinkle *Morchella steppicola* Zerova – rare species;

3 – Bronze boletus *Boletus aereus* Bull. a vulnerable species;

4 – Red lattice clover *Clathrus ruber* P.Micheli ex Pers. rare species;

5 – Larch sponge *Laricifomes officinalis* (Batsch) Kotlaba & Pouzar, endangered species

Table 1

	Title	Degree of vulnerability	Habitat (for plants)	Living conditions (for animals)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

2. According to the selected area (optional), name the species of plants, animals and fungi that are listed in the Red Book, provide photos and fill in Table 2.

Table 2

	Title	Degree of vulnerability	Habitat (for plants)	Living conditions (for animals)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Practical work № 6.
Calculation of biodiversity indices. Determination of indices of species richness and species diversity of plants

Objective: to get acquainted with biodiversity indices, to learn how to determine indices of species richness and species diversity of plants

Procedure

1. Read the theoretical material
2. Complete the task
3. Draw conclusions

Theoretical material

The term "biodiversity" is often considered synonymous with "species diversity", in particular "species richness", which is the number of species in a particular habitat or biotope. The linear size of a habitat can vary widely and depends on the spatial homogeneity of environmental factors and the degree of mosaicism of biosphere components: for birds, for example, it can be a vast forest area, and for zoobenthos, a fragment of the bottom surface.

Species diversity is characterized by two criteria: species richness and even distribution of species.

Numerous formulas based on various modifications of these indicators are called indices in ecology and are used to quantify biodiversity.

The Menhynik Index (species diversity or richness), which is a characteristic of the number of species per unit of total abundance, which can be taken as the total number or biomass. This index allows us to estimate how many species are per total number of individuals.

$$M = A / \sqrt{N},$$

where A- is the number of species, N- is the total abundance of all species in the community.

Simpson's index (of dominance, or concentration and equivalence, or equivalence): reflects the "concentration" of dominance, as its value is higher the stronger the dominance of one or more species. The value of the diversity index depends not only on species richness, but also on the uniformity of the proportions of different species in terms of their numbers.

$$C = \sum (n / N) 2,$$

where n – is the abundance of one species

The Jaccard index (species or faunal similarity), which can be calculated both between communities as a whole (Jag) and between dominant species complexes (Jdom), determines the ratio of common species to the number of species in the combined list:

$$J = c / (a + b - c),$$

where a and b – are the number of species in the compared communities, c is the number of common species.

The MSA index (generalized species diversity index) is calculated as the product of typological units of the agricultural landscape, taking into account the relevant indicators of impact on the state of biodiversity. This index "takes into account" long-term factors of influence and does not "react" to short-term factors that can lead to a crisis state of biodiversity, such as the use of plant protection products, excessive plowing, etc. The index reflects the ratio of the current species diversity of an area to the potential species diversity of the ecosystem integrity within the same area. Accordingly, the index can have a value from 0% in a completely degraded ecosystem to 100% in a complete one. According to the developers, this index can also be interpreted as an indicator of the naturalness of the territory.

The total impact on biodiversity (**MSAi)** is calculated as the product of the MSA values for each of the impact factors: Land Use Change **(MSALUC),** Fragmentation **(MSAI),** Infrastructure **(MSAF),** Climate Change **(MSAN),** and Atmospheric Nitrogen Deposition **(MSACC).**

The Shannon-Weaver index (general or informational diversity), which gives an idea of both aspects of diversity at once: the number of species and the uniformity of their quantitative representation, and therefore may be complexity, organization, and stability). It can be calculated both for individual species and for taxa of superspecies rank or other elements of diversity. Unlike many other indicators, it assesses the diversity of random samples, which is why it is most often used to study the structure of natural communities. In addition, this indicator combines species richness and evenness into a single value and quantifies (in bits) the equivalence of the registration of different species in the community .

$$H = -\sum P_i \cdot ln\ P_i,$$ where:

P_i – probability of contribution of each species to the community.

$P_i – n/N$, n – the number of points that each species receives based on the percentage of projection coverage or abundance (density) in a given community.

N – the total amount of points received by all species of a given grouping for this indicator ($H = \sum N$).

Projection coverage – is the area of projections of the aboveground parts of plants of the same species on the soil surface, excluding the gaps between leaves and branches.

Instead of scoring the abundance of species in the community according to the O. Drude scale:

1 point – plants are closed in separate parts;

2 points – plants are very abundant;

3 points – plants are abundant;

4 points – plants are quite abundant;

5 points – plants are sparse;

6 points – single plants;

7 points – one plant in the detection area.

Objectives:

Study of species richness

1. Fence off four plots of 1m x 1m in the case of the meadow system and 10m x 10m in the case of the forest system.

2. Count the total number of species in the plots, find the average and express the result per unit area.

Survey of species diversity

1. Fence off a 10m x 10m plot (for both the grassland and forest systems) and collect one specimen of each plant species from this plot.

2. Determine the projected cover of the study community or use the O. Drude scoring of species abundance in the community (n).

3. Find the probability of contribution of each species in the community (Ri) and use Shannon's formula to determine species diversity.

4. The results of the calculations are listed in Table 1.

Table 1

Scoring of species by projected cover and probability of contribution of each species to the community

Name of the species	Scores on projective coverage (Drude scale) (n).	Probability of contribution of each species P_i
1	2	3

Table 2

Calculation of species diversity of plant communities

Species diversity index (according to Shannon)	Plant community №1 __________________ __________________ (name)	Plant community №2 __________________ __________________ (name)
1	2	3

Compare the indicators of species diversity of different plant communities (Table 2) and draw a conclusion.

Practical work № 7.

Determination of the quantitative ratio and level of dominance of individual species in the biocenosis

Objective: to learn how to determine the quantitative ratio and level of species dominance using the Simpson, Berger-Parker, Margalef and Pielu indices.

Procedure:

1. Familiarize yourself with the theoretical material
2. Complete the task
3. Draw conclusions

Theoretical part

The quantitative characterization of the relationship between the number of different species is given by the Simpson dominance index.

$$C = \sum(n_i / N)^2,$$

де n_i – is the number of individuals of each species, and N is the total number of individuals of all analyzed species.

The Berger-Parker dominance index takes into account only the share of the dominant species:

$$D_{BP} = n_{max}/X$$

where n_{max} – the number of the most common species.

Both indices take on a smaller numerical value the more equalized the dominance structure is, i.e., the closer the estimates of abundance for all species are. At the same time, the Simpson's index gives more weight to common species, since when squaring small relationships (n_i/N) the resulting values are very small. Diversity, or the measure of species heterogeneity in a community, is determined by the Shannon formula or the Simpson formula.

Both indicators take on a maximum value when the number of all species in the community is equal. In this case, the Shannon diversity index tends to the value $H_{Sh} \rightarrow \ln s$, and Simpson's diversity index – $H_S \rightarrow (s-l)/s$, where s – total number of species.

The Margalef index is used to numerically assess the species richness of the community:

$$DMg = \frac{S - 1}{\ln N}$$

The more species, the higher the value of this index. An increase in the number of individuals with a constant number of species leads to a decrease in the index value.

The uniformity of species distribution, which also reflects the degree of diversity of the community, is determined by the Peel's index of evenness:

$$E = Hsh / \ln s,$$

where H_{Sh} – is the value of Shannon's diversity index for this grouping. The Piëlou's alignment index takes values from 0 to 1. For real communities, this index rarely exceeds 0.80.

Practical task

When analyzing the plant community of an oak-hornbeam forest, the presence of 10 tree species was noted, the number of individuals of which is presented in the table below. It is necessary to estimate the indices of dominance, diversity and species richness of this community.

Table 1

Observation results

Species	Hornbeam	Dub	Maple	Jasen	Aspen	Hazel	Poplar	Birch	Linden	Cherry
	1	2	3	4	5	6	7	8	9	10
Number of units/ha	100	75	60	55	40	35	15	10	5	5

Objectives:

1. Analyze the structure of this plant community.
2. Calculate the Simpson (C) and Berger-Parker dominance indices. (D_{BP}).

3. Draw and analyze a graph of the Whittaker dominance-diversity curve. To do this, plot the share of the total abundance of each species in the total abundance on a semi-logarithmic scale along the Y-axis:

$$p_i = (n_i / N) \cdot 100\%$$

The Type I curve corresponds to a situation where all members of a community are highly dependent on a particular resource, and there is a random, but non-overlapping distribution of species' ecological niches along the gradient of the resource in question (the "broken rod" model).

The type II curve is characteristic of communities consisting of a small number of species that are in fierce competition for limited resources, often in harsh environmental conditions.

The type III curve is characteristic of communities with high species richness, in conditions where the "success" of a species is determined by a large number of independent and homogeneous factors.

Thus, the higher the curve and the flatter it is, the greater the total diversity for a given number of species.

4.Determine what type of curve the curve is. What does its structure indicate?

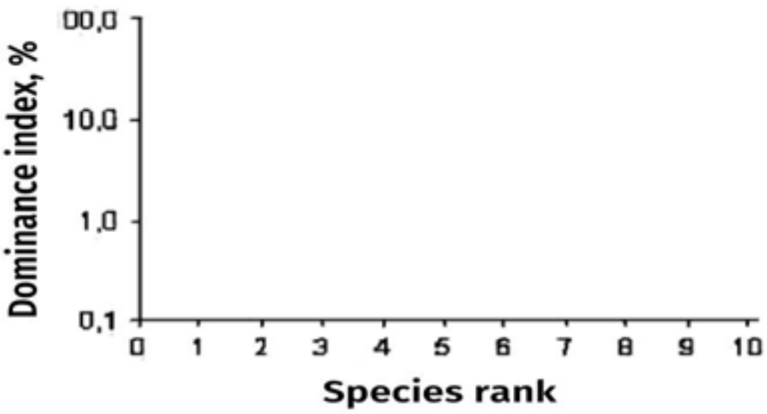


Fig. 1. **Graph of the Whittaker curve**

5. Calculate the Shannon (Hsh) and Simpson (Hs) indices of species diversity.

6. Estimate the species richness of woody plants in the forest using the Margalef index (Dm).

7.Evaluate the uniformity of species distribution by Piel (E).

8. Draw a conclusion.

Options for completing tasks

Task 1.

Calculate the index of species richness (Margalef index), if it is known that the number of individuals in the sample is 259. The sample is represented by 23 species.

Task 2.

It is known that a conditional sample taken in a forest complex consists of 781 birds, which are represented by five species: great tit – 257 individuals, blackbird 152 individuals, jay 209 individuals, oatmeal – 84 individuals, and nettle – 79 individuals. Find the Shannon index and the Berger-Parker dominance index. Draw conclusions about the state of the forest complex's avifauna.

Task 3.

Determine the number of species in the sample, if it is known that the Margalef species richness index is 5.538 and the number of individuals in the sample is 387.

Task 4.

Find the Margalef index for a sample in which 17 mammalian species are represented by 795 individuals.

Task 5.

A conditional sample of birds is taken in a rural area. It consists of 419 individuals, represented by 7 species that are not rare in the area, including: pigeons – 79, starlings – 59, swallows – 37, sparrows – 118, crows – 65, magpies – 34, swifts – 27. Calculate the species diversity index and Shannon's variance.

Task 6.

Calculate the species richness of the ecosystem of Lake Bile, if it is known that it includes 25 species of living organisms, and the total number of individuals is 579.

Task 7.

Using Simpson's species richness index, calculate the species richness of a deciduous forest if its biocenosis includes: oak – 73, birch – 50, hawthorn – 12, squirrel – 26, and mermaid hare – 43 individuals.

Task 8.

Calculate the index of species diversity of a nature reserve if its biogeocenosis includes the following species listed in the Red Data Book: Caucasian beetle – 113, forest cat – 87, deer beetle – 98, berry yew – 75, peach bells – 101, boxwood – 9. Which index should be used to solve this problem? Calculate the Piel's index of alignment (E) of the ecosystem of the nature reserve.

Practical work № 8.
Population and species levels of biodiversity organization

Objective: To get acquainted with the population-species level of biodiversity organization, to learn how to calculate the relationship between the links of the ecological pyramid, to master the rule of the ecological pyramid, to learn how to determine the position of living organisms in trophic chains.

Procedure

1. Read the theoretical material
2. Consider several examples of solving environmental problems.
3. Solve the problem independently according to the options.
4. Draw a conclusion.

Theoretical material.

In nature, any biological species usually consists of a large number of populations. Nowadays, under the influence of anthropogenic factors, the ranges of most populations of wild plant and animal species have shrunk and become fragmented. At the same time, the ranges of populations of species adapted to human economic activity are expanding. The decline in the number of individuals increases the likelihood of accidental extinction and is accompanied by a reduction in intra-population genetic diversity. Population size depends on fertility, the ability of individuals to reproduce, and mortality, the rate at which the population decreases.

From the point of view of biodiversity conservation, the most important indicator is the minimum population size, i.e. the size at which the population still maintains the necessary level of genetic heterogeneity, so that it does not degenerate. By consistently reducing populations to a minimum size, humans destroy them without even killing the last representative.

Favorable climatic conditions, sufficient food, and reduced predation lead to an increase in fertility and birth rates, and an increase in numbers. There are also numerous factors that limit the size of a population

A sequence of living organisms, which can be imagined as consisting of links - species of plants, animals, fungi and bacteria - connected to each other by a food-consumer relationship, is commonly referred to as a trophic chain. Even the simplest food chain has several trophic levels. The first trophic level is formed by green plants (producers); the second is occupied by animals that feed on plants (first-order consumers); the third is occupied by predators that eat herbivores (second-order consumers), and the fourth is occupied by predators that prey on smaller predators (third-order consumers). Reducers are microorganisms (bacteria and fungi) that destroy the remains of dead creatures.

The rule of the ecological pyramid is a regularity according to which the amount of plant matter that is the basis of the food chain is about 10 times greater than the mass of herbivorous animals, and each subsequent food level also has a mass 10 times less than the previous one.

Examples of problem solving.

When drawing up a food chain, you need to correctly position all the links and show with arrows from which level the energy is obtained.

Example 1: The following live in a meadow community: caterpillars, larks, alfalfa, and goldfinches. Make a food chain.

Answer: alfalfa – caterpillars – larks – goldfinches.

Example 2: Based on the rule of the ecological pyramid, determine how much plankton is needed for one individual of a sea otter (30 kg) to grow in the sea if the trophic chain is as follows: phytoplankton, non-predatory fish, predatory fish, sea otter.

From the rule of the ecological pyramid, we know that each successive trophic level has a mass 10 times less than the previous one. Knowing this, you can easily solve the problem.

Solution. Let's make a trophic chain, starting from the producers: phytoplankton – non-predatory fish – predatory fish – squid.

Knowing that the mass of the squid is 30 kg, and the mass of second-level consume should be 10 times greater, let's calculate the mass of the predatory fish it feeds on: 30 X 10 = 300 (kg); respectively, the mass of non-predatory fish: 300 X 10 = 3000 (kg); and the mass of phytoplankton, which feeds on non-predatory fish: 3 000 X 10 = 30 000 (kg). So, we get the answer: in order for one 30 kg squid to grow in the sea, 30,000 kg of phytoplankton are needed.

Problems to solve on your own

Option 1

1. Match the organism with the trophic level of the ecological pyramid at which it is located and enter it in the table below: plants, eagle, frog, microscopic fungi, beetle.

Producer	
Consummate of the 1st order	
Consumptive order 2	
Consumptive order 3	
Reducer	

2. Determine the mass of the components of the power supply circuit if it is known that the mass of the 3rd order consistor is 8 kg.

Components of the power supply chain	Total weight
Phytoplankton	
Small crustaceans	
Fish	
Otter	8 kg

3.Using the rule of the ecological pyramid, determine the area (in m^2) of the corresponding biogeocenosis on which a wolf weighing 55 kg can feed (food chain: herbaceous plants – ungulates – wolf). The biomass of the forest vegetation is 2,000 g/m2. Note that the mass fraction of water in the body is 70% of the total mass.

4.Determine the area of sea water required to feed a common dolphin weighing 60 kg (30% of dry matter) in the food chain: phytoplankton – fish – dolphin. Phytoplankton productivity is 500 g/m^2.

5.The biomass of dry hay per 1 m^2 of field is 300 grams. Based on the rule of the ecological pyramid, determine how many hectares of field are needed to feed one schoolboy weighing 50 kg (70% of the mass is water), according to the food chain: grass-cow-human.

Option 2

1. Match the organism with the trophic level of the ecological pyramid at which it is located and write it in the table: cyclops, phytoplankton, pike perch, crucian carp, river crayfish.

Producer	
1st order consulter	
2nd order consulter	
3rd order consulter	
Reducer	

2. Determine how many owls can be fed by the power supply chain, if it is known that the total mass of the producer is 8,000 kg and the mass of one owl is 0.2 kg.

Power supply components	Total weight
Plants	8 000
Insects	
small birds	
Ospreys	

3. Using the rule of the ecological pyramid, determine how much the weight of a young fox increased during a week of mousing if it ate 200 voles and mice during

that week (the weight of one rodent is approximately 10 g). Note that the mass fraction of water in the body is 70% of the total mass.

4.Determine the area of the river that is needed to feed a 1 kg pike perch (30% dry matter) in the food chain: phytoplankton – herbivorous fish – pike perch. The productivity of phytoplankton is 700 g/m^2.

5. The biomass of plankton is 500 g/m^2 of the sea area. Using the rule of the ecological pyramid, determine how much sea area can feed one polar bear weighing 500 kg (70% is water) according to the food chain: plankton-fish-seal-polar bear.

MODULE II. CHARACTERIZATION OF THE STATE AND ASSESSMENT OF BIODIVERSITY THREATS

Practical work № 9.

Main provisions of environmental legislation in the field of conservation of biotic and landscape diversity

Objective: To study the conventions and agreements ratified by the Verkhovna Rada of Ukraine; to consider the main issues of basic international conventions, agreements and other legal mechanisms for the conservation of biotic and landscape diversity.

Procedure

1. Read the theoretical material
2. Complete the assignment
3. Answer the questions

Theoretical part

It is quite obvious that nature knows no national borders. Living organisms cross them freely during seasonal migrations. Therefore, international cooperation is needed to preserve migratory species, especially rare and endangered ones. There is another acute problem: illegal international trade in wildlife.

The main international regulations in this area are international agreements and treaties. Multilateral agreements – conventions – are enacted (ratified) by the legislative bodies of the participating states (in Ukraine, the Verkhovna Rada). The main conventions related to biodiversity conservation are:

- Convention on Biological Diversity (Rio de Janeiro, 1992);
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington, 1973);
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979);

- Convention on the Protection of Wild Flora and Fauna and Natural Habitats in Europe (Bern, 1979);
- Convention on Wetlands of International Importance as Waterfowl Habitats (Ramsar, 1971).

Traditionally, the highest international protection status is enjoyed by species of living organisms listed in the Washington Convention. As early as 1953, the International Union for Conservation of Nature (IUCN) introduced the so-called International Red List, which initially included only the rarest species of mammals and birds. Later, the IUCN repeatedly revised this book, compiling new Red Lists that included representatives of other taxa of living organisms.

The European Red List, which includes rare and endangered species of living organisms in Europe, is also an important environmental document..

Legal regulation of biodiversity at the present stage

Terminologically, the concepts of "biological diversity" or "biodiversity conservation" are found in national legislation only when setting out the principles of legal regulation of a particular law (Article 3(e) and Article 61 of the Law "On Environmental Protection", Article 9 of the Law "On Fauna", the relevant article of the Law "On Flora" and some others).

The regulation of relations on biodiversity conservation at the national level is largely carried out indirectly: first of all, through the regulation of protection of areas where biological resources occur or grow. We are talking about the nature reserve fund and other categories of natural areas of special protection (Laws of Ukraine "On Environmental Protection", "On the Nature Reserve Fund of Ukraine", etc.)

Secondly, it is natural resource legislation (land, forest, water, mining, faunal, floral, etc.), in particular, the Codes: Land, Water, Forest and Subsoil Codes, the Law of Ukraine "On Wildlife", etc.

Thirdly, legislation on the protection of bioresource species, primarily rare and endangered species (legislation on the Red Data Book, Green Data Book, etc.). A number of national and regional programs have been developed and are being implemented, including the Prospective Program for the Development of Nature Reserves in Ukraine, the National Program for the Formation of the National Ecological Network of Ukraine for 2000–2–15 (approved by the Law of Ukraine of September 21, 2000).

Tasks:

Task 1. Fill in the table 1, using the theoretical material "Conventions and agreements".

Table 1

List of global basic international conventions on the conservation of biotic and landscape diversity

Name, place and year of the convention, agreement	**Legal document on Ukraine's participation**	**Purpose of the convention, agreement**
The Convention on Biological Diversity (CBD@ m. Rio de Janeiro, Brazil, 1992 p.)	Law of Ukraine on Ratification of the Convention of 29.11.1994	
The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES@ Washington, USA, 1973)	The Law of Ukraine on Accession to the Convention of May 14, 1999.	
The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES@ Washington, USA, 1973)	The Law of Ukraine on Accession to the Convention of 14.05.1999	
The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention®, Bonn, Germany, 1979)	Law of Ukraine on Accession to the Convention of 19.03.1999.	
UN Convention to Combat 3 Desertification in those countries suffering from serious drought and/or desertification, particularly in Africa (Paris, France, 1994)	Law of Ukraine on Accession to the Convention of 04.07.2002.	

Task 2. Fill in Table 2, using the theoretical material "Conventions and Agreements".

Table 2

List of pan-European basic international conventions and agreements on the conservation of biological and landscape diversity

Name, place and year of the convention, agreement	Legal document on Ukraine's participation	Purpose of the convention, agreement
Convention on the Conservation of Wild Flora and Fauna and Natural Habitats in Europe (Bern Convention, Bern, Switzerland, 1979)	Law of Ukraine on Accession to the Convention of 29.10.1996	
Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA is a part of the Bonn Convention, The Hague, The Netherlands, 1995)	Law of Ukraine on Accession to the Convention of 04.07.2002	
Agreement on the Conservation of Bats in Europe (EUROBATS operates under the Bonn Convention, London, UK, 1991)	Law of Ukraine on Accession to the Convention of 14.05.1999	
Pan-European Strategy for the Conservation of Biological and Landscape Diversity (Sofia, Bulgaria, 1995)	Signed by the Minister of Environmental Protection of Ukraine in 1995, ratification of the Convention is not required because the	

Task 3. Fill in Table 3, using the theoretical material "Conventions and Agreements".

Table 3

List of regional basic conventions, agreements, directives on the conservation of biotic and landscape diversity

Name, place and year of the convention, agreement	**Purpose of the convention, agreement**
Convention on the Protection of the Black Sea against Pollution (Bucharest Convention, 1992)	
Framework Convention on the Protection and Sustainable Development of the Carpathians (Kyiv, Ukraine, 2003)	
Agreement on the Conservation of Cetaceans of the Black Sea, the Mediterranean Sea and the Adjacent Atlantic Ocean (in force within the framework of the Bonn Convention of Monaco, 1996)	
European Union Directive 79/409/EEC on the Conservation of Wild Birds (EU Wild Birds Directive)	
European Union Directive 92/43/EEC on the protection of habitats and wild fauna and flora (EU Habitats Directive)	

Answer the following questions:

1. What are the goals of the Convention on Biological Diversity (1992)?

2. What are the main objectives of the Bern (1979) Convention?

3. What is the purpose of the Agreement adopted in Monaco in 1996?

4. What is the purpose of the European Union Directive 92/43/EEC??

Practical work № 10.
Study of the structure of the state cadastre of flora of Ukraine

Objective: to study the concept of cadastre, to get acquainted with the structure of the state vegetation cadastre of Ukraine.

Procedure

1. Get acquainted with the theoretical material
2. Complete the task.

Theoretical material

Flora cadastre, floristic cadastre is a systematized collection of information about the flora of a certain territory.

The state cadastre of flora contains information and documents on the distribution of flora objects between owners and users of land plots, quantitative and qualitative characteristics of the economic and scientific value of plant resources, division of natural plant communities into categories, economic assessment of technical, fodder, medicinal, food and other properties of natural plant resources, other data on plant natural resources necessary to ensure their sustainable use, reproduction and effective protection (and Flora is understood as a historically established set of plant species distributed in a certain territory (European flora) or in a territory with certain conditions (wetland flora) at present or in past geological epochs.

The flora of Ukraine is characterized by a significant diversity of species composition. There are up to 16 thousand species of plants in Ukraine, including more than 4 thousand species of higher wild plants. The most common plants in Ukraine are those of the Asteraceae family (700 species) and legumes (about 300 species).

Vegetation is a set of plant communities (phytocoenoses) of the planet as a whole or its individual regions and localities.

There are natural and anthropogenic vegetation, as well as modern vegetation and vegetation of past geographical periods. The main types of vegetation in Ukraine are forest, steppe, meadow and marsh.

Table 1

Structure of the state cadastre of flora of Ukraine

Flora	**Vegetation**	**Plant**
Vascular	Forest	resources
Bryophytes	Shrubby	Medicinal
Lichens	Steppe	Food
Algae	Meadow	Spicy and aromatic
Fungi	Swampy	Technical
	Water	
	Halophytic	
	Arid	
	Synanthropic	

Forest vegetation. The total area of forests in Ukraine is about 10 million hectares, which is approximately 14% of its territory. The highest forest cover is in the Ukrainian Carpathians (40.5%) and the Crimean Mountains (32%).

The forests are dominated by young and middle-aged trees, with pine, spruce, beech, and oak being the most common species. They cover about 90% of the forested area. In addition, there are plantations of hornbeam, linden, maple, birch, poplar, alder, etc. Pine (birch) forests occupy large areas in Polissia, as well as in the river valleys of the Forest-Steppe and Steppe. They grow on sod-podzolic sandy soils, poor in humus and nutrients. On better soils, oak and pine forests are common.

Steppe vegetation in its natural form was preserved only on the slopes of gullies, in the foothills of the Crimea, on the sandy spits of the Azov-Black Sea coast, and on islands. Areas of virgin steppes are protected in nature reserves. In the typical steppe zone, in the north, there was a widespread herbaceous fescue-fescue vegetation on ordinary black soil (feather grass, bluegrass, fescue, spring mountaineer, steppe spurge, sage, astragalus), in the south – fescue–feather grass on southern chernozems and dark chestnut soils (fescue, Ukrainian feather grass, keleriac, and herbs such as thistle and tansy), and along the Azov-Black Sea coast – wormwood-grass vegetation on chestnut saline soils.

Depending on their location, meadows are divided into floodplain, dry, lowland, and mountain meadows. In floodplain meadows, thickets of vines, fescue grass, bent grass, keleriac, as well as clover, buttercup, sorrel, yarrow, etc. are common. Dry meadows are home to bentgrass, sweetgrass, fescue, dandelion, and cornflowers. Lowland meadows are confined to depressions in watersheds, terraces, and valleys, so they are waterlogged for a long time. Their grass cover is dominated by red fescue, meadow timothy, common sedge, meadow clover and white clover. The meadows are used as hayfields. Mountain meadows are common in the Ukrainian Carpathians. Oatmeal, white clover, clover, and ludwig are common in the grassland of mountain meadows. In the subalpine zone, meadows of bentgrass, timothy, evergreen sedge, and fescue are formed.

Marsh vegetation develops in depressions with excessive moisture. Bogs cover about 2% of Ukraine's territory. They are most widespread in Polissia. Bogs have significant peat reserves. According to their location, bogs can be floodplain, lowland, valley, fringe, and old riverbed bogs. Lowland bogs are the most common. Their vegetation is dominated by grass and herbaceous-moss communities. Sedge, reeds, cattails, reeds, horsetail, bindweed, etc. are common. Trees include black alder, less common are pine, birch, willow, and willow and birch shrubs.

Aquatic plants are plants that grow in water. Among them are: hydrophytes – plants that are submerged in water only in the lower part (reeds, cattails, reeds), hydatophytes – plants that are completely or mostly submerged in water (water lilies, duckweed, elodea).

Halophytes are salt-tolerant plants. Halophytes are especially interesting, as they are characterized by significant resistance to high salt concentrations (sarzan, kermek, saltwort, soleros).

Arid vegetation develops in conditions where plants lack moisture during the growing season (phytocoenoses of deserts, xerophytic sparsely vegetated areas). They have developed various ways of adapting to the lack of moisture: a short growing season, morphological and anatomical adaptations (leaf reduction, leaf pubescence), physiological adaptations (increased osmotic pressure of cell sap, etc.).

Synanthropic vegetation is vegetation that benefits from anthropogenic environmental modification measures and, therefore, spreads near anthropogenic landscapes, i.e. near human habitation, fields, pastures, roads, settlements. They include cultivated and weed plants.

Medicinal plants are plants whose organs or parts are raw materials for the production of products used in folk, medical or veterinary practice for therapeutic or prophylactic purposes.

Today, there are about 500,000 known plant species, but only a small part (approximately 10%) of them are widely used in medicine (St. John's wort, chamomile, calendula, rose hips, sea buckthorn, licorice, plantain, mint, sage, calamus, etc.)

Spicy and aromatic plants are plants that contain aromatic or pungent flavoring substances (essential oils, glycosides, tannins, etc.).

These include cloves, black pepper, vanilla, ginger, parsley, garlic, dill, etc.

Industrial crops – agricultural plants used mainly as raw materials for various industries (food, textile, soap, paint, pharmaceutical, etc.): sunflower, flax, castor oil, rapeseed, soybeans, rose, oak, hops**.**

Objectives:

1. Based on the initial data in Tables 2–4, give examples and characterize the flora, vegetation and plant resources of the area you have chosen.

Table 2

Flora of the region

Flora	**Representatives**	**Characteristics of one species**
Vascular		
Bryophytes		
Lichens		
Algae		
Fungi		

Table 3

Vegetation of the region

Flora	**Representatives**	**Characteristics of one species**
Forest		
Shrubby		
Steppe		
Meadow		
Swampy		
Water		
Halophytic		
Arid		
Synanthropic		

Table 4

Plant resources of the region

Plant resources	Representatives	Characteristics of resources
Medicinal		
Food		
Spicy and aromatic		
Technical		
Fodder		

Draw a conclusion.

Practical work № 11.
State of the art and prospects for the development of nature reserves in Ukraine

Objective: to characterize the current state and structure of the region's protected area network, to get acquainted with the provisions of international and national biodiversity conservation programs.

Work in progress

1. Familiarize yourself with the theoretical material
2. Complete the assignment
3. Draw conclusions

Theoretical part

The term "biodiversity" has no standard definition. The most common one is "the variation of life at all levels of biological organization", but it is somewhat too generalized in terms of specific interpretation. According to another definition, biodiversity is a measure of the relative diversity among the set of organisms that make up an ecosystem. "Diversity" in this case refers to both differences within and between species, as well as comparative differences between ecosystems. The basis for the sustainable existence of ecosystems is biodiversity. In 1992, under the auspices of the United Nations, the International Convention on Biological Diversity was adopted in Rio de Janeiro, and in 1998, the Law of Ukraine on the Conservation of Biological Diversity in Ukraine was adopted. In 1995, in Sofia, Ukraine signed the Pan-European Strategy for the Conservation of Biological and Landscape Diversity. Based on this concept, the National Program for the Conservation of Biological Diversity until 2015 and the Program for the Development of the Ecological Network in Ukraine were developed. A number of issues related to the protection of natural habitats of plants and animals are regulated by the Land (1992), Forest (1994) and Water (1995) Codes and the Subsoil Code (1994).

Objectives:

1. Write down the main provisions of the UN Convention on Biological Diversity.

2. Read paragraph 3.5 of the Law of Ukraine "On the National Program for the Formation of the National Ecological Network of Ukraine for 2000–2015" (Vedomosti Verkhovna Rada, 2000, No. 47, p. 405. Write down the main purpose of this paragraph.

3.Analyze the current state of the protected area network in Ukraine and determine its compliance with European indicators.

4. Name the protected areas in your region. Using a map of the nature reserve fund of Ukraine (region), indicate in Table 1 the location and area of protected areas. Name the representatives of flora (fauna) protected in these protected areas. Enter the data in the table.

Table 1

Name of protected areas	**Type**	**Location, area**	**Representatives of protected flora (fauna)**

8. How do you think the implementation of biodiversity conservation provisions in your region, in Ukraine, can be assessed?

9. Draw a conclusion!

Practical work № 12.
Analyzing the peculiarities of the development of the protected area network in Ukraine

Objective: to form an understanding of the development of the protected area network, to find out the role of international and national programs in biodiversity conservation.

Work in progress

1. Read the theoretical material.
2. Using the tables "Nature Reserves of Ukraine" and "Biosphere Reserves of Ukraine", determine the peculiarities of the development of the network of protected areas in our country from 1921 to 2009. Construct a bar chart that will show the decade (on the x-axis) and the number of protected areas created (on the y-axis).
3. How can you explain the decline in the growth rate of the area of the nature reserve fund of Ukraine?
4. Draw a conclusion.

Additional material

The nature reserve fund is an area of land and water whose natural complexes have special environmental, scientific, aesthetic, and recreational value.

Since independence, the area of Ukraine's nature reserve fund has more than doubled. It includes more than 7,250 territories and objects with a total area of 3.3 million hectares, which is about 6% of the country's territory (in 1991, this figure was only 1.9%). But this is not enough: the area of protected land per person in Europe is 2200 m^2, while in Ukraine it is only 570 m^2.

As of March 1, 2010, according to the Ministry of Nature, Ukraine had 19 nature reserves and 4 biosphere reserves, 47 national nature parks, 2853 nature reserves, 3203 natural monuments, 27 botanical gardens, 12 zoos, 54 arboretums, 542 parks-monuments of landscape art, 55 regional landscape parks, and 800 protected tracts.

Biosphere reserves of Ukraine are nature reserves of international importance, where all layers of the biosphere are protected and access to which is extremely limited.

Modern, thorough ecological and economic calculations and models show that preserving the gene pool of any region is possible only if at least 10–15% of its area is occupied by protected areas of the reserve or zakaznik rank. In most European countries, the average percentage of protected areas is 15%. The presence of a developed network of protected areas is a necessary (though not sufficient) condition for biodiversity conservation. Therefore, each state that has joined the Convention on Biological Diversity is obliged to maintain and develop a network of protected areas, primarily nature reserves.

Nature reserves of Ukraine

№ з/п	Name	Year of creation	Area, ha	Region
1.	Gorgany Nature Reserve	1996	5 344,2	Ivano-Frankivsk
2.	Dnipro-Orel Nature Reserve	1990	3 766,2	Dnipropetrovska
3.	Drevlyansky nature reserve	2009	30 872,84	Zhytomyr
4.	Nature reserve "Yelanetska steppe"	1996	1 675,7	Mykolaiv
5.	Kaniv Nature Reserve	1923	2 027	Cherkasy
6.	Luhansk Nature Reserve	1968	2 122	Luhansk
7.	Medobory Nature Reserve	1990	10 521	Ternopil
8.	Mykhailivska Tsilyna Nature Reserve	2009	882,9	Sumy
9.	Opuk Nature Reserve	1998	1 592,3	Autonomous Republic of Crimea
10.	Roztochya Nature Reserve	1984	2 084,5	Lviv
11.	Polissia Nature Reserve	1968	20 104	Zhytomyr
12.	Rivne Nature Reserve	1999	42 288,7	Rivne
13.	Cheremysl Nature Reserve	2001	2 975,7	Volyn
14.	Ukrainian steppe nature reserve	1961	3 335,6	Donetsk, Zaporizhzhya, Sumy

Answer the following questions:

1. Define the term biodiversity?

2. When was the Convention on Biological Diversity adopted and ratified by Ukraine?

3.What is the Ecological Network of Ukraine and why is it?

4.What are the protected areas, list them?

Biosphere reserves of Ukraine

№ з/п	Name	Year of creation	Area, ha	Region
1.	Askania Nova	1921	11 100	Kherson
2.	Danube Biosphere Reserve	1981	50 252,9	Odesa region
3.	Carpathian Biosphere Reserve	1968	57 880	Transcarpathian
4.	Black Sea Biosphere Reserve	1927	89 129	Kherson, Mykolaiv

Practical work № 13.
Criteria for the formation of the ecological network of Ukraine

Objective: to form a holistic view of the formation of an ecological network on the basis of protected areas of Ukraine, to master the main criteria for the formation of an ecological network. To consider the main aspects of creating a national ecological network in Ukraine.

Procedure:

1. Familiarize yourself with the theoretical material
2. Complete the task

Theoretical material

The formation of a pan-European ecological network is a qualitatively new stage in the development of environmental protection activities. Each country forms its own national eco-network to preserve biotic and landscape diversity. The scheme of such a network has also been developed in Ukraine and approved by the relevant law.

The International Union for Conservation of Nature (IUCN) considers the following to be the main criteria for selecting areas for the creation of nature reserves of various types

- preservation of the natural state of ecosystems and their spontaneous dynamics;
- conservation of habitats and species (including water resources)
- support for genetic diversity;
- preservation of traditional landscapes as aesthetic and cultural heritage;
- conservation of renewable resources in natural systems;
- the possibility of conducting scientific research;
- the possibility of developing protection measures for each type of reserve.

Floristic and faunal criteria

Floristic (faunal) criteria are the peculiarities of the composition (set) of taxa (primarily species) of plants and animals in a certain territory. In addition to qualitative (flora as a list of species) and quantitative (flora as the number of species) characteristics of species diversity, flora can be characterized by the composition of its geographical, biomorphological, and ecological elements, i.e. groups of species (typological elements of flora) that have certain common features. The same applies to fauna. Floristic and faunal criteria are among the most important for analyzing the territory and planning ecological network elements.

The selection of areas for the purpose of establishing key areas should be based on the hierarchy of biogeographic zoning. It is desirable to create at least one representative key area of the corresponding rank in each biogeographic zoning division of different rank (except for unique ones that can be located on the same territory).

Geobotanical (syndynamic) criteria

Geobotanical criteria for the selection of areas for inclusion in the eNet list are closely related to floristic criteria. Flora and vegetation are inextricably integrated in one vegetation cover, and each elementary (specific) flora has its own succession system of vegetation A naturally organized system of series of natural changes in vegetation cover (succession series) An additional criterion for including areas in the lists of the ecological network may be the principle of "protection of the weakest link" – for the full preservation of succession series, their most vulnerable stages should be protected, the most rare and least stable areas.

Landscape criteria

In accordance with Article 15 of the Law of Ukraine "On the Ecological Network of Ukraine", the design of the ecological network is carried out by developing regional schemes for the formation of the ecological network of the Autonomous Republic of Crimea and oblasts, as well as local schemes for the formation of the ecological network of districts, settlements and other territories of

Ukraine. In this regard, the first stage of ecological network planning is to analyze and assess the specifics of the territory of an administrative region in a number of respects.

In terms of natural structure, almost every administrative division is an artificial unit, to one degree or another. Administrative divisions, as a rule, have no natural boundaries, so neither floristic nor syndemic criteria, despite their naturalness and absolute necessity, are sufficient. They need to be supplemented by another group of criteria – landscape criteria. It is the landscape criteria that are crucial for a comprehensive analysis of the natural conditions of artificial administrative units; they take into account both the totality of physical and geographical information and data on anthropogenic transformation of the area.

The analysis of the spatial structure of the landscape includes the study of the ratio of natural and anthropogenic elements in its various sections (allocations), as well as the presence of anthropogenic ecotones. To assess the structure of the landscape, it is convenient to use maps M: 1:100000–1:200000. In this scale range, the following 5 types of landscape structure can be distinguished:

A – natural elements of the landscape cover the entire territory of the allotment being analyzed;

B – natural elements cover the area of the designation, but there are anthropogenic ecotopes along communications, reclamation channels, etc;

C – both natural and anthropogenic landscape elements are present in the designated area;

D – anthropogenic landscapes predominate within the designation, including natural ecosystems;

E – there are only anthropogenic landscapes within the designation.

Criteria for selecting structural elements of the ecological network

The next step in selecting areas for inclusion in the ecological network lists is to structure the areas selected according to the criteria discussed above. That is, assigning them the status of a certain structural element of the ecological network.

Structural elements of the regional ecological network are determined by objectively determined natural factors, spatial parameters of ecosystems and other types of territorial entities, in accordance with the principles of territorial structuring of the pan-European ecological network and the Law of Ukraine "On the Ecological Network of Ukraine" (Table 1). Structural elements, key, connecting (eco-corridors), buffer and restoration areas, in their continuous unity, create an ecological network that functionally unites biodiversity centers into a single national and continental system.

Criteria for selecting key ecological network areas

Key areas are areas of conservation of genetic, species, ecosystem and landscape diversity, as well as habitats of organisms, i.e. areas of important biological and ecological significance, well integrated into the landscape. They are characterized by a great diversity of biota species, landscape forms and habitats and are of critical importance for the conservation of endemic, relict and rare species and communities. Their area may vary depending on the territory where natural diversity, distribution of rare species or functional connections with other natural areas are preserved, as well as on the territorial level, but is not less than 500 hectares.

According to their importance, key areas can be divided into three groups:

- areas characterized by diversity or uniqueness of biota;
- areas with well-preserved natural landscapes of continental, national or regional value;
- areas that are human-transformed landscapes of significant historical and cultural value.

Table 1

Components of the structural elements of the ecological network

The name of the structural element of the ecological network	**Territorial level (territorial scale of influence)**	**Characteristics**
Key territory	• biospheric • continental • national • regional • local	A nodal element of the ecological network
Connecting area (eco-corridor)	• biospheric • continental • national • regional • local	The area of conservation of genetic, species, ecosystem and landscape diversity, habitats of organisms
Buffer zone	• biospheric • continental • national • regional • local (according to the status of the key territory)	Connecting element. A spatial, elongated structure that connects natural nuclei and provides support for reproduction, gene pool exchange, migration, maintenance of ecological balance, etc.
Restoration area	It is determined depending on what functions the territory will perform after renaturalization	A promising element. It is intended to restore the integrity of functional connections in a key or connecting area. This may be an area with fully or partially degraded natural elements, where priority measures to restore the original natural state should be taken. In the future, it should be included in other elements of the ecological network.

Table 2

Criteria for selecting key territories

Index	Criterion	Signs of compliance with the criterion
BE – **Bioenvironmental criteria**		
BE-n	Naturalness	The ecosystems and biota of the territory are in a natural or almost natural (little disturbed) state
BE-ds	Species diversity	The territory is characterized by a high level of richness and diversity of flora and fauna (above the average level for the region as a whole)
BE-dc	Cenotic diversity	The area is characterized by a high level (above the average for the region) of richness and diversity of plant communities
BE-s	Uniqueness and uniqueness and rarity of biota	The territory is characterized by a high concentration of endemic, relict and rare species and plant communities
BE-r	Representativeness representativeness	The biota of the territory is representative of the relevant biogeographic region.
L – **Landscape criteria**		
L-n	Naturalness	The landscapes of the territory have preserved their appearance in a natural or close to natural state
L-u	Uniquenesses	The territory has unique natural landscapes
L-d	Landscape diversity diversity	The territory contains a significant number of different and contrasting types of landscapes or natural territorial complexes.
L-r	Representativeness representativeness	The landscape structure of the territory is typical for the region
L-c	Cultural significance	Landscapes of the territory are transformed by humans and have significant historical and cultural value
T – **Territorial criteria**		
T-a	Sufficiency of area	The area of the territory is sufficient to identify its bio-ecological, functional, landscape, historical and cultural significance on a regional scale
T-c	Territorial integrity	Within the core area, the valuable sites are represented by a continuous array, or there are small windows of anthropogenically altered sites in such an array and are spatially connected into a local ecological network.

Thus, key areas are the areas of the highest concentration of biodiversity with a high degree of naturalness, rarity, etc., and they have a particularly high conservation, ecological, scientific and aesthetic value. First of all, key areas include territories and objects of the nature reserve fund of high ranks (natural and biosphere nature reserves, national nature parks, as well as large reserves and protected tracts, regional landscape parks); land plots with plant communities listed in the Green Book of Ukraine; territories that are habitats or growth areas of species of flora and fauna listed in the Red Book of Ukraine.

Criteria for selecting connecting areas (eco-corridors) of the ecological network

Eco-corridors are spatial, elongated structures that connect natural cores and include existing biodiversity of varying degrees of naturalness and habitats. Their main function is to ensure the maintenance of reproduction processes, gene pool exchange, species migration, spread of species to adjacent territories, survival of unfavorable conditions, hiding, and maintenance of ecological balance. The functional purpose of ecological corridors as pathways for migration, colonization and gene exchange through adverse conditions is to cover different geographical distances – from local to global, and for small and sedentary species – from local to regional, which determines the territorial status of ecological corridors.

The shape of the corridors can be either straight or winding. According to the territorial integrity, there are continuous and island eco-corridors. The former are a continuous strip with natural or semi-natural vegetation, while the latter are an elongated contour within which natural areas are located between which there is or is potentially possible exchange of genetic information.

The main conditions for this are:

- the length of the ecocorridor is no longer than the distance over which most species that exist in the key areas that connect the eco-corridor migrate;
- the width of the eco-corridor allows populations to effectively use it as a migration and dispersal channel;
- the edaphic conditions of the eco-corridor are similar or close to the edaphic conditions

- conditions of the key areas it connects;
- there are no migration barriers or other factors that may hinder the migration and dispersal of species within the eco-corridor.

In addition to its connectivity, an eco-corridor can have an independent value for the conservation of biodiversity and landscape diversity. This is especially important for areas or water areas of hydroecological corridors, which themselves have a high level of biodiversity. The components of the connecting territories of the ecological network include: territories and objects of the nature reserve fund (reserves, natural monuments, protected tracts); lands of the water fund, wetlands, water protection zones; lands of the forest fund; other forested areas, including forest strips and other protective plantations that are not classified as forest lands; lands of recreational use with their natural resources; other natural areas and objects (steppe vegetation areas, pastures, hayfields, stone outcrops, sands, salt marshes, land plots within which there are natural objects of special natural value); land plots on which plant communities listed in the Green Book of Ukraine grow; territories that are habitats or growth areas of species of flora and fauna listed in the Red Book of Ukraine; partially agricultural land for extensive use – pastures, meadows, hayfields, etc.

Criteria for selecting ecological network buffer areas

Buffer areas are transitional strips between natural areas and areas of economic use. The main function of the buffer area is to protect the territorial elements of the ecological network from negative anthropogenic impact. Therefore, they should have an area sufficient to protect key areas and eco-corridors from external negative factors and optimize certain forms of management in order to preserve existing and restore lost natural values. When designing specific local and regional ecological networks, the criteria for allocating buffer areas are determined by the characteristics of the key and connecting areas, which the former is created to protect. The width of buffer areas is determined depending on the direction and degree of impact of surrounding agricultural land or industrial facilities on the key and connecting areas of the ecological network, as well as the impact of the latter on agricultural land.

Table 3

Criteria for selecting connecting areas of the ecological network

Index	Criterion	Signs of compliance with the criterion
Ec-n	Naturalness	The eco-corridor should have natural boundaries.
Ec-l	Effective length	The length of the eco-corridor should not exceed the distance over which individuals of the populations for which the eco-network is created migrate or settle, or there should be "islands" on the territory of the eco-corridor where species can temporarily stay to continue migration or settlement.
Ec-w	Effective width	The width of the eco-corridor should allow populations to settle or migrate along it with the necessary efficiency.
Ec-e	Ectopic	The eco-corridor territory should be similar in its edaphic conditions to the key areas it connects or provide conditions for temporary stay (overnight, feeding, etc.) for long-distance migratory species (e.g. birds).
Ec-t	Territorial connectivity	The territory of the eco-corridor should be continuous or have breaks, but the length of the breaks should not interfere with the migration of species.
Ec-d	Biodiversity	The eco-corridor territory should have a fairly well-preserved vegetation cover and a high level of biodiversity.
Ec-s	Sociological	The eco-corridor may include areas where rare, endemic or relict species of plants and animals grow or exist, or rare areas of the ecological network.

Criteria for selecting restoration areas of the ecological network

Restoration areas are created as part of the ecological network in order to further its development and improve its functioning. These are the areas where it is necessary and possible to restore the natural vegetation cover and repatriate plant and animal species. This is a potential reserve that can be used to increase the area of key and connecting areas in the future. Therefore, the main criteria for selecting restoration areas are the preservation of habitats, even if the natural biodiversity is completely destroyed (drained peatlands, degraded meadow and steppe natural pastures, lignified forests, intensive agrocenoses) and the real possibility of carrying out renaturalization measures.

The following territories are included in the restoration areas of the ecological network:

- long plowed, low productive;
- re-salinized due to excessive irrigation;
- pasture failures, areas of livestock grazing and places of their permanent concentration;
- overgrown with quarantine weed species, including those harmful to human health;
- quarries, rock dumps, etc;
- arable land on slopes that are allocated for soil protection strips or permanent areas intended for breeding wild pollinating insects;
- slopes of embankments and exclusion zones along roads, railways, oil and gas pipelines, power lines and other communications;
- areas of open ground where gully and landslide processes are occurring or may develop;
- places of permanent recreation and other recreational areas;
- sites subject to long-term conservation due to radiation, chemical or other contamination that poses a threat to human and animal health;
- rural areas subject to reclamation - estates, abandoned farms, etc.

Formation of Ukraine's ecological network

The new outlook has led to the formation of *two strategic directions for the development* of protected sozology in Ukraine, namely: 1) improvement of the categorical and functional structures of the protected areas system and 2) creation of a national ecological network as an integral part of the pan-European network. *Therefore, the following scientific requirements are the basis for the concept of developing the protected areas network in Ukraine:*

1) the objects of the protected areas network should have a multifunctional purpose in terms of their main functions (protection, recreation, environmental education and upbringing, balanced use of territories and their restoration);

2) the selection of territories should be based on the typicality and uniqueness of ecosystems of natural and geographical zones;

3) objects should be located more or less evenly;

4) they should be considered in connection with long-term plans for the economic development of natural resources;

5) depending on the specific conditions of the region and the tasks of development, the network will have different ranks, namely: national, regional and local. This implies that in the near-term conservation sozology, undoubted preference should be given to the creation of a dense network of NNPs and BRs, which are intended to embody models of sustainable development and rational nature management for both individual regions and Ukraine as a whole.

The creation of a system of protected areas (hereinafter referred to as PAs) should be based on a clear scientific basis.

I. Group of scientific approaches. This group of approaches is intended to ensure that the PA system has the necessary set of elements that create conditions for biodiversity protection and stabilization of ecological balance.

Rare. For scientific purposes, it is necessary to preserve rare ecosystems, phytocoenoses and species, primarily relict, endemic or endangered ones. Based on this, forest components are primarily reserved and protected.

Categorical and functional. A unified structure of complementary categories and functions of protected areas is formed, and new ones are developed if necessary. A system of palliatives and ways to implement protected areas is envisaged. The categorical structure should be dynamic, depending on the priority goals of protection and changes in the functions of some of its elements.

Protection regimes. All scientifically based types of forest ecosystem protection regimes are introduced, and new ones are developed if necessary, especially in cases where several protected area functions conflict. The system of protection regimes should be combined with the system of natural resource management and territorial organization and is formed together with a single PA system.

Monitoring. When forming a PA system, it plays an important role in fulfilling global, regional and local environmental objectives. The PA system will be complete only when it has an extensive network of facilities necessary for monitoring and controlling anthropogenic processes occurring at different ecological levels of the forest biome.

II. A group of scientific principles. This includes the principles according to which state protected areas (hereinafter referred to as SPAs) that form the system are selected. It will be the basis for solving scientific problems of preserving the gene and price pool, ensuring the existence of all forms and varieties of life.

Ecological and phytocoenotic. This principle ensures the representativeness of biodiversity protection, namely, the gene pool, price pool and ecological fund of a certain territory (network), especially in extreme environmental conditions. This principle is fundamental to stabilizing ecological balance.

Zonal and geographical. In the PA system, it provides landscape-geographical, latitudinal-meridional, and in mountainous regions – altitude-belt patterns of distribution of forest natural ecosystems in historical, geographical and other respects.

Evolutionary and genetic. It ensures the preservation of all links of the biostroma's evolutionary processes. It is based on the population approach, where special attention is paid to evolutionarily progressive and ancient species and their forms. This principle is used to protect dynamic forest ecosystems, which have important ecological and stabilizing value.

III. The group of natural and social principles. This group complements the PA system with principles that are not the main ones in solving the problem of biodiversity conservation, but only represent a scheme of balanced development in nature management, which embodies the attitude of society to nature in an ideal way.

Cultural and educational. It provides for the inclusion of all forest objects that have general educational, scientific, informational, cognitive, and cultural significance in the PAs. First of all, these are classical objects that contribute to the development of the population's understanding of the general laws of nature, its functioning, and its importance for society.

Aesthetic. It determines the inclusion of the most picturesque areas of nature in the PA system, which contribute to the development of the emotional sphere of a person and his/her aesthetic ideas.

Recreational. It stipulates the inclusion of areas rich in recreational resources, i.e. forest areas of general health, balneological, sanitary and hygienic, sports and tourist importance. The area of these objects should ensure year-round mass recreation of people without harming nature.

Resource and economic. It ensures the preservation of forest areas that have applied economic value and are used by people in the production sector.

In terms of qualitative and quantitative content, scientific and ecological value, and protection regime, protected areas are unequal. Therefore, they can be grouped on the basis of similar features into certain aggregates representing a certain environmental category. A unified categorical structure of the PA system has not yet been developed, as the Ukrainian PA system is not perfect in terms of the number and quality of categories. Apart from artificially created ones, it includes only natural universally recognized PAs and NNRs and a regional nature park (hereinafter referred to as RNP), nature reserves and monuments, and protected tracts. In foreign countries, there are a number of other categories that are represented in the IUCN classification.

The main elements of the national ecological network of national importance are presented in the Table 4.

Table 4

Key elements of the national ecological network of national importance

An element of of the ecological network	Distribution by physical and geographical conditions	Main territories and objects - components of the ecological network
Natural regions		
Carpathian	Carpathian mountainous country	Biosphere reserves: Carpathian, Roztochansky, Eastern Carpathians; Gorgany Nature Reserve; Natural national parks: Synevir, Carpathian, Uzhansky, Skole Beskydy, Hutsulshchyna Galician Nature National Park
West Polissya	Predkarpattya and Opillya	Western Polissia Biosphere Reserve; Nature reserves: Cheremsky, Rivnensky, Yuzhnopolsky.
Central	Western Polissya	Polissia Biosphere Reserve; Nature reserves: Dniprovskyi, Desnianskyi; Natural national parks: Mezynskyi, Korostyshivskyi, Ichnianskyi, Holosiivskyi forests.
Polissya	Prydniprovia Polissya	Natural national parks: Sredneseimsky, Desniansko-Starogutsky, Trostyanets-Vorsklyansky;
Eastern Polissya	Eastern Polissya	Medobory Nature Reserve; Natural national parks: Podilski Tovtry, Kremenets Mountains, Central Podilskyi, Savranskyi Forest, Dniester Canyon.
Medium Dniprovsky	Middle Prydniprovia	Ukrainian forest-steppe Biosphere reserve; national nature parks: Cherkasy Bor, Kholodnyi Yar, Sredne-Prydniprovskyi, Trakhtemyrivskyi, Preiaslav-Khmelnytskyi, Chornolisskyi; Kanivskyi Nature Reserve.
Prydonetsky Donetsk Priazovsky	Siverskyi river valley Donets River	National natural parks: Holy Mountains, Siversko-Donetskyi, Slobozhanskyi, and Gomolshanskyi.
Tauride	Donetsk ridge, Azov upland	Ukrainian Steppe Nature Reserve; National Nature Parks: Azov Meotida.

Lower Dniester	Dnipro-Molochanske interfluve	Biosphere reserves: Black Sea, Askania Nova; National nature parks: Nizhnedniprovsky, Azov-Sivash.
Lower Danube	Lower reaches of the Dniester River valley	Nizhnednistrovsky Natural National Park.
Azov	Lower reaches of the Danube River valley	Danube Biosphere Reserve.
Black Sea	Sea of Azov	Kazantip and Opuk nature reserves; national nature parks: Azov-Sivash, Meotida.
Medium Dniprovsky	North-eastern shelf of the Black Sea	National natural parks: Big Phyllophora Field, Zernova, Small Phyllophora Field, Kinburn Spit.
Natural corridors		
Polissya	Mixed forest zone	Forests of the first and second groups, marshes.
Galician Slobozhansky	Forest-steppe zone	Forests of the first and second groups, forest belts, meadows, pastures.
South Ukrainian	Steppe zone	Forest belts, pastures, hayfields.
Coastal sea	Coastal zone of the Azov and Black Seas	Inland sea waters, sea spits, shoals, beaches, islands.
Dniester region	Dniester river valley	Floodplain meadows, shrubs, sloping lands with little vegetation, forests, water bodies.
Buzky	Valleys of the Western and Southern Bug rivers	Floodplain meadows, shrubs, sloping lands with little vegetation, forests, water bodies.
Dnipro	Dnipro river valley	Floodplain meadows, shrubs, sloping land with little vegetation, forests, water bodies
Siversko-Donetsky	Siverskyi river valley Donets River Valley	Floodplain meadows, shrubs, sloping lands with little vegetation, forests, water bodies

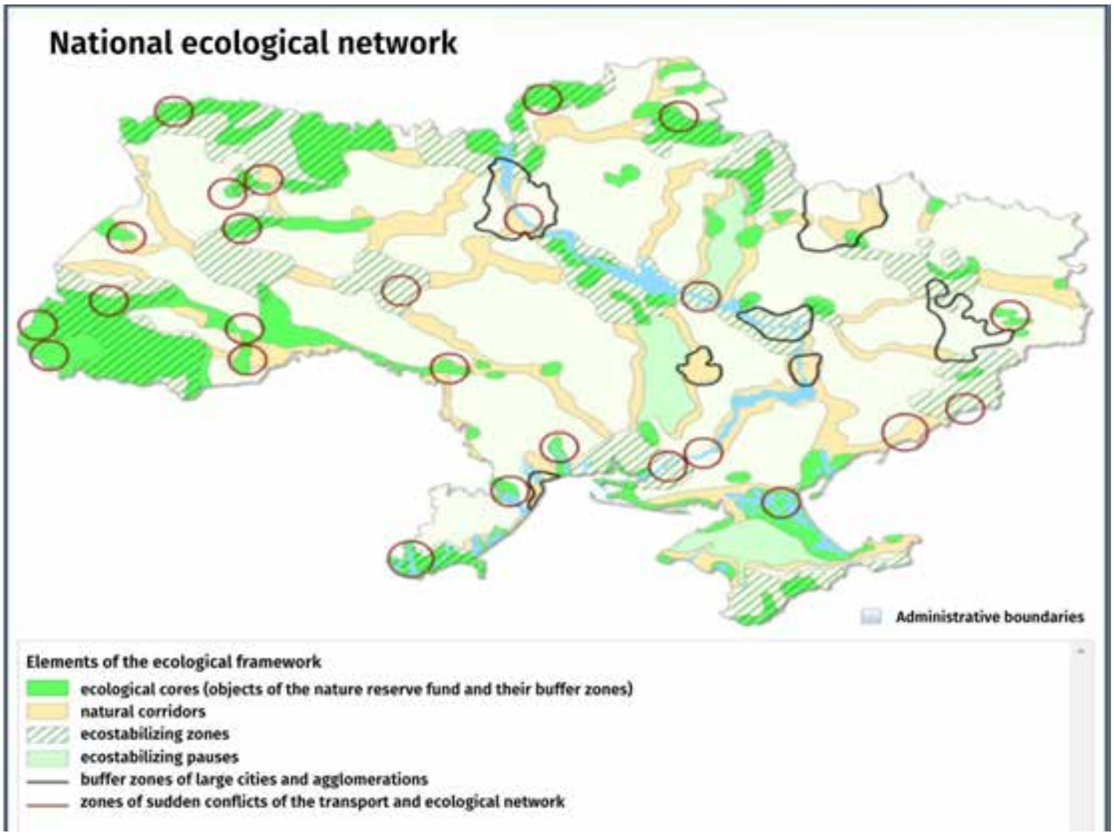


Fig. 1. **National ecological network**

Objectives:

Task 1. Based on the theoretical material, make a crossword puzzle (10 questions horizontally and vertically).

Task 2. Fill in Table 5 based on the theoretical material contained in the practical work.

Table 5

Group of scientific approaches

Scientific approaches	**Significance**

Task 3. Describe the group of scientific and socio-natural principles and fill in the table 6.

Table 6

A group of scientific and socially natural principles

№	**Principles**	**Characteristics**

Task 4. Describe the main elements of the national ecological network and indicate which ecological element of the ecological network they belong to. Fill in the table 7.

Table 7

Key elements of the national ecological network of national importance

Main territories and objects - components of the ecological network	**An element of the ecological network**
Biosphere reserves: Carpathian, Roztochansky, Eastern Carpathians; Gorgany Nature Reserve; Natural National Parks: Synevir, Carpathian, Uzhansky, Skole Beskydy, Hutsulshchyna Natural National Park Galician	
Nature reserves: Crimean, Yalta, Karadazh, Opuk; Natural national parks: Sevastopol, Chatyr-Dag.	
Western Polissya Biosphere Reserve; Nature reserves: Cheremsky, Rivne, Yuzhnopolsky.	

Polissia Biosphere Reserve; Nature reserves: Dniprovskyi, Desnianskyi; Natural national parks: Mezynskyi, Korostyshivskyi, Ichnianskyi, Holosiivskyi forests.	
Natural national parks: Sredneseimsky, Desniansko-Starogutsky, Trostyanets-Vorsklyansky;	
Medobory Nature Reserve; Natural National Parks: Podillia Tovtry, Kremenets Mountains, Central Podillia, Savransky Forest, Dniester Canyon.	
Ukrainian Forest-Steppe Biosphere Reserve; national nature parks: Cherkasy Bor, Kholodnyi Yar, Sredne-Prydniprovskyi, Trakhtemyrivskyi, Preiaslav-Khmelnytskyi, Chornolisskyi;	
National natural parks: Sviati Hory, Siversko-Donetskyi, Slobozhanskyi, and Gomolshanskyi National Parks.	
Ukrainian Steppe Nature Reserve; National Nature Parks: Azov Meotida.	
Biosphere reserves: Black Sea, Askania Nova; National nature parks: Nizhnedniprovsky, Azov-Sivash.	
Nizhnednistrovsky natural national park.	
Danube Biosphere Reserve.	
Kazantip and Opuk nature reserves; national nature parks: Azov-Sivash, Meotida.	
National nature parks: Big Phyllophora Field, Zernova, Small Phyllophora Field, Kinburn Spit.	

Draw conclusions:____

Practical work № 14.
Determining the amount of damage caused by the illegal destruction of wild animals

***Objective**:* to determine the amount of damage caused by the illegal harvesting or destruction of wildlife, damage or destruction of their habitats and habitats and breeding grounds**.**

Methods of work

1. Familiarize yourself with the theoretical material.

2. Calculate the damage caused by the violation of the legislation on the nature reserve fund as a result of illegal extraction or destruction of wildlife, damage or destruction of their homes and structures, habitats and breeding grounds according to your option.

3. Describe the species of exterminated animals listed in the Red Data Book of Ukraine according to the options.

4. Draw a conclusion about the damage caused to the environment and ways to minimize it.

Theoretical part

According to the National Program of Biodiversity Conservation for 2005–2025, biodiversity is a national wealth of Ukraine, the conservation and sustainable use of which is recognized as one of the priorities of state policy in the field of natural resources management, environmental safety and environmental protection, an essential condition for improving its condition and environmentally balanced social and economic development.

This is facilitated by taxes (fees) for damage to or destruction of objects listed in the Red Book of Ukraine.

The calculation of damage caused by violation of the legislation on the nature reserve fund as a result of illegal hunting or destruction of wildlife, damage or destruction of their homes and structures, habitats and breeding grounds is carried out in accordance with the Resolution of the Cabinet of Ministers of Ukraine No. 541 of 29.07. 2013 "On Approval of Tariffs for Calculating the Amount of Damage Caused by Violation of the Nature Reserve Fund Legislation" (CMU Resolution No. 521 of 21.04.1998 "On Approval of Tariffs for Calculating the Amount of Compensation for Damage Caused by Violation of Environmental Legislation within the Territories and Objects of the Nature Reserve Fund of Ukraine" has been repealed).

The calculation of damage is performed according to the formula:

$$D = \sum n_{i=0} (DM_i \cdot n) + \sum n_{i=0} (DM_i \cdot n_l \cdot K_l) + \sum n_{i=0} (DM_i \cdot n_e \cdot K_e) + \sum n_{i=0} (DM_i \cdot n_j \cdot K_j), \quad (1)$$

where ***DM_i*** – the amount of damage caused by illegal hunting or destruction of wildlife listed in the Red Data Book of Ukraine, UAH/person (Table 2);

n – the number of individuals of illegally harvested or destroyed wildlife listed in the Red Book of Ukraine (Table 1);

n_j – number of damaged homes of wildlife listed in the Red Book of Ukraine, pcs. (Table 1);

K_j – a coefficient that is taken into account in case of damage to the housing of wildlife listed in the Red Book of Ukraine ***(K_j=2);***

n_e – number of illegally extracted or destroyed embryos of wildlife species listed in the Red Book of Ukraine, pcs. (Table 1);

Ke – a coefficient that is taken into account when extracting or destroying embryos of wildlife listed in the Red Book of Ukraine (**K_e=2**);

N_{ya} – number of illegally harvested or destroyed eggs of birds listed in the Red Data Book of Ukraine, pcs.;

K_{ya} – a coefficient that is taken into account when extracting or destroying eggs of birds listed in the Red Book of Ukraine (**K_{ya} =1)**.

Special cases of damage assessment:

1. The amount of damage caused by the illegal taking or destruction of animals from the classes of insects and amphibians also applies to the larval stage of development.

2. The amount of damage established for systematic groups of animals shall apply to all species in these groups.

3. If illegal activities on the territory of the nature reserve fund cause the destruction of an animal colony (including without destruction or ruin of nests and other dwellings), compensation for damage shall be calculated as for the destruction of all nests (dwellings) in the colonial settlement.

4. For the destruction or illegal removal of animals in the zoological collections of zoos, zoos, oceanariums, other institutions and objects of the nature reserve fund established for the purpose of organizing educational and upbringing work and keeping animals in captivity or semi-free conditions, as well as for cruel treatment of animals that led to their death, the amount of damage is determined by three times the amount of costs for the purchase of animals of the relevant species to renew the collections.

Table 1

Characterization of illegally harvested or destroyed wildlife, damaged or destroyed dwellings and structures, habitats and breeding grounds

№	Type of animal object world	Quantity, units	Note
1	2	3	4
1	moose	1	
	lesser petrel	2	
	marsh turtle	5	
2	Turkmen kulan	1	
	great white heron	1	1 nest destroyed
	egret	6	
3	red deer	2	Destroyed 1
	mute swan	8	embryo
	cranesbill	15	
4	fallow deer	1	Destroyed 1
	quail	3	embryo
	scarab	15	

5	spotted deer	2	
	lesser white heron	1	1 nest destroyed
	newt	2	3 burrows damaged
6	wild pig	2	
	gray heron	1	1 nest destroyed
	scorpion	2	
7	mouflon	2	
	flamingo	1	
	flounder	2	
8	roe deer	1	Destroyed 1
	mute swan	8	embryo
	ant lion	5	
9	beaver	1	
	white stork	4	
	burrowing wasp	10	
10	fox	3	3 nests destroyed
	great hawk	2	
	peacock eye	5	
11	єнотовидний собака	2	
	red heron	1	1 nest destroyed
	common viper	5	
12	wolf	4	Destroyed 2 embryos
	white partridge	3	
	pike	2	Destroyed 2 embryos
13	American mink	2	
	common pheasant	1	2 burrows destroyed
	singing cicada	5	1 nest destroyed
14	marmot	1	
	long-tailed eagle	1	
	mackerel	3	
15	muskrat	2	
	harrier	2	1 nest destroyed
	caviar of amphibians	1	
16	ordinary hedgehog	4	
	common cuckoo	1	
	crayfish	10	
17	squirrel	1	
	nuthatch	3	
	spinning wheel	4	
18	ordinary blind man	4	Destroyed 1
	halcyon	8	embryo
	lobster	2	4 eggs destroyed
19	the rat is black	4	
	long-eared owl	3	
	shuttlecock	5	
20	water vole	14	3 burrows destroyed
	remez	2	1 nest destroyed
	mantis	5	3 burrows destroyed

Table 2

Reference data for practical work

Objects of the animal world	Unit of measurement	The amount of damage, UAH
Beasts:		
elk	per 1 individual	40000
Turkmen kulan		20000
red deer		16500
fallow deer, spotted deer, wild pig		11000
mouflon, roe deer		8800
beaver, badger		2860
fox, raccoon dog		2605
wolf		1000
marmot, American mink		2710
muskrat, nutria free		1824
common hedgehog, mole		260
squirrel		495
common blind man		521
black rat		182
water vole		26
Birds:		
Great White Heron and Lesser White Heron	per 1 individual	3645
gray and red heron		1730
white stork		2970
mute swan, whooper swan		2657
great hawk		4950
marsh harrier		1250
long-tailed eagle		3000
flamingo		2657
white partridge		939
common pheasant		939
martin		250
common cuckoo		396
barn owl		1484
remez		521
nuthatch		350
quail		469
little petrel		250
Reptiles:		
marsh turtle	per 1 individual	350
common viper, spindle viper		730
Amphibians:		
newt	per 1 individual	26
duckweed		47
amphibian caviar	for 1 laying	26
Pisces:		
pike	per 1 individual	602
flounder		1515
mackerel		752

Butterflies:		
peacock's eye, large forest nacre	per 1 individual	16
singing cicada, mantis		21
Bugs:		
cranesbill (turun)	per 1 individual	31
scarab, rhinoceros		26
Lepidoptera:		
ant lion	per 1 individual	16
Hymenoptera:		
bee, burrowing wasp	per 1 individual	10
Arachnids:		
scorpio, pseudoscorpio	per 1 individual	8
Crustaceans:		
river crayfish, hermit crab	per 1 individual	45
lobster		1560
Roundworms:		
rotisserie	per 1 individual	301
Intestinal:		
hydroids, jellyfish, coral polyps	per 1 individual	2

Answer the following questions:

1. According to which document is the damage caused by violation of the legislation on the nature reserve fund as a result of illegal extraction or destruction of wildlife objects calculated?
2. What coefficients should be taken into account when calculating the amount of damage caused by the illegal harvesting or destruction of wildlife listed in the Red Book of Ukraine?
3. What indicators are used to calculate the damage caused by the violation of the legislation on the nature reserve fund as a result of illegal harvesting or destruction of wildlife, damage or destruction of their homes and structures, habitats and breeding grounds?
4. Describe special cases of damage assessment.

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APPENDICES

Addition 1.

List of entomological biodiversity of geobionts in agrolandscapes of the Forest Steppe

Isoptera; Termitidae South European termite – *Reticuliterme (Leucotermes) lucifugus* Rossi, 1792	–
Orthoptera; **Gryllotalpidae** Common wolfsbane – *Gryllotalpa gryllotalpa* Linnaeus, 1758	+
Dermatoptera; **Forficulidae** *Forficula auricularia* Linnaeus, 1758	+
Forficula tomis Kolenati, 1846	–
Homoptera; **Cixiidae** *Cixius nervosus* Linnaeus, 1758	–
Koreneva cicada – *Pentastiridius leporinus* Linnaeus, 1761	–
Diptera; **Tipulidae** Harmful longhorned mosquito – *Tipula paludosa* Meigen, 1830	+
Coleoptera; Silphidae Dark dead beetle – *Silpha obscura* Linnaeus, 1758 *Necrophorus humator* Heinzel and Biihm, 1984	+
Carabidae	-
Pterostichus vernalis Panzer, 1795	+
Harpalus distinguendus Duftschmied, 1812	+
Harpalus luteicornis Duftschmied, 1812	+
Broscus cephalotes Linnaeus, 1758	+
Calathus erratus Sahlberg, 1827	+
Bembidion properans Stephens, 1828	+

Amara aenea DeGeer, 1774	+
Amara familiaris Duftschmid, 1812	+
Pterostichus cupreus Linnaeus, 1758	+
Pterostichus versicolor Sturm, 1824	–
Pterostichus melanarius Illiger, 1798	+
Common rat – *Amara plebeja* Gyllenhal, 1810	+
Yellow-legged rat – *Amara familiaris* Duftschmid, 1812	–
Broad rat – *Amara eurynota* Panzer, 1797	–
Seed rat – *Amara similata* Gyllenhal, 1810	+
Flattened rat – *Amara spreta* Dejean, 1831	+
Narrow rat – *Amara bifrons* Gyllenhal, 1810	+
Humpbacked rat – *Amara convexiuscula* Marsham, 1802	–
Yard rat – *Amara aulica* Panzer 1797	–
Bitter rat – *Amara apricaria* Paykull, 1790	–
Tar-brown rat – *Amara consularis* Duftschmid, 1812	+
Thick-headed rat – *Amara ingenua* Duftschmid, 1812	+
Common Bread Pipistrelle – *Zabrus tenebrioides* Goeze, 1777	+
Steppe runner – *Ophonus azureus* Fabricius, 1775	–
Speckled-breasted runner – *Ophonus puncticollis* Paykull, 1798	–
Hairy runner – *Ophonus rufipes* De Geer, 1774	–
Gray runner – *Ophonus griseus* Panzer, 1797	–
Scarabaeidae	
Corn dung beetle – *Pentodon idiota* Herbst, 1789	+
Meadow beetle – *Anomala dubia* Scopoli, 1763	–
Steppe borer – *Anomala errans* Fabricius, 1775	–
Garden borer – *Phyllopertha horticola* Linnaeus, 1758	–
Seed beetle – *Anisoplia segetum* Herbst, 1783	+
Cuzka or bread beetle – *Anisoplia austriaca* Herbst, 1783	+

Desert borer – *Anisoplia deserticola* Fischer von Waldheim, 1824	–
Western May beetle – *Melolontha melolontha* Linnaeus, 1758	+
Oriental May beetle – *Melolontha hippocastani* Fabricius, 1801	–
July marbled beetle – *Polyphylla fullo* Linnaeus, 1758	–
Gray hairy beetle – *Anoxia pilosa* Fabricius, 1792	+
Common root beetle – *Rhizotrogus aestivus* Olivier, 1789	+
Spring root beetle – *Miltotrogus vernus* Germar, 1823	+
April beetle – *Miltotrogus aeguinoctialis* Herbst, 1790	–
June beetle – *Amphimallon solstitialis* Linnaeus, 1758	–
Red beetle – *Serica brunnea* Linnaeus, 1758	–
Silky beetle – *Maladera holosericea* Scopoli, 1772	–
Hoplia parvula Krynicki, 1832	+
Elateridae	
Pollenous grasshopper – *Actenicerus sjaelandicus* Müller, 1764	–
Broad grasshopper – *Selatosomus latus* Fabricius, 1801	+
Shiny grasshopper – *Selatosomus aeneus* Linnaeus, 1758	+
Willow moth – *Cidnopus aeruginosus* Olivier, 1790	–
Narrow grasshopper – *Athous jejunus* Kiesenwetter, 1858	+
Brown-legged grasshopper – *Melaotus brunnipes* Germar, 1824	–
Striped grasshopper – *Agriotes lineatus* Linnaeus, 1767	+
Dark grasshopper – *Agriotes obscurus* Linnaeus, 1758	+
Sowing moth – *Agriotes sputator* Linnaeus, 1758	+
Lesser grasshopper – *Agriotes rachifer* Geoffroy, 1785	–
Yellow-eared grasshopper – *Adrastus pallens* Fabricius, 1792	–
Alleculidae	
Daghestan pollen beetle – *Podonta daghestanica* Reitter, 1885	+
Tenebrionidae	+
Sandy inkworm – *Opatrum sabulosum* Linnaeus, 1761	+

Coastal inkweed – *Opatrum riparium* Gerhardt, 1896	+
Sod ink – *Crypticus quisquilius* Linnaeus, 1761	+
Black ink – *Oodescelis polita* Sturm, 1807	+
Corn borer – *Pedinus femoralis* Linnaeus, 1767	–
Steppe copperhead – *Blaps halophila* Fischer von Waldheim, 1832	–
Broad-breasted copperhead – *Blaps lethifera* Marsham, 1802	+
Chrysomelidae	
Colorado potato beetle – *Leptinotarsa decemlineata* Say, 1824	+
Striped flea – *Phyllotreta vittula* Redtenbacher, 1849	+
Curculionidae	
Spotted mower – *Otiorrhynchus fullo* Schrank, 1781	+
Alfalfa mower – *Otiorrhynchus ligustici* Linnaeus, 1758	–
Small black mower – *Otiorrhynchus raucus* Fabricius, 1776	–
Spherical mower – *Otiorrhynchus rotundatus* Siebold, 1837	–
Forest mower – *Otiorrhynchus singularis* Linnaeus, 1767	–
Sad mower – *Otiorrhynchus tristis* Harold, 1872	–
Globular weevil – *Mylacus globulus* Boheman, 1843	–
Variegated leaf elephant – *Phyllobius maculicornis* Germar, 1824	–
Beech leaf elephant – *Phyllobius viridicollis* Fabricius, 1792	–
Nettle leaf beetle – *Phyllobius urticae* Degeer, 1775	–
Gray bud weevil – *Sciaphobus squalidus* Gyllenhal, 1834	–
Weevil of the wire – *Brachysomus echinatus* Bonsdorff, 1785	–
Bristle weevil – *Cneorrhinus albinus* Boheman, 1833	+
Bristle weevil – *Sitona crinitus* Herbst, 1795	+
Melilot weevil – *Sitona cylindricollis* Fahraeus, 1840	+
Butterfly weevil – *Sitona flavescens* Marsham, 1802	+

Lupine weevil – *Sitona griseus* Fabricius, 1775	+
Yellow-legged tuberous weevil – *Sitona hispidulus* Fabricius, 1776	+
Alfalfa tuberous weevil – *Sitona humeralis* Stephens, 1829	+
Small alfalfa weevil – *Sitona inops* Gyllenhal, 1834	+
Striped tuberous weevil – *Sitona lineatus* Linnaeus, 1758	+
Alfalfa root weevil – *Sitona longulus* Gyllenhal, 1834	+
Clover root weevil – *Sitona puncticollis* Stephens, 1831	+
Clover bulb weevil – *Sitona sulcifrons* Thunberg, 1798	–
Lodgepole weevil – *Sitona waterhousei* Walton, 1846	–
Gray beet weevil – *Tanymecus palliatus* Fabricius, 1787	+
Green weevil – *Chlorophanus viridis* Linnaeus, 1758	–
Common beet weevil – *Bothynoderes punctiventris* Germar, 1794	+
Striped beet weevil – *Chromoderus fasciatus* Müler, 1776	–
Tiger weevil – *Cyphocleonus tigrinus* Panzer, 1789	–

Addition 2.

List of entomological biodiversity of herpetobionts in the agrolandscapes of the Forest Steppe

Coleoptera; **Cicindelidae**	
German jumping jay – *Cicindella germanica* Linnaeus, 1758	+
C. soluta Dejean, 1822	–
C. arenaria viennensis Fuesslin, 1775	–
C. hybrida Linnaeus, 1758	–
Carabidae	
Calosoma inquisitor Linnaeus, 1758	–
C. auropunctatum Herbst, 1784	–
C. granulatus Linnaeus, 1758	–
Carabus excellens Fabricius, 1798	–
C. investigator Illiger, 1798,	–
C. estreicheri Fischeri, 1822	–
Lattice-headed turun – *C. cancellatus* Illiger, 1798	+
C. clathratus Linnaeus, 1761	–
C. marginalis Fabricius, 1794	–
Purple loosestrife – *C. violaceus* Fabricius 1787	+
Liestus ferrugineus Linnaeus, 1758	–
Omophron limbatum Fabricius, 1777	–
Blethisa multipunctata Linnaeus, 1758	–
Elaphrus cupreus Duftschmidt, 1812	–
Notiophilus aquaticus Linnaeus, 1758	–
Notiophilus palustris Duftschmid, 1812	–
Loricera pilicornis Fabricius, 1775	–
Clivina fossor Linnaeus, 1761	–
Headed Raven – *Broscus cephalotes* Linnaeus, 1758	+

Asaphidion flavipes Linnaeus, 1761	–
Bembidion lampros Herbst, 1784	–
Bembidion properans Stephens, 1828	+
Bembidion quadrimaculatus Linnaeus, 1761	+
B. dentellum Thunberg, 1787	–
B. ustulatum Linnaeus, 1758	–
Trechus secalis Paykull, 1790	–
T. quadristriatus Schrank, 1781	–
Panagaeus crux-major Linnaeus, 1758	–
Badister unipustulatus Bonelli, 1813	–
B. bipustulatus Fabricius, 1792	–
Chlaenius festivus Panzer, 1796	–
C. vestitus Paykull, 1790	–
C. tristis Schaller, 1783	–
C. alutaceus Gebler, 1829	–
Oodes helopioides Fabricius, 1792	–
O. gracilis Villa, 1833	–
Poecilus punctulatus Schaller, 1783	–
P. sericeus Fiscer de Waldheim, 1824	–
P. lipidus Leske, 1785	–
Copper pecilus – *P. cupreus* Linnaeus, 1758	+
P. versicolor Sturm, 1824	–
P. crenuliger Chaudoir, 1876	–
P. puncticollis Dejean 1828	–
Pterostichus longicollis Duftschmid, 1812	–
P. angustatus Duftschmid, 1812	–
P. vernalis Panzer, 1795	–
P. aterrimus Herbst, 1784	–

P. niger Schaller, 1783	+
P. oblongopunctatus Fabricius, 1787	–
P. nigrita Paykull, 1790	–
P. anthracinus Panzer, 1795	–
P. melanarius Illiger, 1798	+
P. maculates Panzer, 1796	–
Pterostichus cupreus Linnaeus, 1758	–
Agonum viridicupreum Goeze, 1777	–
A. sexpunctatum Linnaeus, 1758	–
A. gracilipes Duftschmid, 1812	–
A. lugens Duftschmid, 1812	–
A. moextum Duft.	–
A. assimile Paykull, 1790	–
A. dorsale Pontoppidian, 1763	–
Sinuchus nivalis Panzer, 1797	–
Calathus halensis Schall, 1783	+
C. maculates Paykull, 1790	+
C. erratus Sahlberg, 1827	+
C. fuscipes Goeze, 1777	+
C. melanocephalus Linnaeus, 1758	–
Taphoxenus gigas Fischer von Waldheim, 1823	–
Oxypselaphus obscurum Herbst, 1784	–
Nebria brevicollis Fabricius, 1792	+
Amara aenea Degeer, 1774	–
A. ovata Fabricius, 1792	–
A. apricaria Paykull, 1790	–
A. municipalis Duftschmid, 1812	–
A. fulva Mueller, 1776	–

Common rat – *Amara plebeja* Gyllenhal, 1810	–
Yellow-footed rat – *Amara familiaris* Duftschmid, 1812	–
Broad rat – *Amara eurynota* Panzer, 1797	–
Seed rat – *Amara similata* Gyllenhal, 1810	–
Flattened rat – *Amara spreta* Dejean, 1831	–
Narrow rat – *Amara bifrons* Gyllenhal, 1810	+
Humpbacked rat – Amara convexiuscula Marsham, 1802	–
Yard rat – *Amara aulica* Panzer, 1797	–
Bitter rat – *Amara apricaria* Paykull, 1790	–
Tar-brown rat – *Amara consularis* Duftschmid, 1812	–
Thick-headed rat – *Amara ingenua* Duftschmid, 1812	–
Forest rat – *Amara communis* Panzer, 1797	+
Common bread shrew – *Zabrus tenebrioides* Goeze, 1777	–
Curtonotus aulica Panzer, 1797	–
Zabrus spinipes Fabricius, 1798	–
Ophonus diffinis Dejean, 1829	–
O. seladon Schauberger, 1926	–
O. subquadratus Dejean, 1829	–
O. hospes Sturm, 1818	–
Steppe runner – *Ophonus azureus* Fabricius, 1775	–
Spotted-breasted runner – *Ophonus puncticollis* Paykull, 1798	–
Hairy runner – *Ophonus rufipes* De Geer, 1774	–
Gray runner – *Ophonus griseus* Panzer, 1797	–
Pseudophonus griseus Panzer, 1797	–
P. rufipes De Geer, 1774	–
P. calceatus Duftschmid, 1812	–
Shiny Harpal – *Harpalus affinis* Schrank, 1781	+
Harpalus luteicornis Duftschmied, 1812	+

Red-footed Harpal – *Harpalus rufipes* Degeer, 1774	+
Red-footed Harpal – *Harpalus rubripes* Duftschmid, 1812	+
Green Harpal – *Harpalus distinguendus* Duftschmid, 1812	+
H. flavesceus Piller et Mitterpacher, 1783	–
H. rubripes Duftschmid, 1812	–
H. latus Linnaeus, 1758	+
H. politus Dejean, 1829	–
H. tardus Panzer, 1796	–
H. calathoides Motschulsky, 1844	–
H. cerripes Quensel, 1806	–
H. froelichi Sturm, 1818	–
H. zabroides Dejean, 1829	–
Stenolophus teutonus Schrank, 1781	–
S. mixtus Herbst, 1784	–
Acupalpus meridianus Linnaeus, 1761	+
A. elesaus Dej.	–
Polystichus connexus Fourcroy, 1785	–
Anisodactiius pseudoaeneus Dej.	–
A.signatus Panzer, 1796	+
Mycrolestes plagiatus Duftschmid, 1812	–
M. minutulus Goeze, 1777	+
Elateridae	
Steppe grasshopper – *Agriotes gurgistanus* Faldermann, 1835	+
Pollenous sjaelandicus – *Actenicerus sjaelandicus* Müller, 1764	+
Broad anvil – *Selatosomus latus* Fabricius, 1801	+
Shiny grasshopper – *Selatosomus aeneus* Linnaeus, 1758	+
Willow moth – *Cidnopus aeruginosus* Olivier, 1790	+
Narrow grasshopper – *Athous jejunus* Kiesenwetter, 1858	+

Brown-legged grasshopper – *Melaotus brunnipes* Germar, 1824	+
Striped grasshopper – *Agriotes lineatus* Linnaeus, 1767	+
Dark grasshopper – *Agriotes obscurus* Linnaeus, 1758	+
Sowing moth – *Agriotes sputator* Linnaeus, 1758	–
Lesser grasshopper – *Agriotes rachifer* Fourcroy, 1785	+
Yellow-eared grasshopper – *Adrastus pallens* Fabricius, 1793	+
Flattened grasshopper – *Neopristilophus depressus* Germar, 1822	+
Common sowing bug – *Agriotes sputator* Linnaeus, 1758	+
Gray leafhopper – *Lacon murinus* Linnaeus, 1758	+
Chrysomelidae	
Phyllotreta nemorum Linnaeus, 1758	+
Ph. maculata Kutschera, 1860	–
Ph. armoraciae Koch, 1803	–
Ph. striolata Fabricius, 1801	–
Ph. atra Fabricius, 1775	–
Ph. cruciferae Goeze, 1777	–
Cruciferous earth flea – *Ph. nigripes* Fabricius, 1775	–
Beetroot scale insect – *Cassida nebulosa* Linnaeus, 1758	+
Beet green scale insect – *Cassida viridis* Linnaeus, 1758	+
Striped flea – *Phyllotreta vittula* Redtenbacher, 1849	+
Labistomis longimata L.	+
Pacnephorus sp. Redtenbacher, 1845	+
Longitarsis sp. S. Jansson, 1942	+
Chaetocnema hortensis Geoffroy, 1785	+
Buckwheat chetoknema – *Chaetocnema concinna* Marsham, 1802	+
Silphidae	
Nicrophorus humator Gleditsch, 1767	–
Nicrophorus investigator Zetterstedt, 1824	–

Nicrophorus vespillo Linnaeus, 1758	+
Oiceoptoma thoracica Linnaeus, 1758	–
Phosphuga atrata Linnaeus, 1758	–
Necrodes littoralis Linnaeus, 1758	–
Silpha tristis Illiger, 1798	–
Dendroxena quadripunctata Linneaus, 1761	–
Ribbed dead beetle – *Silpha carinata* Herbst, 1783	+
Dark dead beetle – *Silpha obscura* Linnaeus, 1758	+
Sharp-shouldered scavenger – *Tanatophilus sinuatus* Fabricius, 1775	+
Lathridiidae	
Enismus fungicola P.	+
Staphylinidae	
Gray staphylin – *Creophilus maxillosus* Linnaeus, 1758	+
Xantholinus sp. Dejean, 1821	+
Leptinus sp. Müller, 1817	–
Dinothenarus pubescens Degeer,1774	–
Creophilus maxillosus Linnaeus, 1758	–
Ocypus nitens Schrank, 1781	–
Ontholestes tesselatus Geoffroy, 1785	–
Oxyporus mannerheimi Gyllenhal, 1827	–
Oxyporus maxillosus Fabricius, 1792	–
Oxyporus rufus Linnaeus, 1758	–
Paederus riparius Linnaeus, 1758	–
Philonthus nitidus Fabricius, 1787	–
Philonthus spinipes Sharp, 1874	–
Quedius fuliginosus Gravenhorst, 1802	–
Staphylinus caesareus Cederhjelm, 1798	–
Staphylinus erythropterus Linnaeus, 1758	–

Stenus bimaculatus Gyllenhal, 1810	–
Curculionidae	
Otiorhynchus (Dodecastichus) pulverulentus Germar, 1824	–
O. (Otiorhynchus) hungaricus Germar, 1824	–
O. (Otiorhynchus) multipunctatus Fabricius, 1792	–
O. (Otiorhynchus) bisulcatus Fabricius, 1781	–
O. (Otiorhynchus) laevigatus Fabricius, 1792	–
O. (Otiorhynchus) fuscipes Oliver, 1807	–
O. (Otiorhynchus) niger Fabricius, 1775	–
O. (Otiorhynchus) repletus Boheman, 1843	–
O. (Otiorhynchus) aurifer Boheman, 1843	–
O. (Phalantorhynchus) morio Fabricius, 1781	–
O. (Microphalantus) puncticornis Gyllenhal, 1834	–
O. (Microphalantus) denigrator Boheman, 1843	–
Forest mower - Otiorrhynchus singularis Linnaeus, 1767	–
O. (Cirorhynchus) valachiae Fuss, 1868	–
O. (Padilehus) pinastri Herbst, 1795	–
Sad mower – *Otiorrhynchus tristis* Harold, 1872	–
O. (Pseudocryphiphorus) conspersus Herbst, 1795	–
O. (Pseudocryphiphorus) semitarius Reitter, 1913	–
O. (Pseudocryphiphorus) babughanicus Herbst,1795	–
O. (Pseudocryphiphorus) infensus Faust, 1888	–
O. (Pontotiorhynchus) peregrinus Stierlin, 1861	–
O. (Pontotiorhynchus) achaeus Stierlin, 1861	–
O. (Pontotiorhynchus) atronitens Formánek, 1925	–
O. (Pontotiorhynchus) asphaltinus Germar, 1824	–
O. (Pontotiorhynchus) brauneri Smirnov, 1912	–
O. (Dorymerus) sulcatus Fabricius, 1775	–

O. (Dorymerus) turca Boheman, 1843	–
O. (Melasemnus) ovalipennis Boheman, 1843	–
O. (Prilisvanus) asplenii Miller, 1868	–
O. (Zustalestus) rugosostriatus Goeze, 1877	–
O. (Panorosemus) vitis vitis Gyllenhal, 1834	–
O. (Panorosemus) vitis theodosianus Retowski, 1887	–
O. (Paracryphiphorus) orbicularis Herbst, 1795	–
O. (Lolatismus) porcatus Herbst, 1795	–
O. (Lolatismus) dacicus Daniel, 1898	–
O. (Eprahenus) elongatus Hochhuth, 1847	–
O. (Pendragon) ovatus Linnaeus, 1758	–
O. (Neobudemus) mandibularis Redtenbacher, 1842	–
O. (Asphaerorhynchus) brunneus Krynicki, 1829	–
O. (Aspaerorrhynchus) raucus Fabricius, 1777	–
O. (Asphaerorrhynchus) formaneki Reitter, 1913	–
O. (Asphaerorrhynchus) zhantievi Korotyaev, 1992	–
O. (Tournieria) starcki Retowsky, 1885	–
O. (Tournieria) frater Stierlin, 1861	–
O. (Amosilnus) simulans Stierlin, 1877	–
O. (Amosilnus) reichei Stierlin, 1861	–
O. (Proremus) pauxillus Rosenhauer, 1847	–
O. (Proremus) coarctatus Stierlin, 1861	–
O. (Proremus) lederi Stierlin, 1876	–
O. (Proremus) smreczynskii Cmoluh, 1959	–
O. (Proremus) rotundus Marseul, 1872	–
O. (Proremus) ukrainicus Korotyaev, 1984	–
O. (Podoropelmes) fullo Schrank, 1781	–
O. (Podoropelmes) albidus Stierlin, 1861	–

O. (Podoropelmes) scopularis Hochhuth, 1847	–
O. (Namertanus) nasutus Stierlin, 1876	–
O. (Namertanus) pseudomias Hochhuth, 1847	–
O. (Choilisanus) balcanicus Stierlin, 1861	–
Spherical mower – *Otiorrhynchus rotundatus* Siebold, 1837	–
O. (Choilisanus) caucasicus Stierlin, 1872	–
Otiorrhynchus velutinus Germar, 1824	+
Small black mower – *Otiorrhynchus raucus* Fabricius, 1776	–
Alfalfa mower – *Otiorrhynchus ligustici* Linnaeus, 1758	+
Lupine cryptid – *Sitona grissorius* Fabricius, 1801	+
O. (Postaremus) nodosus Müller, 1764	–
Stomodes ganglbaueri Wagner, 1912	–
S. gyrosicollis Boheman, 1843	–
S. tolutarius Boheman, 1834	–
Parameira setosa Seidlitz, 1868	–
P. taurica Magnano et Osella, 1971	–
Centricnemus leucogrammus Germar, 1824	–
Peritelus familiaris Boheman, 1834	–
P. sphaeroides Germar, 1824	–
Ptochus porcellus Boheman, 1834	–
Nastus goryi Boheman, 1842	–
Attactagenus albinus Boheman, 1833	–
Philopedon plagiatus Schaller, 1783	–
Humeromima nitida Boheman, 1843	–
H. rufipes Boheman, 1834	–
Bryodaemon hanaki Frivaldszky, 1865	–
B. rosneri Podlussány, 1998	–
B. boroveci Podlussány, 1998	–

Omiamima concinna Boheman, 1834	–
O. mollina Boheman, 1834	–
Elytrodon bidentatus Steven, 1829	–
Omias murinus Boheman, 1843	–
O. verruca Steven, 1829	–
O. globosus Gyllenhal, 1834	–
O. borysthenicus Korotyaev, 1991	–
O. rotundatus Fabricius, 1792	–
Nanomias terricola. N.	–
Urometopus moczarskii Penecke, 1929	–
U. strigifrons Gyllenhal, 1834	–
U. nemorum L. Arnoldi, 1965	–
Phyllobioides rugifrons Hochhuth, 1851	–
Trachyphloeus laticollis Boheman, 1843	+
T. amplithorax Formánek, 1907	–
T. parallelus Seidlitz, 1868	–
T. scabriculus Linnaeus, 1771	–
T. aristatus Gyllenhal, 1827	–
T. alternans Gyllenhal, 1834	–
T. spinimanus Germar, 1824	–
T. ventricosus Germar, 1824	–
T. bifoveolatus Beck, 1817	+
T. turcicus Seidlitz, 1868	–
Pseudomyllocerus (Neohenschia) lukjanovitshi L. Arnoldi, 1965	–
P. (Neohenschia) periteloides Fuss, 1861	–
P. (Argoptochus) subsignatus Boheman, 1834	–
P. (Argoptochus) bisignatus Germar, 1824	–
P. (Pseudomyllocerus) sinuatus Fabricius, 1801	–

P. (Pseudomyllocerus) cinerascens Fabricius, 1792	–
Phyllobius (Ectomogaster) fulvago Steven, 1829	–
Ph. (Nemoicus) oblongus Linnaeus, 1758	–
Ph. (Dieletus) argentatus Linnaeus, 1758	–
Ph. (Plagius) pallidus Fabricius, 1792	–
Ph. (Alsus) brevis Gyllenhal, 1834	–
Ph. (Nanoschetus) cylindricollis Gyllenhal, 1834	–
Ph. (Subphyllobius) thalassinus Gyllenhal, 1834	–
Ph. (Subphyllobius) virideaeris Laicharting, 1781	–
Ph. (Pterygorrhynchus) maculicornis Germar, 1824	–
Ph. (Metaphyllobius) pilicornis Desbrochers, 1873	–
Ph. (Metaphyllobius) maculatus Tournier, 1880	–
Ph. (Metaphyllobius) calcaratus Fabricius, 1792	–
Ph. (Metaphyllobius) pomaceus Gyllenhal, 1834	–
Ph. (Phyllobius) betulae Fabricius, 1801	–
Ph. (Phyllobius) pyri Linnaeus, 1758	–
Ph. (Phyllobius) arborator Herbst, 1797	–
Ph. (Phyllobius) seladonius Brullé, 1832	–
Ph. (Phyllobius) canus Gyllenhal, 1834	
Ph. (Phyllobius) transsylvanicus Stierlin, 1894	–
Листяний слоник кропив'яний – *Phyllobius urticae* DeGeer, 1775	–
Ph. (Phyllobius) alpinus Stierlin, 1859	–
Ph. (Phyllobius) contemptus Steven, 1829	–
Ph. Vespertilio Faust, 1884	–
Sciaphilus asperatus Bonsdorff, 1785	–
Sciaphobus (Sciaphobus) caesius Hampe, 1870	–
Gray bud weevil - Sciaphobus squalidus Gyllenhal, 1834	–
Green grass weevil – *Eusomus ovulum* Germar, 1824	–

Euidosomus elongatus Boheman, 1833	–
E. elongatus Boheman, 1833	–
E. jailensis L. Arnoldi, 1965	–
E. acuminatus Boheman, 1840	–
E. mirabilis Formánek, 1912	–
Eusomatus taeniatus Krynicki, 1834	–
E. virens Boheman, 1833	–
Barypeithes (Exomias) interpositus Roubal, 1920	–
B. (Exomias) mollicomus Ahrens, 1812	–
B. (Exomias) leptoviensis Weise, 1894	–
B. (Exomias) globus Seidlitz, 1868	–
B. (Exomias) carpathicus Reitter, 1885	–
B. (Exomias) lebedevi Roubal, 1926	–
B. (Exomias) chevrolati Boheman, 1843	–
B. (Exomias) pellucidus Boheman, 1834	+
Paophilus afflatus hampei Seidlitz, 1833	–
Brachysomus dispar Penecke, 1910	–
B. strawinskii Cmoluh, 1960	–
Bristle weevil – *Brachysomus echinatus* Bonsdorff, 1785	–
B. hispidus Redtenbacher, 1849	–
B. subnudus Seidlitz, 1868	–
B. lituratus Stierlin, 1884	–
B. sulcatus Yunakov, 1999	–
Archeophloeus inermis Boheman, 1843	–
Parafoucartia squamulata Herbst, 1795	+
Sauromates arnoldii Korotyaev, 1991	–
Psallidium maxillosum Fabricius, 1792	–
Polydrusus (Metallites) impar Gozis, 1882	–

P. (Metallites) atomarius Olivier, 1807	–
P. (Chlorodrosus) amoenus Germar, 1824	–
P. (Metadrosus) ornatus Gyllenhal, 1834	–
P. (Leucodrusus) mariae Faust, 1882	–
P. (Polydrusus) picus Fabricius, 1792	–
P. (Polydrusus) tereticollis De Geer, 1775	–
P. (Polydrusus) ruficornis Bonsdorff, 1785	–
P. (Eustolus) flavipes De Geer, 1775	–
P. (Eustolus) corruscus Germar, 1824	–
P. (Eustolus) pterygomalis Boheman, 1840	–
P. (Eustolus) impressifrons Gyllenhal, 1834	–
P. (Eudipnus) mollis Ström, 1768	–
P. (Chrysoyphis) sericeus Schaller, 1783	–
P. (Eurodrusus) confluens Stephens, 1831	–
P. (Poecilodrusus) viridicinctus Gyllenhal, 1834	–
P. (Scythodrusus) astutus Gyllenhal, 1834	–
P. (Scythodrusus) pilifer Hochhuth, 1847	–
P. (Scythodrusus) inustus Germar, 1824	–
P. (Neoeustolus) cervinus Linnaeus, 1758	–
P. (Neoeustolus) pilosus Gredler, 1866	–
Liophloeus (Liophloeodes) herbsti Gyllenhal, 1834	–
L. (Liophloeodes) lentus Germar, 1824	–
L. (Liophloeodes) gibbus Germar, 1842	–
L. (Liophloeodes) leptoviensis Weise, 1894	–
L. (Liophloeus) tessulatus Müller, 1776	–
Neliocarus faber Herbst, 1784	–
Brachyderes incanus Linnaeus, 1758	–
Strophomorphus porcellus Schönherr, 1832	–

Pholicodes perdurus Reitter, 1895	–
Ph. inauratus arzanovi Davidian, 1992	–
Strophosoma (Strophosoma) melanogrammum Förster, 1771	–
S. (Strophosoma) capitatum De Geer, 1775	–
S. (Pelletierius) albosignata Boheman, 1840	–
Mesagroicus pilifer Boheman, 1833	–
M. obscurus Boheman, 1840	–
M. poriventris Reitter, 1903	–
Tanymecus dilaticollis Gyllenhal, 1834	–
Gray beet weevil – *Tanymecus palliatus* Fabricius, 1787	+
Tanymecus ponticus Arnoldi et Blinstein, 1971	–
Megamecus (Acercomecus) argentatus Gyllenhal, 1840	–
Chlorophanus graminicola Olivier, 1807	–
Chlorophanus sellatus Fabricius, 1798	–
Chlorophanus excisus Fabricius, 1801	–
Chlorophanus gibbosus Paykull, 1792	–
Chlorophanus viridis Linnaeus, 1758	–
Cycloderes canescens Rossi, 1792	–
Cycloderes pilosus Fabricius, 1729	–
Bristlecone weevil – *Sitona crinitus* Herbst, 1795	–
Sweet clover weevil – *Sitona cylindricollis* Fahraeus, 1840	–
Butterfly weevil – *Sitona flavescens* Marsham, 1802	–
Lupine weevil – *Sitona griseus* Fabricius, 1775	–
Yellow-legged tuberous weevil – *Sitona hispidulus* Fabricius, 1777	–
Alfalfa tuberous weevil – *Sitona humeralis* Stephens, 1829	–
Small alfalfa weevil – *Sitona inops* Gyllenhal, 1832	–
Striped tuberous weevil – *Sitona lineatus* Linnaeus, 1758	+

Alfalfa root weevil – *Sitona longulus* Gyllenhal, 1834	–
Clover root weevil – *Sitona puncticollis* Stephens, 1831	–
Clover bulb weevil – *Sitona sulcifrons* Thunberg, 1798	–
Red-legged or cattail weevil – *Sitona tibialis* Herbst, 1795	–
Water weevil – *Sitona waterhousei* Walton, 1846	–
Tiger weevil – *Cyphocleonus tigrinus* Panzer, 1789	+
Striped beet weevil – *Chromoderus fasciatus* Müler, 1776	–
Green weevil – *Chlorophanus viridis* Linnaeus, 1758	–
Common beet weevil – *Bothynoderes punctiventris* Schoenherr, 1834	+
Scarabaeidae	
Tailor's beetle – *Lethrus apterus* Laxman, 1770	–
Common rhinoceros beetle – *Oryctes nasicornis* Linnaeus, 1758	–
Hercules beetle – *Dynastes hercules* Linnaeus, 1758	–
Beetle-crane – *Anisoplia segetum* Herbst, 1783	+
Onthophagus sp. Latreille, 1802	+
Onthophagus semicornis Panzer, 1798	+
Small dung beetle – *Onthophagus ovatus* Linnaeus, 1767	+
Dumpster beetle (hermit) – *Osmoderma eremite* Scopoli, 1763	+
Mordellidae	
Mordellistena pumila Gyllenhal, 1810	+
Mordella sp. Linnaeus, 1758	+
Leptinidae	
Leptinus seriatus Dodero, 1916	+
Anthicidae	
Common unicorn – *Notoxus monoceros* Linnaeus, 1761	+
Ant's quicksand – *Anthicus antherinus* Linnaeus, 1760	+
Histeridae	
Semi-furrowed saprin – *Saprinus semistriatus* Scriba, 1790	+

Hister quadrinotatus G. Scriba, 1790	+
Atholus purpurascens Herbst, 1792	+
Apionidae	
Apion flavipes Herbst, 1797	+
Tenebrionidae	
Sod ink – *Crypticus quisquilius* Linnaeus, 1761	+
Sand ink – *Opatrum sabulosum* Linnaeus, 1761	+
Coastal inkweed – *Opatrum riparium* Gerhardt, 1896	+
Crypticus quisquilius Linnaeus, 1761	+
Black ink – *Oodescelis polita* Sturm, 1807	+
Corn borer – *Pedinus femoralis* Linnaeus, 1767	+
Steppe copperhead – *Blaps halophila* Fischer von Waldheim, 1832	+
Broad-breasted copperhead – *Blaps lethifera* Marsham, 1802	+
Dermestidae	
Ham dermestid – *Dermestes laniarius* Illiger, 1801	+
Cerambycidae	
Crusader root beetle – *Dorcadion equestre* Laxmann, 1770	+
Hemiptera; Miridae	
Adelphocoris quadripunctatus Fabricius, 1794	+
Adelphocoris lineolatus Goeze, 1778	–
Nabidae	
Nabis punctatus Costa, 1847	+
Pyrrhocoridae	
Red worm – *Pyrrhocoris apterus* Linnaeus, 1758	+
Coreidae	
Spiky-footed kravenik – *Alydus calcaratus* Linnaeus, 1758	+
Camptopus lateralis Germar, 1817	+
Batysolen nubilis Germar, 1824	+

Lygaeidae	
Lygaeus equestris Wagner, 1955	–

Addition 3.

List of entomological biodiversity of chortobionts in agrolandscapes of the Forest Steppe

Homoptera; Cixidae	
Root cicada – *Pentastiridius leporibus* Linnaeus, 1761	–
Reptalus panzer Low, 1883	–
Delphacidae	
Pale cicada – *Javesella pellucid* Fabricius, 1794	+
Dark cicada – *Laodelphax striatella* Fallen, 1826	+
Hooked dicranocropis – *Dicranocropis hamata* Boh.	+
Darkened Javesella – *Javesella obscurella* Boheman, 1847	+
Javesella dubia Kirschbaum, 1868	+
Ribautodelphax collinus Boheman, 1847	+
Tettigometridae Oblique tettigometra – *Tettigometra oblique* Pnz.	+
Cercopidae Field slug – *Lepyronia coleoptrata* Linnaeus, 1758	+
Cicadellidae Green cicada – *Cicadella viridis* Linnaeus, 1758	+
Yellowish cicada – *Empoasca flavescens* Fabricius, 1794	+
Variegated cicada – *Eupteryx atropunctata* Goeze, 1778	+
Six-spotted cicada – *Macrosteles laevis* Ribaut, 1927	+
Crested cicada – *Macrosteles cristatus* Ribaut, 1927	+
Doratura homophyla Flor, 1861	+
Hardya tenuis Germar, 1821	+
Schenck's cicada – *Euscelidius schenki* Kirschbaum, 1868	+
Striped cicada – *Psammotettix striatus* Linnaeus, 1758	+
Mass Turrutus – *Turrutus socialis* Flor, 1861	+

Jassargus obtusivalvis Kirschbaum, 1868	+
Jassargus pseudocellaris Flor, 1861	+
Diplocolenus abdominalis Fabricius, 1803	+
Sorghum medius Ulsant & Rey, 1855	+
Pemphigidae Elm-grass aphid – *Tetraneura ulmi* Linnaeus, 1758	 +
Forda marginata Mordvilko, 1935 (= follicularia Passerini, 1856)	+
Anoeciidae Green pork and cereal aphid – *Anoecia vagans* Koch, 1856	 +
Chaitophoridae Hairy corn aphid – *Rungsia maydis* Passerini, 1860	 +
Kurdyumov's aphid – *Rungsia elegans* Del Guercio, 1905	+
Aphididae	
Apple-cereal aphid – *Rhopalosiphum insertum* Walker, 1849	+
Corn aphid – *Rhopalosiphum maidis* Fitch, 1856	+
Common cereal aphid – *Schizaphis graminum* Rondani, 1852	+
Pear-cereal aphid – *Melanaphis piraria* Pass.	+
Barley aphid – *Brachycolus noxium* Mordv.	+
Large cereal aphid – *Sitobion avenae* Fabricius, 1775	+
Pseudococcidae	
Barley stem borer – *Trionymus (Pseudococcus) aberrans* Goux, 1938	+
Phenacoccopsis bufo Kiritishenkel, 1936	+
Barley mealybug – *Phenacoccus hordei* Lindeman, 1886	+
Wheat stem borer – *Heterococcus tritice* Kiritshenko, 1932	+
Hemiptera; Miridae Cereal bug – *Trigonotylus coelestialium* Kirkaldy, 1902	 +
Green stenodema – *Stenodema virenis* Linnaeus, 1767	+
Notostria elongata Geoffroy, 1785	+

Leptopterna doloabrata Linnaeus, 1758	+
Steppe leptoptera – *Leptopterna ferrugata* Fallen, 1807	+
Rhopalidae Schilling's chorosoma – *Chorosoma schillingi* Schummel, 1829	+
Pyrrhocoridae	
Red-crowned Falcon – *Pyrrhocoris apterus* Linnaeus, 1758	+
Scutelleridae	
Harmful turtle – *Eurygaster integriceps* Puton, 1881	+
Moorish turtle – *Eurygaster maurus* Linnaeus, 1758	+
Moisture-loving turtle – *Eurygaster testudinarius* Geoffroy, 1785	+
Austrian turtle – *Eurygaster austriacus* Schrank, 1776	+
Pentatomidae Black thorn scabbard – *Carpocoris fuscispinus* Boheman, 1851	+
Spring scale insect – *Holcosotethus vernalis* Wolff, 1804	+
Rapeseed cruciferous bug – *Eurydema oleracea* Linnaeus, 1758	+
Thysanoptera; Thripidae Field thrips – *Chirothrips manicatus* Haliday, 1836	+
Nasty thrips – *Chirothrips molestus* Priesner, 1926	+
Migratory thrips – *Chirothrips ambulans* Bagnali, 1932	+
Gray-mustached thrips – *Chirothrips angusticornis* Bagnall, 1932	+
Pallid thrips – *Chirothrips pallidicornis* Priesner, 1925	+
Narrow-winged thrips – *Chirothrips ruptipennis* Priesner, 1938	+
Transcaucasian thrips – *Limothrips transcaucasicus* Savenko, 1944	–
Timothy thrips – *Limothrips ingulicornis* Jablonow.	+
Bread thrips – *Limothrips cerealium* Haliday, 1836	+
Schmutz's thrips – *Limothrips schmutci* Priesner.	–
Rye thrips – *Limothrips denticornis* Haliday, 1836	+
Paradoxical thrips – *Idolimothrips paradoxus* Priesner, 1920	–

Pinkish-tailed thrips – *Aptinothrips rufus* Haliday, 1836	–
Inconspicuous thrips – *Apothrips stylifera* Trybom, 1894	–
Fedovsky's thrips – *Prosopothrips vejdovskyi* Uzel, 1895	–
Chestnut thrips – *Anaphothrips badius* Williams, 1913	
Cereal thrips – *Anaphothrips obscures* Müller, 1776	+
Tamus thrips – *Anaphothrips tamicola* Bagnall, 1914	+
Rhynchosporium thrips – *Tmetothrips subapterus* Haliday, 1836	–
Belothrips acuminatus Haliday, 1836	–
Frankliniella tenuicornis Uzel, 1895	+
Different thrips – *Frankliniella intonsa* Trybom, 1895	+
Smoky-winged thrips – *Rhaphidothrips longistylosus* Uzel, 1895	+
Wingless thrips – *Bregmatothrips dimorphus* Priesner, 1919	–
Thrips frontalis – *Taeniothrips frontalis* Uzel, 1895	–
Stubble thrips – *Taeniothrips innocens* Priesner, 1922	–
Red-eyed thrips – *Rhopalandrothrips annulicornis* Uzel, 1895	–
Stubble thrips – *Astenothrips georgicus* Sawenko, 1941	–
Phloeothripidae	
Haplothrips oculeatus Fabricius, 1803	–
Haplothrips wheat – *Haplothrips tritici* Kurdjumov, 1912	–
Coleoptera; Chrysomelidae	
Labidostomis beckeri Weise, 1881	+
Chess pachnephorus – *Pachnephorus tessellatus* Duftschmid, 1825	+
Garden galeruca – *Galeruca pomonae* Scopoli, 1763	+
Chaetocnema aridula Gyllenhal, 1827	+
Chaetocnema hortensis Geoffroy, 1785	+
Yellow mountain flea – *Psylliodes luteola* Müller, 1776	+
Curculionidae	
Covered weevil – *Otiorhynchus kelutinus* Germar, 1824	+

Rounded weevil – *Mylacus rotundatus* Fabricius, 1792	+
Globular weevil – *Mulacus globulus* Boh.	+
Southern gray or corn weevil – *Tanymecus dilaticollis* Gyllenhal, 1834	+
Alleculidae	
Daghestan pollen beetle – *Podonta daghestanica* Reitter, 1885	+
Proteus pollen beetle – *Omophlus proteus* Kirsch, 1869	+
Bread beetle – *Omophlus flavipennis* Küster, 1850	+
Omophlus lividipes Mulsant, 1856	+
Mordellidae	
Mordellistena pumila Gyllenhal, 1810	+
Meloidae	
Meloe variegates Donovan, 1793	+
Mylabris polymorpha Pallas, 1771	+
Lepidoptera; Psychidae	
Unicolored pouch moth – *Lepidopsyche unicolor* Hufnagel, 1766	–
Clean pouch moth – *Fumea casta* Pallas, 1767	–
Dark pouch grass – *Acanthopsy cheatra* L.	–
Ochsenheimetiidae	
Bread stem moth – *Ochsenheimeria vacculella* Fischer von Röslerstamm, 1842	–
Wheatgrass stem moth – *Ochsenheimeria bisontella* Zeller, 1846	–
Danilevsky's stem moth – *Ochsenheimeria danilevsky* Zag.	–
Tortricidae	
Cereal leaf miner – *Cnephasia pascuana* Hübner, 1799	–
Eana argentana Cl.	–
Glyphipterigidae	
Cereal glyphipterid – *Glyphipterix slmpliciella* Hw.	–
Elachistidae	

Sedge moth – *Elachista nobilella* Zeller, 1839	–
Thin-legged moth miner – *Elachista revinctella* Zeller, 1850	–
Rice midge – *Elachista bedella* Sircom, 1848	–
Reed moth – *Elachista pullicomella* Zeller, 1839	–
Bromus moth – *Elachista subnigrella* Douglas, 1853	–
Wheat moth – *Elachista albifrontella* Hübner, 1817	–
Mud moth – *Elachista luticomella* Zeller, 1839	–
Sieve moth – *Elachista apicipunctella* Stainton, 1849	–
Pyralidae	
Northern firefly – *Pyralis lienigialis* Zeller, 1843	–
Hay firefly – *Hypsopygia costalis* Fabricius, 1775	–
Phycitidae	
Grass firefly – *Anerastia lotella* Hübner, 1813	–
Pyraustidae	
Hay moth – *Evergestis pallidata* Hufnagel, 1767	–
Scoop-shaped moth – *Nomophila noctuella* Denis & Schiffermüller 1775	–
Painted moth – *Diasemia litterata* Scopoli, 1763	–
Crambidae	
Pearl grass firefly – *Crambus perlellus* Scopoli, 1763	–
Meadow fireworm – *Crambus pratellus* Linnaeus, 1758	–
Brown grass fireweed – *Pediasia jucundella* Herrich-Schaffer, 1847	–
Cereal unclean fireweed – *Agriphila inguinatellus* Den. et. Schiff.	–
Yellow wheatgrass moth – *Pediasia luteella* Denis & Schiffermüller, 1775	–
Linear wheatgrass moth – *Pediasia fascelinella* Hübner, 1813	–
Spotted wheatgrass moth – *Pediasia contaminella* Hubner, 1796	–
Hay moth – *Talis quercella* Denis & Schiffermüller, 1775	–

Noctuidae	
Wheat ground beetle – *Euxoa tritici* Linnaeus, 1761	+
Blackish ground scoop – *Euxoa nigricans* Linnaeus, 1761	+
Black-spotted moth – *Euxoa temera* Hübner, 1808	–
Deceitful scoop – *Rhyacia simulans* Hufnagel, 1766	–
Leaf scoop – *Mythimna loreyi* Duponchel, 1827	–
Red-brown field scoop – *Apamea lateritia* Hufnagel, 1766	–
Great field scoop – *Apamea monoglypha* Hufnagel, 1766	–
Gray grain moth – *Apamea anceps* Denis & Schiffermüller, 1775	–
Common grain scoop – *Apamea sordens* Hufnagel, 1766	–
Brown field scoop – *Apamea oblonga* Haworth, 1809	–
Light brown cereal moth – *Oligia strigilis* Linnaeus, 1758	–
Northern stem moth – *Mesapamea secalis* Linnaeus, 1758	–
Yellow and white field moth – *Eremobia ochroleuca* Denis & Schiffermüller, 1775	–
Spring moth – *Amphipoea fucosa* Freyer, 1830	–
Southern stem moth – *Oria musculosa* Hübner, 1808	–
Hymenoptera; Cephidae	
Black bread sawfly – *Trachelus tabidus* Fabricius, 1775	+
Tentredinidae	
Dolerus haematodes Schrank, 1781	–
Black wheat dolerus – *Dolerus nigratus* Muller, 1776	+
Wheat yellow sawfly – *Phachynematus cliitellatus* Lep.	+
Eurytomidae	
Wingless phalachyra – *Philachyra aptera* Portschinsky, 1881	–
Wheat gall tetramesa – *Tetramesa tritici* Fitch, 1859	–
Wheat spikelet tetramesa – *Tetramesa vaginicola* Doane, 1916	–
Diptera; Cecidomyiidae	

Cereal stem gall midge – *Hybolasioptera cerealis* Lindeman, 1880	+
Orange cereal gall midge – *Sitopidiposis mosellana* Gehin.	+
Cereal saddleback gall midge – *Haplodiplosis equestris* Wagner, 1871	+
Agromyzidae	
Cereal agromyza – *Agromyza albipennis* Meigen, 1830	+
Cereal miner – *Agromyza cinerescens* Mcq.	+
Rhygrace miner – *Poemyza incisa* Meigen, 1830	+
Bordered miner – *Poemyza lateralis* Macquart, 1835	+
Opomyzidae	
Wheat moth – *Opomyza florum* Fabricius, 1794	+
Cereal moth – *Opomyza germinationis* Linnaeus, 1758	+
Ephydridae	
Barley moth – *Hydrellia griseola* Fallén, 1813	+
Chloropidae	
Barley midge – *Oscinella pusilla* Meigen, 1830	+
Cereal moth – *Oscinella frit* Linnaeus, 1758	+
Oscinella phlei Nartshuk, 1955	+
Bread moth – *Meromyza nigriventris* Macquart, 1835	+
Green-eyed moth – *Chlorops pumilionis* Bjerkander, 1778	+
Anthomyidae	
Spring forb – *Phorbia genitalis* Schnabl in Schnabl & Dziedzicki, 1911	+
Wheat forb – *Phorbia securis* Tiensuu, 1935	+
Winter fly – *Leptohylemia coarctata* Fll.	+

Addition 4.

List of entomological biodiversity of dendrobionts in agrolandscapes of the Forest Steppe

Orthoptera; Gryllotalpidae	
Common wolfsbane – *Gryllotalpa gryllotalpa* Linnaeus, 1758	+
Acrididae	
Wingless podisma – *Podisma pedestris* Linneus, 1758	+
Short-winged grasshopper – *Chorthipus parallelus* Zetterstedt, 1821	–
Homoptera; Cicadidae	
Mountain cicadeta – *Cicadetta montana* Scopoli, 1772	–
Cicadellidae	
Colonized cicada – *Kyboasca bipunctata* Oshanin, 1871	+
Yellowish cicada – *Empoasa flavescens* Fabricius, 1794	+
Star cicada – *Eupteroidia stellulata* Burm	+
Oncopsis flavicollis Linnaeus, 1758	+
Silver atysanus – *Athysanus argentarius* Metcalf.	+
Green cicada – *Cicadella viridis* Linnaeus, 1758	+
Matsumurella expansa Linnaeus, 1758	+
Membracidae	
One-horned humpbacked damselfly – *Gargara genistae* F.	+
Common horned humpback – *Centrotus cornutus* Linnaeus, 1758	+
Aphrophoridae	
Slobbery damselfly – *Philaenus spumarius* Linnaeus, 1758	–
Willow slug – *Aphrophora salicis* Deg.	+
Alder slug – *Aphrophora alni* Fallun.	
Field slug – *Lepyronia coleoptrata* L.	–
Aleyrodidae	

Honeysuckle whitefly – *Aleyrodes lonicerae* Haliday, 1835	–
Maple whitefly – *Aleurochiton complanatus* Daer.	–
Aphrastasia pectinatae Cholodkovsky, 1888	–
Caucasian fir and spruce hermes – *Dreyfusia nordmannianae* Eckstein, 1890	–
Green larch hermes – *Cholodkovskya viridana* Cholodkovsky, 1896	–
Hermes larch – *Adelges laricis* Vallot, 1836	–
Late larch-spruce hermes – *Adelges tardoides* Cholodkovsky, 1911	–
Spruce Hermes – *Adelges tardus* Dreyfus, 1888	–
Douglas fir hermes – *Gilletteella cooleyi* Gillette, 1907	–
Yellow spruce hermes – *Sacchiphantes abietis* Linnaeus, 1758	–
Green Hermes – *Sacchiphantes viridis* Ratzeburg, 1843	–
Aphididae	
Thecabius affinis Kaltenbach, 1843	+
Pemphigus bursarius Linnaeus, 1758	+
Late pemphigus – *Pemphigus spirothecae* Passerini, 1860	+
Early pemphigus – *Pemphigus protospirae* Lichtenstein, 1885	–
Olive pemphigus – *Pemphigus populinigrae* Schrank, 1801	–
Lichtenstein pemphigus – *Pemphigus lichtensteini* Tullgren, 1909	–
Blood aphid – *Eriosoma lanigerum* Hausmann, 1802	–
Elm-currant blood aphid – *Eriosoma ulmi* Linnaeus, 1758	+
Elm-cereal aphid – *Tetraneura ulmi* Linnaeus, 1758	–
Elm aphid – *Tetraneura caerlilescens* Passerini, 1856	–
Long-haired coniferous aphid – *Cinara pilicornis* Hartig, 1841	–
Fir almond – *Mindarus abietinus* Koch, 1857	–
Birch glyphine – *Glyphina betulae* Linnaeus, 1758	–
Striped oak aphid – *Thelaxes dryophila* Schrank, 1801	–
Birch leaf aphid – *Symydobius oblongus* Heyden, 1837	–

Beech leaf aphid – *Phyllaphis fagi* Linnaeus, 1767	–
Upper walnut aphid – *Callaphis juglandis* Goeze, 1778	–
Lower walnut aphid – *Chromaphis juglandicola* Knowlton, 1929	–
Chaitophorus leucomelas Koch, 1854	–
Poplar haitophorus – *Chaitophorus populeti* Panzer, 1801	–
Chaitophorus Nassonowi Mordvilko, 1895	–
Poplar pterocoma – *Pterocomma populea* Kaltenbach, 1843	–
Beet aphid – *Aphis fabae* Scopoli, 1763	–
Raspberry aphid – *Aphis idaei* Goot, 1912	–
Gooseberry aphid – *Aphis grossulariae* Kaltenbach, 1843	–
Alfalfa aphid – *Aphis craccivora* Koch, 1854	–
Pea aphid – *Acyrthosiphon pisum* Harris, 1776	–
Lachnidae	
Eulachnus agilis Kaltenbach, 1843	–
Schizolachnus pineti Fabricius, 1781	–
Cinarella pinea Mordvilko, 1895	–
Large fir dinolachnus – *Dinolachnus piceae* Panzer, 1801	–
Variegated oak lachnus – *Lachnus robris* Linnaeus, 1758	–
Cupressobium juniperi De Geer, 1773	–
Coccidae	
Maple mealybug – *Phenacoccus aceris* Signoret, 1875	–
Spruce mealybug – *Paroudablis piceae* Low, 1883	–
Viburnum cushion beetle – *Filippia viburai* Sign.	–
Pulvinaria betulae Signoret, 1873	–
Pseudo-scabbard of hawthorn – *Palaeolecanium bituberculatum* Targioni Tozzetti, 1868	–
Peach pseudo-scabbard – *Parthenolecanium persicae* Fabricius, 1776	–
Acacia pseudo-scabbard – *Parthenolecanium corni* Bouché, 1844	–

Oak pseudo-scabies – *Parthenolecanium rufulum* Cockerell, 1903	–
Linden pseudo-scabbard – *Eulecanium tiliae* Linnaeus, 1758	–
Eriococcidae	
Boxwood felt – *Eriococcus buxi* Fonsc.	–
Elm felt – *Gossyparia spuria* Modeer, 1778	–
Oak felt – *Acanthococcus roboris* Goux, 1931	–
Maple felt – *Acanthococcus aceris* Signoret, 1875	–
Kermesidae	
Kermes oak – *Kermococcus querus* Henriksen, 1921	–
Southern kermes – *Kermococcus corticalis* Borchsenius, 1949	–
Asterolecaniidae	
Great shiny worm – *Asterodiaspis variolosa* Ratzeburg, 1870	–
Shiny oak worm – *Asterodiaspis quercicola* Bouché, 1851	–
Diaspididae	
Pine spindle scale insect – *Anamaspis loewi* Leonardi, 1906	–
Apple scale insect – *Lepidosaphes ulmi* Linnaeus, 1758	–
Willow scale insect – *Chionaspis salicis* Linnaeus, 1758	–
Rose scale insect – *Aulacaspis rosae* Bouché, 1833	–
Spruce scale insect – *Nuculaspis abietis* Schrank, 1776	–
Poplar scale insect – *Quadraspidiotus gigas* Thiem et Gerneck, 1934	–
Pseudo-Californian scale insect – *Quadraspidiotus ostreaeformis* Curtis, 1843	–
California scale insect – *Quadraspidiotus perniciosus* Comstock, 1881	–
Psyllidae	
Birch leaf miner – *Psylla betulae* L.	+
Hemiptera; Tingidae	
Pear lacewing – *Stephamitis pyri* Fabricius, 1775	+

Poplar bug – *Monosteira unicostata* Mulsant & Rey, 1852	+
Myridae	
Adelphocoris reicheli Fieber, 1836	+
Capsus ater Linnaeus, 1758	+
Deraeocoris ruber Linnaeus, 1758	+
Pilophorus clavatus Linnaeus, 1758	+
Notostira elongata Geoffr.	+
Field ligus – *Lygus pratensis* Linnaeus, 1758	+
Grass ligus – *Lygus rugulipennis* Popp.	+
Plagiognathus chrysanthemum – *Plagiognathus chrysanthemi* Wolff, 1804	+
Brown mud-slime – *Adelphocoris seticornis* Fabricius, 1775	+
Darkish umbrella mould – *Orthops basalis* Costa, 1853	+
Pyrrhocoridae	
Red-crowned – *Pyrrhocoris apterus* Linnaeus, 1758	+
Coreidae	
Gonocerus acuteangulatus Goeze, 1778	+
Dicranocephalus agilis Scopoli, 1763	
Sorrel marginator – *Coreus marginatus* Linnaeus, 1758	–
Aradidae	
Pine bark beetle – *Aradus cinnamomeus* Panzer, 1806	+
Cydnidae	
Thyreocoris scarabaeoides Linnaeus, 1758	
Garbar – *Tritomegas sexmaculatus* Rambur, 1842	+
Bicolored grabar – *Tritomegas bicolor* Linnaeus, 1758	–
Pentatomidae	
Green shieldworm – *Palomena prasina* Linnaeus, 1761	+
Alfalfa shieldworm – *Piezodoras lituratus* Fabricius, 1794	+

Carpocoris pudicus Poda, 1761	+
Nezara viridula Linnaeus, 1758	+
Stolia aenea Linnaeus, 1758	+
Aelia acuminate Linnaeus, 1758	+
Italian bug – *Graphosoma italicum* Linnaeus, 1758	+
Birch borer – *Elasmucha betulae* DeCeer	+
Linear shield – *Graphosoma lineatum* Linnaeus, 1758	+
Blue shield – *Zicrona coerulea* Linnaeus, 1758	+
Red-legged shield – *Pentatoma rufipes* Linnaeus, 1758	+
Black-backed scabbard – *Carpocoris fuscispinus* Boheman	+
Berry shield – *Dolycoris baccarum* Linnaeus, 1758	+
Rhopalidae	
Rhopalus subrufus Gmelin, 1790	+
Stictopleurus punctatonervasus Goeze	+
Coptosomidae	
Hemispherical shield – *Coptosoma scutellatum* Geoffroy, 1785	+
Scutellaridae	
Moorish turtle – *Eurygaster maurus* Linnaeus, 1758	+
Harmful turtle – *Eurygaster integriceps* Put.	+
Lygaeidae	
Polyphagous ligeon – *Oxycarenus corallis* Mls. R.	–
Dark sphragisticus – *Sphragisticus nebulosus* Fallen, 1807	–
Reduviidae	
Dirty reduvius – *Reduvius personatus* Linnaeus, 1758	–
Thysanoptera; Thripidae	
Linden thrips – *Dendrothrips ornatus* Jablonowski, 1894	–
Pin thrips – *Oxythrips ajugae* Uzel, 1895	–
Coniferous thrips – *Oxythrips brevistylis* Trybom, 1895	+

Pear thrips – *Taeniothrips inconsequens* Uzel, 1895	+
Pine thrips – *Taeniothrips pini* Uzel, 1895	–
Nightshade thrips – *Thrips fuscipennis* Haliday, 1836	–
Common thrips – *Thrips physapus* Linnaeus, 1758	–
Coleoptera; Scarabaeidae	
Meadow beetle – *Anomala dubia* Scopoli, 1763	–
Garden beetle – *Phyllopertha horticola* Linnaeus, 1758	–
Western мay beetle – *Melolontha melolontha* Linnaeus, 1758	+
Oriental мay beetle – *Melolontha hippocastani* Fabricius, 1801	+
July marbled beetle – *Polyphylla fullo* Linnaeus, 1758	+
Gray hairy beetle – *Anoxia pilosa* Fabricius, 1792	+
Root beetle – *Miltotrogus aequinoctialis* Herbst, 1790	–
June beetle – *Amphimallon solstitialis* Linnaeus, 1758	+
Hairy deerstalker – *Epicometis hirta* Poda, 1761	+
Oxythyrea funesta Poda, 1761	+
Golden bronze moth – *Cetonia aurata* Linnaeus, 1761	+
Metal bronze moth – *Potosia metallica* Herbst, 1782	+
Red silkworm – *Serica brunnea* Linnaeus, 1758	+
Short-winged warbler – *Valgus hemipterus* Linnaeus, 1758	–
Bread moth – *Anisoplia austriaca* Herbst	–
Sowing moth – *Anisoplia segetum* Herbst	–
Common dung beetle – *Anoplotrupes stercorosus* Scriba, 1791	+
Lymexylidae	
Leaf borer – *Elateroides dermestoides* Linnaeus, 1761	+
Coniferous borer – *Elateroides feabellicornis* Schneider, 1791	+
Oak borer – *Lymexylon navale* Linnaeus, 1758	+
Coccinellidae	
Thea duoctovigintipunctata Linnaeus, 1758	+

Fourteen-spotted cow – *Calvia quatordecimpunctata* Linnaeus, 1758	+
Sixteen-spotted cow – *Halyzia sedecimguttata* Linnaeus, 1758	+
Propylea quadridecempunctata Linnaeus, 1758	+
Four-pointed heartwort – *Exochomus quadripustulatus* Linnaeus, 1758	+
Seven-spotted ladybug – *Coccinella septempunctata* Linnaeus, 1758	+
Fourteen-spotted ladybug – *Coccinella duaquatordecimpustulata* Linnaeus, 1758	+
Anobiidae	
Pine shoot sharpener – *Ernobius nigrinus* Sturm, 1837	–
Pine cone sharpener – *Ernobius abietinus* Gyllenhal, 1808	–
Crested sharpener – *Ptilinus pectinicornis* Linnaeus, 1758	–
Variegated sharpener – *Xestobium rufovillosum* De Geer, 1774	–
Cantharidae	
Cantharis lateralis Linnaeus, 1758	+
Rhagonycha hirta Linnaeus, 1758	+
Umbrella millipede (red soft-bodied) – *Rhagonycha fulva* Scopoli	+
Oculate softshell – *Cantharis oculata* Gebl.	+
Cantharis rufipes Hbst.	–
Bostrichidae	
Depressed hooded bat – *Xylonites retusus* Müller, 1987	–
Common hooded beetle – *Bostrichus capucinus* Linnaeus, 1758	–
Caucasian six-toothed hooded beetle – *Sinoxylon perforans* Schrank, 1789	+
Mordellidae	
Anaspis frontalis Linnaeus, 1758	+
Mordellistena minima Costa, 1854	+
Humpbacked bittersweet – *Mordellistena pumila* Gyllenhal, 1810	–

Lyctidae	+
Furrowed woodborer – *Lyctus linearis* Goeze, 1777	+
Malachiidae	
Malachius geniculatus Germar, 1824	–
Green borer – *Malachius viridis* Linnaeus, 1758	+
Black dasytes – *Dasytes niger* Linnaeus, 1758	–
Elateridae	
Broad grasshopper – *Selatosomus latus* Fabricius, 1801	+
Shiny grasshopper – *Selatosomus aeneus* Linnaeus, 1758	–
Striped sowing bug – *Agriotes lineatus* Linnaeus, 1767	+
Sowing bug – *Agriotes sputator* Linnaeus, 1758	+
Steppe sowing moth – *Agriotes gurgistanus* Faldermann, 1835	+
Cardiophorus asellus Erichson, 1840	+
Limonius parvulus Linnaeus, 1758	+
Melanotus crassicollis Erichson, 1840	+
Synaptus filiformis Linnaeus, 1758	+
Willow-blossomed grasshopper – *Cidnopus aeruginosus* Olivier, 1790	+
Hairy grasshopper – *Athous hirtus* Hbst.	
Lesser blacksmith – *Adrastus rachifer* Fourcroy, 1785	+
Mosaic moth – *Prosternon tesselatum* Linnaeus, 1758	+
Red grasshopper – *Athous rufus* De Geer, 1774	+
Gray grasshopper – *Lacon murinus* Linnaeus, 1758	+
Cruciferous grasshopper – *Selatosomus cruciatus* Linnaeus, 1758	+
Red-legged grasshopper – *Melanotus rufipes* Herbst, 1784	+
Red-tailed grasshopper – *Athous haemorreidalis* Fabricius, 1801	+
Black -backed grasshopper – *Athous niger* Linnaeus, 1758	+
Buprestidae	

Acmaeodera degener Scopoli, 1763	–
Yellow-banded goldenrod – *Acmaeodera flavofasciata* Herbst, 1801	–
Anthaxia quadripunctata Linnaeus, 1758	–
Southern antaxis – *Anthaxia croesus* Villiers, 1789	–
Willow antaxis – *Anthaxia salicis* Fabricius, 1776	–
Antaxia bicolor – *Anthaxia bicolor* Faldermann, 1835	–
Golden semolina – *Cratomerus mansus* Linnaeus, 1767	–
Golden elm goldenrod – *Cratomerus aurulentus* Gmelin, 1788	–
Blue pine goldenrod – *Phaenops cyanea* Fabricius, 1775	–
Burns' goldenrod – *Melanophila acuminata* De Geer, 1774	–
Eight-pointed coniferous goldenrod – *Ancylocheira octoguttata* Linnaeus, 1758	–
Nine-pointed coniferous goldenrod – *Ancylocheira novemmaculata* Linnaeus, 1767	–
Coniferous red-headed lacewing – *Ancylocheira haemorrhoidalis* Herbst, 1780	–
Rustic coniferous goldenrod – *Ancylocheira rustica* Linnaeus, 1758	–
Rustic coniferous gilt – *Ancylocheira rustica* Linnaeus, 1758	–
Linden broom – *Lampra rutilans* Fabricius, 1777	+
Aspen ash – *Poecilonota variolosa* Paykull, 1799	–
Beech goldenrod (Dicerca) – *Dicerca berolinensis* Herbst, 1779	–
Alder gilding (Dicerca) – *Dicerca alni* Fischer v. Waldheim, 1823	+
Copper bullion – *Perotis lugubris* Fabricius, 1777	–
Large bronze bug – *Buprestis mariana* Linnaeus, 1758	–
Bronze oak bronze – *Chrysobothris affinis* Fabricius, 1794	–
Bronze pine bronze – *Chrysobothris ingiventris* Reitter, 1895	–
Wavy oak bronze – *Coroebus undatus* Fabricius, 1787	–
Blackberry goldenrod – *Coroebus rubi* Linnaeus, 1767	–

Narrow-bodied oak goldenrod – *Agrilus angustulus* Illiger, 1803	+
Narrow-bodied toothed goldenrod – *Agrilus hastulifer* Ratzeburg, 1839	–
Narrow-bodied hornbeam broom – *Agrilus olivicolor* Kiesenwetter, 1857	+
Dark narrow-bodied goldenrod – *Agrilus ater* Linnaeus, 1767 (A. sexguttatus Brahm, 1790)	–
Narrow-bodied colonized lacewing – *Agrilus biguttatus* Fabricius, 1777	–
Green narrow-bodied goldenrod – *Agrilus viridis* Linnaeus, 1758	+
Rose-horned goldenrod – *Agrilus chrysoderes* Abeille, 1897	–
Narrow-bodied honeysuckle broom – *Agrilus coeruleus* Herbst, 1795	–
Narrow-bodied birch broom – *Agrilus betuleti* Ratzeburg, 1837	+
Anthaxia cichorii Olivier, 1790	+
Grape narrow-bodied goldenrod – *Agrilus derasofasciatus* Lacordaire, 1835	+
Willow miner's goldenrod – *Trachys minuta* Linnaeus, 1758	+
Leafy narrow-bodied goldenrod – *Agrilus laticornis* Illiger, 1803	+
Byturidae	
Byturus tomentosus De Geer, 1774	+
Oedemeridae	
Oedemera lurida Marsham, 1802	+
Green narrow-winged moth – *Oedemera virescens* Linnaeus, 1758	+
Oedemera popagrariae Linnaeus, 1758	+
Meloidae	
Lytta vesicatoria Linnaeus, 1758	+
Oedemera flavescens Linnaeus, 1758	+
Cerambycidae	

Grainy mustache – *Megopis scabricornis* Scopoli, 1763	–
Carpenter's mustache – *Ergates faber* Linnaeus, 1761	–
Leather mustache – *Prionus coriarius* Linnaeus, 1758	–
Red cattail – *Rhagium sycophauta* Schrank, 1781	–
Prickly cattail – *Rhagium mordax* Degeer, 1775	–
Rhagium inguisitor Linnaeus, 1758	–
Rhamnusium bicolor Schrank, 1781	+
Red leptura – *Leptura rubra* Linnaeus, 1758	+
Large shortwing – *Necydalis major* Linnaeus, 1758	–
Short-eared mustache – *Spondylis buprestoides* Linnaeus, 1758	–
Brown comlee's mustache – *Criocephalus rusticus* Linnaeus, 1758	–
Ribbed mustache – *Asemum striatum* Linnaeus, 1758	–
Shiny-breasted mustache – *Tetropium castaneum* Linnaeus, 1758	–
Small mustache – *Cerambyx scopolii* Fuesslins, 1775	–
Short-winged coniferous mustache – *Molorchus minor* Linnaeus, 1758	–
Musk mustache – *Aromia moschata* Linnaeus, 1758	+
Gray house mustache – *Hylotrupes bajulus* Linnaeus, 1758	–
Bronze maple mustache – *Rhopalopus ungaricus* Herbst, 1784	–
Big maple mustache – *Rhopalopus clavipes* Fabricius, 1775	–
Small maple mustache – *Rhopalopus macropus* Germar, 1824	–
Purple flat mustache – *Callidium violaceum* Linnaeus, 1758	–
Red oak mustache – *Pyrrhidium sanguineum* Linnaeus, 1758	–
Aspen mustache – *Xylotrechus rusticus* Linnaeus, 1758	–
Oak top mite – *Xylotrechus antilope* Schönherr, 1817	–
Clytus rhamni Germar, 1817	+
Coniferous mite – *Clytus lama* Mulsant, 1847	–
Cross-striped mustache – *Plagionotus arcuatus* Linnaeus, 1758	–

Variable clytus – *Chlorophorus varius* Müller, 1766	–
Small figured mite – *Chlorophorus sartor* Müller, 1766	–
Great black fiddlehead – *Monochamus urussovi* Fischer–Waldheim, 1806	–
Small black fiddlehead – *Monochamus sutor* Linnaeus, 1758	–
Black pine warbler – *Monochamus galloprovincialis pistor* Germar, 1818	+
Small mustache – *Cerambyx scopolii* Fuesslins, 1775	–
Yellow-spotted moustache – *Mesosa myops* Dalman, 1817	–
Long-spotted weevil moustache – *Mesosa curculionoides* Linnaeus, 1761	–
Gray mesenteric moustache – *Mesosa nebulosa* Fabricius, 1781	–
Large long-eared mustache – *Acanthocinus aedilis* Linnaeus, 1758	–
Poplar squeaker – *Saperda populnea* Linnaeus, 1758	–
Marble creeper – *Saperda scalaris* Linnaeus, 1758	–
Menesia bipunctata Zoubkoff, 1829	–
Honeysuckle mustache – *Oberea pupillata* Gyllenhal, 1817	–
Hazel mustache – *Oberea linearis* Linnaeus, 1761	–
Clytra quadripunctata Linnaeus, 1758	–
Grammoptera stenurella Linnaeus, 1758	+
Pseudovagonia livida pecta J. Daniel & K. Daniel, 1891	+
Brown mustache – *Allosterna tabacicolor* De Geer, 1775	+
Great oak mustache – *Cerambyx cerdo* Linnaeus, 1758	+
Red-breasted willow mustache – *Oberea oculata* Linnaeus, 1758	+
Maple gray mustache – *Leiopus nebulosus* Linnaeus, 1758	+
Agapanthia dahlia Richter, 1821	+
Stenurella melanura Linnaeus, 1758	+
Chrysomelidae	

Pachybrachys hieroglyphicus Laicharting, 1781	–
Pachybrachys scriptidorsum Mars.	–
Stylosomus tamaricis Herrich-Schaeffer, 1838	–
Blue willow leaf beetle – *Plagiodera versicolora* Laicharting, 1781	+
Poplar leaf beetle – *Chrysomela populi* Linnaeus, 1758	+
Red-winged willow leaf beetle – *Chrysomela saliceti* Suffrian, 1849	–
Aspen leaf beetle – *Chrysomela tremulae* Paykull, 1799	–
Common willow leaf beetle – *Phratora vulgatissima* Linnaeus, 1758	–
Phratona vitellinae Linnaeus, 1758	+
Viburnum leaf beetle – *Pyrrhalta viburni* Paykull, 1799	–
Elm broomstick – *Pyrrhalta luteola* Müller, 1766	–
Alder broom – *Agelastica alni* Linnaeus, 1758	–
Garden lupine – *Luperas xanthopoda* Schrnk.	+
Chalcoides plutus Latreille, 1804	–
Golden chalcoides – *Chalcoides aurata* Marsham, 1802	–
Altica quercetorum Foudras, 1860	+
Yellow mountain flea – *Psylliodes luteola* Müller, 1776	–
Chrysochus asclepiadeus Pallas, 1776	+
Chrysolina herbacea Duftschmid, 1825	+
Chrysolina sturmi Westhoff, 1882	+
Altica brevicollis Foudras, 1859	+
Galeruca tanaceti Linnaeus, 1758	+
Oak chess leaf beetle – *Pachybrachys epidusix* Olivier, 1791	+
Clytra laeviuscula Ratzeburg, 1837	+
Labidostomis longimana Linnaeus, 1758	+
Chrysolina fastuosa Scopoli, 1763	+
Alder leaf beetle – *Melasoma aeneum* Linnaeus, 1758	+
Polished leaf beetle – *Chrysolina polita* Linnaeus, 1758	+

Red-winged poplar leaf beetle – *Melasoma populi* Linnaeus, 1758	+
Long-eared looper – *Luperus longicornis* Fabricius, 1781	+
Yellow-legged looper – *Luperus flavipes* Linnaeus, 1758	+
Blue leech – *Lema cyanescens* Linnaeus, 1758	+
Red-breasted leech – *Oulema melanopus* Linnaeus, 1758	+
Cryptocephalus laevicollis Gebl.	+
Ocellated cryptocephalus – *Cryptocephalus ocellatus* Drapiez, 1819	+
Yellow-legged cryptocephalus – *Cryptocephalus flavipes* Fabricius, 1781	+
Hazel cryptocephalus – *Cryptocephalus coryli* Linnaeus, 1758	+
Beet shieldworm – *Cassida nebulosa* Linnaeus, 1758	+
Green scale insect – *Cassida viridis* Linnaeus, 1758	+
Attelabidae	
German cenorrhynus – *Coenorrhinus germanicus* Herbst, 1797	+
Dark blue cenorrhynus (petiole weevil) – *Coenorrhinus interpunctatus* Stephens, 1831	–
Birch pipistrelle – *Byctiscus betulae* Linnaeus, 1758	+
Poplar pipistrelle – *Byctiscus populi* Linnaeus, 1758	+
Black birch warbler – *Deporaus betulae* Linnaeus, 1758	+
Oak pipistrelle – *Attelabus nitens* Scopoli, 1763	+
Hazel pipistrelle – *Apoderus coryli* Linnaeus, 1758	+
Hawthorn buzzard – Coennorhinus aequatus Linnaeus, 1758	+
Fruit borer – *Coenorrhinus pauxillus* Germar, 1824	+
Curculionidae	
Spotted mower – *Otiorrhynchus fullo* Schrank, 1781	–
Small oval mower – *Otiorrhynchus ovatus* Linnaeus, 1758	+
Spherical leafhopper – *Otiorrhynchus rotundatus* Siebold, 1837	+
Leaf elephant – *Phyllobius oblongus* Linnaeus, 1758	+

Pear leaf elephant – *Phyllobius piri* Linnaeus, 1758	+
Beech leaf elephant – *Phyllobius viridicollis* Linnaeus, 1758	–
Nettle leaf elephant – *Phyllobius urticae* Degeer, 1775	+
Silk leaf beetle – *Polydrosus sericeus* Schoenherr, 1834	–
Gray pine weevil – *Brachyderes incanus* Linnaeus, 1758	–
Green grass weevil – *Eusomus ovulum* Germar, 1824	+
Gray bud weevil – *Sciaphobus squalidus* Gyllenhal, 1834	+
Green weevil – *Chlorophanus viridis* Linnaeus, 1758	+
Large pine weevil – *Hylobius abietis* Linnaeus, 1758	–
Cryptorrhynchidius lapathi Linnaeus, 1758	–
Elm borer – *Magdalis armigera* Fourcroy, 1785	+
Purple broom – *Magdalis violacea* Linnaeus, 1758	–
Spruce tar – *Pissodes harcyniae* Herbst, 1795	–
Speckled tarn – *Pissodes notatus* Sturm, 1826	–
Pine pine cone tar – *Pissodes piniphilus* Herbst, 1795	–
Pine cone beetle – *Pissodes validirostris* Gyllenhal, 1835	–
Birch weevil – *Curculio cerasorum* Fabricius, 1775	–
Chestnut weevil – *Curculio elephas* Gyllenhal, 1836	–
Acorn weevil – *Curculio glandium* Marsham, 1802	+
Acorn weevil of cork oak – *Curculio pellitus* Boheman, 1843	–
Red pear flower beetle – *Anthonomus pedicularius* Linnaeus, 1758	–
Ash weevil – *Lignyodes enucleator* Panzer, 1798	–
Elephant - poplar flea beetle – *Rhynchaenus populi* Fabricius, 1792	+
Archarius pyrrhoceras Marsham, 1802 (= *Curculio pyrrhoceras* (Marsham, 1802))	+
Baris artemisiae Herbst, 1795	+
Barypeithes pellucidus Boheman, 1834	+
Curculio rubidus Gyllenhal, 1836	+

Dorytomus taeniatus Fabricius, 1781	+
Graptus triguttatus Fabricius, 1775	+
Larinus (Phyllonomeus) turbinatus Gyllenhal, 1835	+
Lepyrus capucinus Schaller, 1783	+
Lixus (Dilixellus) fasciculatus Boheman, 1835	+
Nedius quadrimaclatus Linnaeus, 1758	+
Omphalapion hookerorum W. Kirby, 1808 (=*hookeri* auctt.)	+
Orchestes avellanae Donovan, 1797	+
Phyllobius seladonius Brullé, 1832	+
Polydrusus tereticollis De Geer, 1775 (=*undatus* Fabricius, 1781)	+
Pseudostyphlus pillumus Gyllenhal, 1835	+
Strophosoma capitatum DeGeer, 1775	+
Aspidapion validum Germar, 1817	+
Clover crabgrass – *Protapion apricans* Herbst, 1797	+
Clover yellow-legged weevil – *Apion flavipes* Herbst, 1797	+
Lupine weevil – *Sitona (Charagmus) griseus* Fabricius, 1792	+
Butterfly weevil – *Sitona lepidus* Gyllenhal, 1834 (= flavescens Marsham, 1802)	+
Red-legged tuberous weevil – *Sitona tibialis* Herbst, 1797	+
Black cherry borer – *Magdalis (Porrothus) cerasi* Linnaeus, 1758	+
Willow weevil – *Rhamphus pulicarius* Herbst, 1795	+
Grape and fruit weevil – *Peritelus familiaris* Boheman, 1834	+
Gray weevil – *Tanymecus palliates* Fabricius, 1792	+
Larinus (Phyllonomeus) turbinatus Gyllenhal, 1835	+
Thistle-backed larin – *Larinus (Phyllonomeus) sturnus* Schaller, 1873	+
Thorny leaf elephant – *Phyllobius (Metaphyllobius) glaucus* Scopoli, 1763	+
Birch leaflet – *Polydrusus picus* Fabricius, 1792	+

Hairy leafhopper – *Polydrusus (Scythodrusus) inustus* Germar, 1824	+
Alfalfa mower – *Otiorrhyncus ligustici* Linnaeus, 1758	+
Sad mower – *Otiorhynchus tristis* Scopoli, 1763	+
Bean stem borer – *Lixus (Dilixellus) pulverulentus* Scopoli, 1763 (=algirus act.)	+
Umbrella stem borer – *Lixus iridis* Olivier, 1807	+
Sorrel stem borer – *Lixus (Dilixellus) bardanae* Fabricius, 1787	+
Ipidae	
Striped bog beetle – *Scolytus multistriatus* Marsham, 1802	–
Kirsch's borer – *Scolytus kirschi* Skalitzky, 1876	–
Zaitzev's marsh marmoset – *Scolytus zaitzevi* Butovitsch, 1929	–
Pygmy marsh moth – *Scolytus pygmaeus* Fabricus, 1787	–
Sword-bearer – *Scolytus ensifer* Eichhoff, 1881	–
Marsh destroyer – *Scolytus scolytus* Fabricius, 1775	_
Birch borer – *Scolytus ratzeburgi* Janson, 1856	+
Elm swamp – *Scolytus laevis* Chapuis, 1869	–
Maple swamp – *Scolytus konigi* Schew	–
Oak swamp – *Scolytus intricatus* Ratzeburg, 1873	+
Hornbeam borer – *Scolytus carpini* Ratzeburg, 1837	+
Large ash borer – *Hylesinus crenatus* Fabricius, 1787	–
Olive ash borer – *Hylesinus oleiperda* Fabricius, 1801	–
Variegated ash borer – *Hylesinus fraxini* Panzer, 1779	+
Decorated ash beetle – *Hylesinus orni* Fuchs, 1906	–
Kraatz's beetle – *Pteleobius kraatzi* Eichhoff, 1864	–
Elm larvae – *Pteleobius vittatus* Fabricius, 1787	–
Large spruce beetle – *Dendroctonus micans* Kugelann, 1794	–
Hairy spruce beetle – *Hylurgus ligniperda* Fabricius, 1787	–
Lesser spruce beetle – *Hylurgops palliatus* Gyllenhal, 1813	–

Western rootwort – *Hylastes linearis* Erichson, 1836	–
Black rootwort – *Hylastes ater* Erichson, 1836	–
Spruce root – *Hylastes cunisularius* Erichson, 1836	–
Caucasian root – *Hylastes attenuates* Erichson, 1836	–
Ukrainian rootwort – *Hylastes angustatus* Herbst, 1793	–
Small spruce root – *Hylastes opacus* Erichson, 1836	–
Fluffy polygraph – *Polygraphus polygraphus* Linnaeus, 1758	–
Lesser pistachio moth – *Carphoborus perrisi* Chapuis, 1869	–
Small steppe lupoid – *Carphoborus minimus* Fabricius, 1798	–
Spruce cryphal – *Cryphalus abietis* Ratzeburg, 1837	–
Linden bark beetle – *Ernoporus tiliae* Panzer, 1793	+
Caucasian bark beetle – *Phloeotribus caucasicus* Reitter, 1891	–
Crimean thuja borer – *Phloeosinus keimaeus* Egg.	–
Thuja beetle – *Phloeosinus thujae* Perris, 1855	–
Nut borer – *Lymantor soryli* Perr.	+
Bicolor bark beetle – *Taphrorychus bicolor* Herbst, 1793	–
Coniferous woodworm – *Dryocoetes autographus* Ratzeburg, 1837	–
Taiga woodworm – *Dryocoetes hectographus* Reitter, 1913	–
Common micrograph – *Pityophthorus micrographus* Linnaeus, 1758	–
Western micrograph – *Pityophthorus pityographus* Ratzeburg, 1837	–
Liechtenstein micrograph – *Pityophthorus lichtensteini* Ratzenusg, 1837	–
Pine micrograph – *Pityophthorus glabratus* Eichhoff, 1879	–
Oak woodworm – *Trypodendron domesticus* Linnaeus, 1758	+
Trypodendron lineatum Olivier, 1795	–
Common engraver – *Pityogenes chalcographus* Linnaeus, 1761	–
European graver – *Pityogenes trepanatus* Nordlinger, 1848	–
Four-toothed graver – *Pityogenes quadridens* Hartig, 1834	–

Two-toothed engraver – *Pityogenes bidentatus* Herbst, 1784	–
Six-toothed bark beetle – *Ips sexdentatus* Boerner, 1776	+
Duplicate bark beetle – *Ips duplicatus* Sahlberg, 1836	–
Typographical bark beetle – *Ips typographic* L.	–
Ips amitinus Eichhoff, 1871	–
Western European bark beetle – *Ips cembrae* Heer, 1836	–
Long-breasted bark beetle – *Orthotomicus longicollis* Gyllenhal, 1827	–
Burns bark beetle – *Orthotomicus suturalis* Gyllenhal, 1827	–
Larch bark beetle – *Orthotomicus laricis* Fabricius, 1792	–
Eastern crooked-toothed beetle – *Pityokteines curvidens* Germar, 1824	–
Western crooked-toothed bark beetle – *Pityokteines spinidens* Reitter, 1894	–
Small crooked-toothed bark beetle – *Pityokteines vorontzovi* Jacobson, 1895	–
Western unpaired bark beetle – *Xyleborus dispar* Fabricius, 1792	–
Unpaired pine bark beetle – *Xyleborus eurygraphus* Ratzeburg, 1837	–
Odd oak bark beetle – *Xyleborus monographus* Fabricius, 1792	+
Unpaired southern bark beetle – *Xyleborus dryographus* Ratzeburg, 1837	–
Unpaired omnivorous bark beetle – *Xyleborus saxeseni* Ratzeburg, 1837	+
Fruit borer – *Scolytus mali* Bechst.	+
Platypodidae	
Cylindrical flatworm – *Platypus cylindrus* Fabricius, 1792	–
Nitidulidae	
Dark flower beetle – *Meligethes coracinus* Sturm, 1845	+
Silphidae	

Wood dead beetle – *Xylodrepa quadripunctata* Linnaeus, 1761	+
Ptinidae	
Ptinus fur Linnaeus, 1758	+
Cleridae	
Trichodes apiarius Linnaeus, 1758	+
Carabidae	
Poecilus crenuliger Chaudoir, 1876	+
Hairy runner – *Ophonus rufipes* De Geer, 1774	+
Shiny Harpal – *Harpalus affinis* Schrank, 1781	+
Lesser Harpal – *Harpalus anxius* Duftschmid, 1812	+
Red-legged Harpal – *Harpalus rubripes* Duftschmid, 1812	+
Fragrant beautybird – *Calosoma sycophanta* Linnaeus, 1758	+
Copper pterostich – *Poecilus cupreus* Linnaeus, 1758	+
Smooth broomstick – *Carabus glabratus* Paykull, 1790	+
Lattice borer – *Carabus cancellatus* Illiger, 1798	+
Red-fronted field moth – *Anisodactylus signatus* Panzer, 1796	+
Narrow rat – *Amara bifrons* Gyllenhal, 1810	+
Humpbacked rat – *Amara convexiuscula* Marsham, 1802	+
Common rat – *Amara plebeja* Gyllenhal, 1810	+
Lagriidae	
Common mossy bat – *Lagria hirta* Linnaeus, 1758	+
Tenebrionidae	+
Wood borer - Neatus picipes Herbst, 1797	+
Large inkworm - Tenebrio molitor Linnaeus, 1758	+
Beetles - Phalacridae	
Olibrus bisignatus Ménétries, 1849	+
Olibrus bicolor Fabricius, 1792	+
Eriocraniidae	

Oak eriocrania – *Dyseriocrania fastuosella* Zeller, 1839	+
Tischeriidae	
Oak tischeria – *Tischeria complanella* Hübner, 1817	–
Adelidae	
Adela associella Zeller, 1839	+
Long-nosed spruce adela – *Adela congruella* Zeller, 1839	+
Long-nosed willow adela – *Adela cupreela* Denis et Sciffermüller, 1775	+
Nemophora degeerella Linnaeus, 1761	+
Cossidae	
Katran tree beetle – *Zeuzera pyrina* Linnaeus, 1761	–
Plutellidae	
Willow sickle-winged moth – *Ypsolopys seguella* Cl.	–
Oak sickle-winged moth – *Cerostoma alpella* Denis & Schiffermüller, 1775	+
Maple sickleback moth – *Cerostoma chazariella* Mann.	+
Fruit sickleback moth – *Cerostoma horridella* Treitschke, 1835	+
Broadleaf sickleback moth – *Cerostoma lucella* Fabricius, 1775	+
Honeysuckle sickle moth – *Cerostoma xylostella* Linnaeus, 1758	+
Pterophoridae	
Five-legged fingerworm – *Alucita (Pterophorus) pentadactyla* Linnaeus, 1758	+
Merrifieldia lecodactyla Denis. & Schifff	+

Appendix 5. Red Data Book species of Ukraine

Steppe dipper (*Saga pedo* Pallas, 1771)
Order Orthoptera
Family Tettigoniidae

Giant kite (*Satanas gigas* Eversmann, 1855)
Order Diptera
Family Asilidae

Fragrant sweet-scented buttercup (*Calosoma sycophanta* Linnaeus, 1758)
Order Coleoptera
Family Carabidae

Hungarian crane beetle
(*Carabus hungaricus* Fabricius, 1792)
Order Coleoptera
Family Carabidae

Sacred scarab (*Scarabaeus sacer* Linnaeus, 1758)
Order Coleoptera
Family Scarabaeidae

Dumpster beetle (*Osmoderma eremita* Scopoli, 1763)
Order Coleoptera
Family Scarabaeidae

Hairy staphylin
(*Emus hirtus* Linnaeus, 1758)
Order Coleoptera
Family Staphilinidae

Cheerful moth (*Lygaena laeta* Hubner, 1790)
Order Lepidoptera
Family Zygaenidae

Axe-winged moth (*Periphanes delphinii* Linnaeus, 1758)
Order Lepidoptera
Family Noctuidae

Fragrant bumblebee *(Bombus fragrans* Pallas, 1771)
Order Hymenoptera
Family Apidae

FOR NOTES:

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Tutorial

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