MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ENVIRONMENTAL SAFETY,
ENGINEERING AND TECHNOLOGIES
DEPARTMENT OF ENVIRONMENTAL SCIENCE

APPROVED TO DEFENCE
Head of the Graduate Department
_____ Tamara DUDAR
«_____» _____ 2023

BACHELOR THESIS

(EXPLANATORY NOTE)

SPECIALTY 101 "ECOLOGY",
EDUCATIONAL AND PROFESSIONAL PROGRAM:
"ECOLOGY AND ENVIRONMENT PROTECTION"

Theme: « Evaluation of the functionality of the ecosystems of the Rivne oblast»

Done by: student of EK. 402 group, Kavich Rostislav Olegovich
(student, group, surname, name, patronymic)

Supervisor: PhD, Ass.Prof., Ass.Prof of the Department of Environmental Science
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KYIV 2023

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ ЕКОЛОГІЧНОЇ БЕЗПЕКИ,
ІНЖЕНЕРІЇ ТА ТЕХНОЛОГІЙ
КАФЕДРА ЕКОЛОГІЇ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_____ Тамара ДУДАР
«_____» _____ 2023 р.

КВАЛІФІКАЦІЙНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ БАКАЛАВРА

ЗА СПЕЦІАЛЬНІСТЮ 101 «ЕКОЛОГІЯ»
ОПП «ЕКОЛОГІЯ ТА ОХОРОНА НАВКОЛИШНЬОГО СЕРЕДОВИЩА»

Тема: «Оцінка функціональності екосистем Рівненської області»

Виконавець: студента группи ЕК 402, Кавича Ростислава Олеговича
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КИЇВ 2023

NATIONAL AVIATION UNIVERSITY

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Specialty, Educational and Professional Program: specialty 101 “Ecology”, Educational and Professional Program: “Ecology and Environment Protection”

(code, name)

APPROVED
Head of the Department
_____ Tamara DUDAR
«____» _____ 2023

BACHELOR THESIS ASSIGNMENT

Kavich R. Olegovich

1. Theme: «**Evaluation of the functionality of the ecosystems of the Rivne oblast**» approved by the Rector on September 29, 2016, № 2484/ст.

2. Duration of work: from 29.05.2023 to 20.06.2023.

3. Output work (project): Environmental Passport of Rivne oblast, Reports on the State of Environment, research results from open sources

4. Content of explanatory note: (list of issues): Introduction, Ecosystem functioning, Natural ecosystems of the Rivne oblast, Assessment of ecosystems functioning, Conclusions..

5. The list of mandatory graphic (illustrated materials): tables, figures, charts, graphs.

6. Schedule of thesis fulfilment

№ з/п	Task	Term	Advisor's signature
1	Justification of the goal, object and subject of research	29.05.2023 – 04.06.2023	
2	Review of literary sources	01.06.2023 – 08.06.2023	
3	Collection and analysis of materials	01.06.2023 – 10.06.2023	
4	Writing chapters I of the thesis	02.06.2023 – 05.06.2023	
5	Writing chapters II of the thesis	05.06.2023 – 12.06.2023	
6	Writing chapters III of the thesis	09.06.2023 – 12.06.2023	
7	Issuance of an explanatory note	13.06.2023 – 20.06.2023	
8	Defense of the thesis	20.06.2023	

7. Date of task issue: «_19_» April 2023

Diploma (project) advisor: _____ Radomska M. Myroslavivna

(advisor's signature) (S.N.P.)

Task is taken to perform: _____ Kavich R. Olegovich

(graduate's signature) (S.N.P.)

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет екологічної безпеки, інженерії та технологій

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Спеціальність, освітньо-професійна програма: спеціальність 101 «Екологія», ОПП «Екологія та охорона навколишнього середовища»

(шифр, найменування)

ЗАТВЕРДЖУЮ

Завідувач кафедри

_____Тамара ДУДАР

«____» _____ 2023 р.

ЗАВДАННЯ

на виконання кваліфікаційної роботи

Кавича Ростислава Олеговича

1. Тема роботи «Оцінка функціональності екосистем Рівненської області» затверджена наказом ректора від «29» вересня 2016 р. №2484/ст

2. Термін виконання роботи: з 29.05.2023 до 20.06.2023.

3. Вихідні дані роботи: Екологічний паспорт Рівненської області, Звіти про стан довкілля, результати досліджень з відкритих джерел.

4. Зміст пояснювальної записки: Вступ, Функціонування екосистем, Природні екосистеми Рівненської області, Оцінка функціонування екосистем, Висновки..

5. Перелік обов’язкового графічного (ілюстративного) матеріалу: таблиці, рисунки, діаграми.

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Обґрунтування мети, об’єкта та предмета дослідження	29.05.2023 – 04.06.2023	
2	Огляд літературних джерел	01.06.2023 – 08.06.2023	
3	Збір та аналіз матеріалів	01.06.2023 – 10.06.2023	
4	Написання І розділу дипломної роботи	02.06.2023 – 05.06.2023	
5	Написання 2 розділу дипломної роботи	05.06.2023 – 12.06.2023	
6	Написання 3 розділу дипломної роботи	09.06.2023 – 12.06.2023	
7	Видача пояснювальної записки	13.06.2023 – 20.06.2023	
8	Захист дипломної роботи	20.06.2023	

7. Дата видачі завдання: «____» _____ 20 __ р.

Керівник кваліфікаційної роботи (проекту): _____ Радомська М.М.

(підпис керівника) (П.І.Б.)

Завдання прийняв до виконання: _____ Кавич Р.І.

(підпис випускника) (П.І.Б.)

CONTENT

ABSTRACT

Explanatory note to thesis « Biodiversity change and its support in the territory of the Rivne region »: 60 pages, 24 figures, 5 tables, 14 references.

Object of research – ecological processes, running within ecosystems.

Subject of research – functional ability of ecosystems in Rivne oblast.

Aim of work The aim of the work is to analyze the state of the typical ecosystems in the Rivne oblast and evaluate their functional ability.

Methods of research: Comparative analysis, data comparison, statistical data processing, graded evaluation.

Keyword: COSYSTEM FUNCTIONING, TRANSFORMATION OF ECOSYSTEMS, PROTECTED AREAS, BIODIVERSITY.

INTRODUCTION

Relevance of the work. The functioning of ecosystems is a set of ecological processes that, thanks to internal and external ecological connections, ensure vegetation and development of the ecosystem over time. The safety of living organisms depends on the functional ability of their environment. The functional ability depends on biodiversity in ecosystems, which defines, in turn, the quality of ecosystem services provided by nature. As a result, the study of functional ability of ecosystems can provide valuable information for the improvement of nature conservation practices in the oblast

Aim and tasks of the work. The aim of the work is to analyze the state of the typical ecosystems in the Rivne oblast and evaluate their functional ability.

Tasks of work:

1) to define and describe the most typical ecosystems of the Rivne oblast;
2) to characterize the sources and intensity of anthropogenic pressure on ecosystems;
3) to study the data about biodiversity in the oblast and sufficiency of its protection;
4) to evaluate the functional ability of typical ecosystems;
5) to give recommendations for the improvement of the current status of ecosystems in Rivne oblast.

Object of research – ecological processes, running within ecosystems.

Subject of research – functional ability of ecosystems in Rivne oblast

Methods of research. Comparative analysis, data comparison, statistical data processing, graded evaluation

The practical value of the results obtained. The results obtained could be used for planning of the expansion of protected areas network in the oblast, as well as planning activities for the revival of natural communities in the area.

Personal contribution of the graduate. Analysis of literature, formation of description and characteristics, collection of information for graded evaluation and conduction of these assessments.

Aprobation:

Kavych R. The environmental performance assessment of Rivne oblast // Polit. Challenges of science today: Abstracts of XXIII International conference of higher education students and young scientists. – National Aviation University. – Kyiv, 2023. – P. 110–111.

SECTION 1 – ECOSYSTEM FUNCTIONING

1.1. The concept of Ecosystem functioning

Ecosystem functioning refers to the processes and interactions that occur within an ecosystem, resulting in the flow of energy, cycling of nutrients, and maintenance of ecological balance. It encompasses a wide range of biological, physical, and chemical processes that collectively determine the overall health, resilience, and productivity of an ecosystem.

The Key Points, which characterize Ecosystem functioning:

Structure and Components: Ecosystems are composed of both living (biotic) and non-living (abiotic) components. Biotic components include plants, animals, microorganisms, and their interactions, while abiotic components encompass physical factors like soil, water, climate, and nutrients.

- Energy Flow: Ecosystems are powered by the flow of energy, usually originating from the sun through photosynthesis. Producers (plants or algae) capture solar energy and convert it into chemical energy, which is then transferred through the food chain as organisms consume one another.
- Nutrient Cycling: Ecosystems also involve the cycling of nutrients, such as carbon, nitrogen, phosphorus, and others. Nutrients are absorbed by plants, passed on to consumers, and eventually returned to the environment through decomposition and other processes, completing the nutrient cycle.
- Trophic Levels: Ecosystems are organized into trophic levels, which represent the feeding relationships between different organisms. Producers occupy the primary trophic level, followed by herbivores (primary consumers), carnivores (secondary consumers), and so on. Each trophic level has a specific role in energy transfer and nutrient cycling.
- Biodiversity and Stability: Biodiversity plays a crucial role in ecosystem functioning. High biodiversity often leads to increased stability and resilience of

ecosystems, as different species perform various functions such as nutrient cycling, pollination, pest control, and decomposition.

- Ecosystem Services: Ecosystem functioning provides numerous services that are essential for human well-being, including provisioning services (food, water, timber), regulating services (climate regulation, water purification), supporting services (soil formation, nutrient cycling), and cultural services (recreation, aesthetic value).

Ecosystem functioning is influenced by a complex network of ecological interactions, including competition, predation, symbiosis, and mutualism. These interactions shape the structure and dynamics of ecological communities, affect population sizes, and regulate the flow of energy and nutrients through the ecosystem. This complex web of interactions within ecosystems is vital for managing and conserving balance in biosphere. At the same time, all these components can be and are already affected by human impacts and transformed by human interventions.

Ecosystem functioning is closely linked to the resilience and stability of ecosystems. Resilience refers to the ability of an ecosystem to recover from disturbances and maintain its structure and functions. Stability implies the ability to resist changes and maintain a relatively steady state. Ecosystems with higher functional diversity and redundancy tend to be more resilient and stable.

Functional diversity refers to the variety of species and functional traits within an ecosystem. Different species perform specific roles and functions, such as nutrient cycling, pollination, seed dispersal, and predator-prey interactions. Higher functional diversity enhances the efficiency and stability of ecosystem processes and services.

Obviously, ecosystems and their functioning vary at different scales, from small local ecosystems to large landscapes or even global systems. The heterogeneity of habitats, such as variations in vegetation, topography, and hydrology, can influence the distribution and functioning of species within an ecosystem. This also defines the intensity and efficiency of ecological processes, like primary production, decomposition, nutrient and water cycling etc. The unregulated interventions of human activity cause violations of ecosystem functioning at different scales. Moreover, the ecosystem functioning is not static and

fluctuates according to its internal regularities, influenced by various environmental factors and ecological interactions. In these terms

1.2. The Key Players of Ecosystem Functioning

Ecosystem functioning is based on the interactions between various organisms, each playing a unique role in shaping the dynamics and stability of ecosystems. These key players, from microorganisms to large predators, are instrumental in maintaining the intricate balance within ecological communities. They can be differentiated depending on their position in trophic chains or based on the specific functions they perform.

Producers, consumers and decomposes play their own crucial roles in energy flow, providing correspondingly the input, transfer and return of energy and matter to ecosystems.

The functional roles of organisms are also quite different, with engineers, foundation and key-stone species being responsible for shaping, population control and overall stability of ecosystems. The loss of these species, especially keystone, can lead to cascading effects and disruption of ecosystem functioning. Even the species present in small quantities, like indigenous and endemic Species have their unique ecological roles and adaptations. They have co-evolved with their environment and contribute to ecosystem functioning in distinct ways. Their presence enhances ecosystem resilience, as they possess specialized traits and interactions that may be crucial for ecosystem processes and the survival of other species.

Understanding the roles of organisms in ecosystem functioning is essential for managing and conserving them effectively. Their interactions, dependencies, and responses to environmental changes shape the resilience, stability, and productivity of ecosystems

1.3 Sustaining Ecosystem Functioning

Ecosystem functioning relies on a delicate balance of interconnected processes that work together to sustain the health, productivity, and resilience of ecosystems. These processes encompass both biotic and abiotic factors, forming a complex web of interactions that support the intricate functioning of ecological communities.

Energy flow is a fundamental process in sustaining ecosystem functioning. It begins with primary production, where autotrophic organisms, such as plants and algae, capture sunlight and convert it into chemical energy through photosynthesis. This energy is transferred through the food chain as organisms consume one another, ensuring the availability of energy for higher trophic levels. The efficiency of energy transfer influences the overall productivity and functioning of ecosystems.

Nutrient cycling plays a crucial role in sustaining ecosystem functioning, since it ensures nutrients availability for primary production and the maintenance of biological processes.

But the key component in sustaining ecosystem functioning is biodiversity. High species diversity and functional redundancy, where multiple species perform similar ecological roles, enhance ecosystem resilience and stability. Biodiversity contributes to ecosystem functioning by promoting efficient resource use, enhancing nutrient cycling, and providing ecological services such as pollination and pest control. The loss of biodiversity can disrupt ecosystem functioning and compromise the ability of ecosystems to withstand disturbances, both natural and manmade.

Disturbances, both natural and human-induced, are integral to ecosystem functioning. Disturbances, such as wildfires, storms, or human activities like logging, can temporarily disrupt ecosystem processes. However, ecosystems have the ability to recover and adapt through succession, the process of ecological change over time. Succession restores ecosystem functioning by facilitating the establishment of new species and promoting the development of complex community structures.

Ecological succession involves the colonization of new species, the replacement of existing species, and the development of more complex and diverse ecosystems. Succession is a vital process in sustaining ecosystem functioning as it allows for the recovery and renewal of ecosystems following disturbances. It promotes the establishment of species that are better adapted to the prevailing environmental

Under natural conditions feedback mechanisms sustain ecosystem functioning by regulating processes and maintaining balance. Positive feedback loops amplify changes in an ecosystem, while negative feedback loops help to stabilize and regulate ecosystem

processes. For example, in a positive feedback loop, increased plant growth due to higher nutrient availability can lead to further nutrient uptake and enhanced productivity. In contrast, negative feedback loops, such as predator-prey interactions, help to regulate population sizes and prevent unchecked population growth.

From the other side, human actions are also contributing to ecosystem functioning: humans are able to initiate successions and manage or affect the rate of its development. Responsible stewardship involves recognizing the value and importance of ecosystems and implementing sustainable practices that minimize negative impacts. Conservation efforts, habitat restoration, sustainable land-use practices, and the reduction of pollution contribute to the preservation and enhancement of ecosystem

Another important factor for sustaining balance in ecosystems, besides biodiversity, is landscape connectivity. Landscape connectivity is the degree to which habitats and ecosystems are connected and allow for the movement of organisms and the exchange of genetic material. It plays a vital role in sustaining ecosystem functioning by facilitating gene flow, promoting species migration, and maintaining biodiversity. Landscape connectivity allows for the dispersal of species, colonization of new habitats, and the formation of ecological corridors, which can help mitigate the negative effects of habitat fragmentation.

Well functioning ecosystem is able to provide high-quality ecosystem services (Fig. 1). Ability of an ecosystem to provide ecosystem services is important since it gives direct material resources and benefits to humans, but part of these services work on proving normal functioning of communities and their habitats via provisions and regulating services.

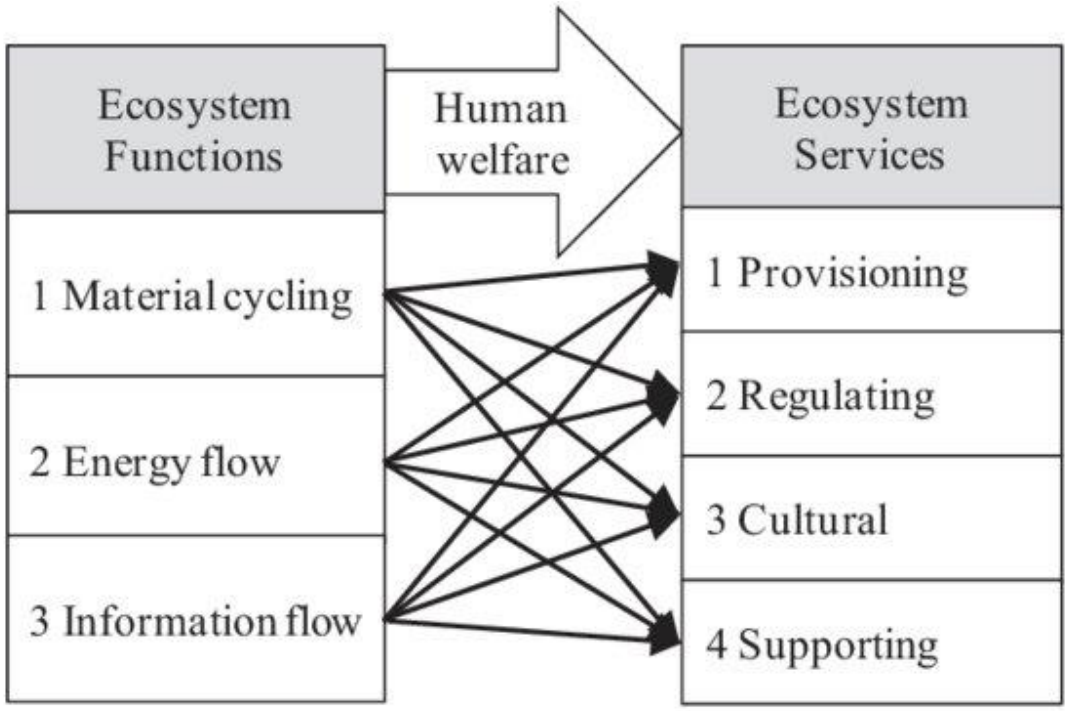

Fig. 1 Interconnection between Ecosystem Functions and Ecosystem Services

1.4 Threats to Ecosystem Functioning

Ecosystems worldwide face numerous threats that compromise their functioning, integrity, and long-term sustainability. These threats arise from various human activities, natural processes, and interactions between them. Understanding these threats is crucial for devising effective conservation and management strategies to safeguard ecosystem functioning.

Among the most common problems, threatening Ecosystem Functioning, are:

- Habitat Loss and Fragmentation reduce the available space for species, limits their movement, and disrupts ecological interactions. Fragmentation can lead to reduced biodiversity, altered nutrient cycling, and decreased ecosystem resilience.
- Pollution and Contamination pose serious threats to ecosystem functioning. Industrial activities, agriculture, and improper waste disposal contribute to the release of pollutants into the air, water, and soil. Chemical pollutants, such as pesticides, heavy metals, and toxic substances, can accumulate in ecosystems, impacting the health and survival of

organisms. Pollution disrupts nutrient cycling, contaminates food chains, and degrades habitat quality, leading to detrimental effects on ecosystem functioning.

- Climate change is a global threat that has far-reaching implications for ecosystem functioning. Rising temperatures, changing precipitation patterns, and altered weather conditions disrupt ecosystems and species' interactions. Climate change affects phenology (timing of biological events), distribution and abundance of species, and the functioning of ecological processes such as photosynthesis and nutrient cycling. These changes can lead to shifts in species composition, mismatches in timing between species interactions, and the loss of ecosystem services.
- Invasive species, introduced to ecosystems outside their native range, can have severe impacts on ecosystem functioning. Invasive species often outcompete native species for resources, alter habitat structure, and disrupt trophic interactions. They can displace native species, reduce biodiversity, and negatively impact ecosystem processes such as nutrient cycling and pollination. Invasive species pose a significant challenge to ecosystem functioning, particularly in vulnerable ecosystems and islands.
- Unsustainable overexploitation of natural resources, including overfishing, illegal wildlife trade, and excessive logging, threatens ecosystem functioning. Overexploitation disrupts trophic interactions, depletes populations of key species, and compromises ecosystem resilience. The removal of keystone species can lead to cascading effects, disrupting entire food webs and altering ecosystem structure and dynamics.
- Land and water degradation, including soil erosion, desertification, and water pollution, degrade ecosystem functioning. Unsustainable agricultural practices, improper land management, and excessive use of water resources contribute to land and water degradation. Soil erosion reduces soil fertility, affects nutrient cycling, and impairs plant growth. Water pollution affects aquatic ecosystems, impairs water quality, and compromises the health of aquatic organisms.
- Unsustainable land-use practices, such as monoculture agriculture, deforestation, and overgrazing, degrade ecosystem functioning. These practices deplete soil nutrients, reduce soil moisture retention, and increase vulnerability to erosion. They also

reduce habitat quality, disrupt ecological processes, and contribute to the loss of ecosystem services.

- Disease outbreaks and the introduction of pathogens can significantly impact ecosystem functioning. Pathogens, including viruses, bacteria, and fungi, can cause declines in population sizes, disrupt ecological interactions, and alter community dynamics. Disease outbreaks can lead to the loss of keystone species, shifts in species composition, and disruptions in nutrient cycling and energy flow within ecosystems.
- Human Exploitation and Disturbance, mentioned above, often play the role of limitation on ecosystem stability and expansion. Direct human exploitation and disturbance of ecosystems, such as hunting, fishing, and recreational activities pose threats to ecosystem functioning. Over-harvesting of species can disrupt trophic interactions, leading to imbalances in ecosystem structure and function. Recreational activities can degrade habitats, disturb wildlife, and contribute to the spread of invasive species. Human disturbance can disrupt natural processes and negatively impact the overall health and functioning of ecosystems.

At the same time, it is important to recognize that many threats to ecosystem functioning interact and compound each other. The combined effects of multiple stressors, such as climate change, habitat loss, and pollution, can have synergistic impacts that surpass the sum of their individual effects. These synergistic effects can lead to rapid and profound changes in ecosystems, affecting multiple components of ecosystem functioning simultaneously (Fig. 2).

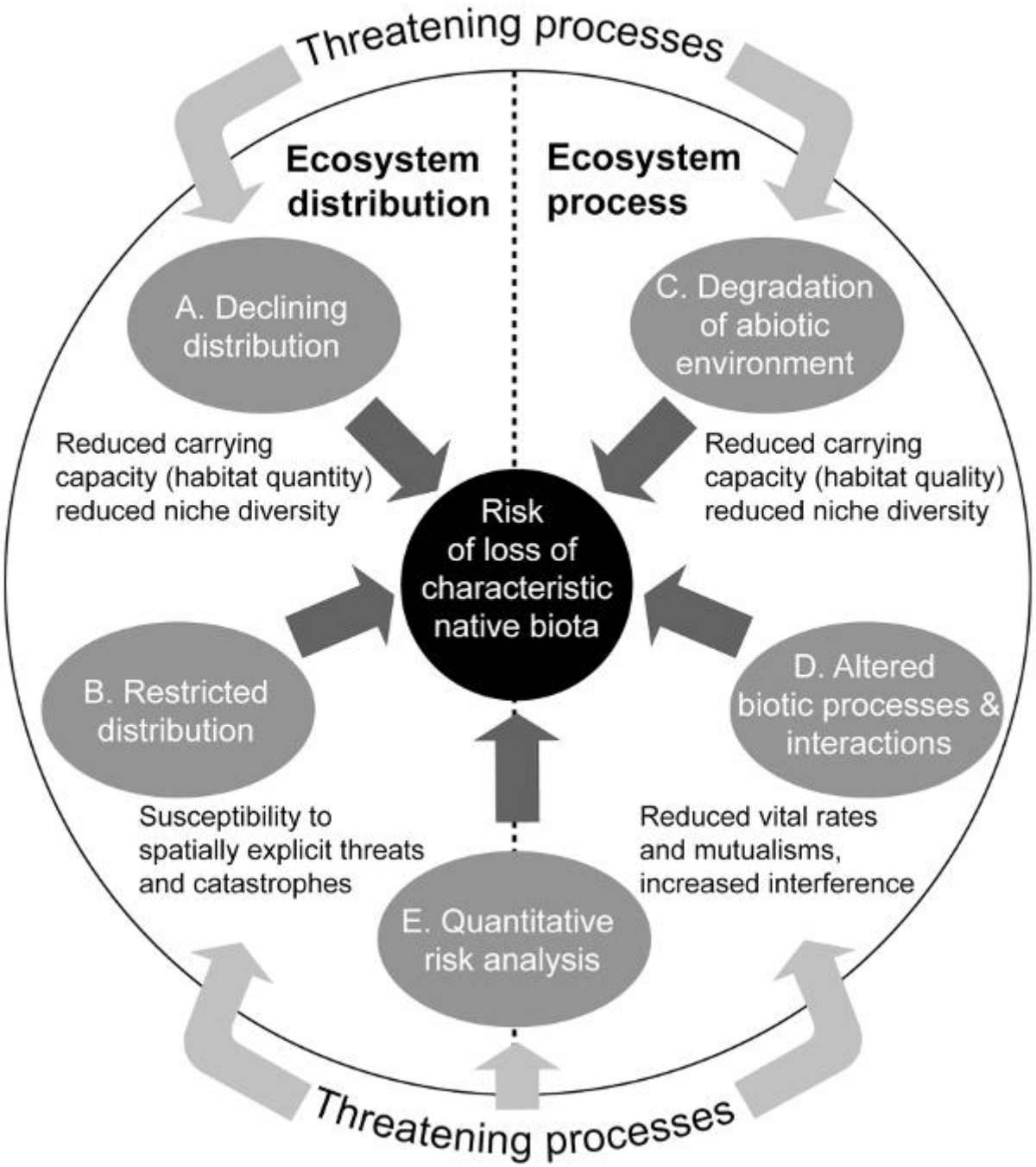

Fig. 2 Principle of threatening processes work

A significant threat to ecosystem functioning is the lack of environmental awareness and insufficient conservation efforts. Limited understanding of the importance of ecosystems and their functioning can lead to unsustainable practices and inadequate protection measures. Insufficient conservation efforts, including the lack of protected areas, weak enforcement of environmental regulations, and inadequate restoration initiatives, further exacerbate the challenges faced by ecosystems.

Addressing these threats and ensuring the long-term sustainability of ecosystem functioning requires a multi-faceted approach. Conservation strategies should focus on protecting and restoring habitats, promoting sustainable land-use practices, mitigating climate change, and reducing pollution. It is crucial to foster public awareness, engage local communities, and promote sustainable practices to minimize the negative impacts on ecosystems. Collaboration between governments, organizations, scientists, and local communities is essential to implement effective conservation and management measures.

By recognizing and addressing the threats to ecosystem functioning, we can work towards safeguarding the invaluable services and benefits that ecosystems provide. Preserving the integrity and functioning of ecosystems is not only vital for the survival of countless species but also for the well-being and sustenance of humanity.

Conclusions to Section 1

Ecosystem processes form interactions between components of environment and are the basis for ecosystem functioning. In its turn, ecosystem functions produce a wide complex of values and benefits for humans, known as ecosystem services. Biodiversity is a key player in all elements of ecosystem dynamics. The balance of all processes, taking place in ecosystems, is essential for the existence of biosphere.

The assessment of the ecosystems functional ability is based on the evaluation of the biodiversity levels and integrity, as well as evaluation of major threats to its consistency. It aims to predict risk of environmental safety and living standards degradation, as well as to find nature-based solutions for the prevention of degrading processes.

CHAPTER 2 - NATURAL ECOSYSTEMS OF THE RIVNE OBLAST

2.1. Geographical location and climate

The Rivne oblast is located in the Volhynian-Podolian Upland, which is part of the larger East European Plain. The region shares borders with Belarus to the north, Volyn Oblast to the east, Zhytomyr Oblast to the south, and Lviv Oblast to the west. It is situated in the historic region of Volhynia, which is known for its cultural and historical significance. The region covers an area of approximately 20,100 square kilometers

The Rivne oblast experiences a humid continental climate. Summers are generally mild to warm, with average temperatures ranging from 16°C to 23°C in July, the warmest month. Winters are cold, with average temperatures in January, the coldest month, ranging from -6°C to -2°C. The region receives a moderate amount of precipitation throughout the year, with an annual average ranging from 550 mm to 650 mm.

Snowfall is common during the winter months, with the region typically experiencing a snowy winter season. The climate and weather conditions in the Rivne oblast support the growth of forests, wetlands, and various natural ecosystems, contributing to its rich biodiversity.

The Rivne oblast features diverse topography, including plains, lowlands, and rolling hills. The western part of the region is relatively flat, while the eastern part is slightly more hilly. It is characterized by numerous rivers and streams, including the Prypiat, Styr, and Sluch rivers. The Prypiat River, one of the largest and most important rivers in the region, flows through its southern parts. These rivers, along with their tributaries, contribute to the region's hydrology and support diverse ecosystems. The region is also dotted with numerous lakes, including Lake Svityaz, which is the largest lake in Ukraine, and Lake Belsk, known for its scenic beauty.

In addition to the lakes and rivers, the Rivne oblast is characterized by extensive forests, wetlands, and peatlands. The region's natural features contribute to its ecological diversity and provide habitats for various plant and animal species. These geographical and

climatic characteristics shape the natural landscapes and ecosystems found in the Rivne oblast, making it a region of natural beauty and ecological importance.

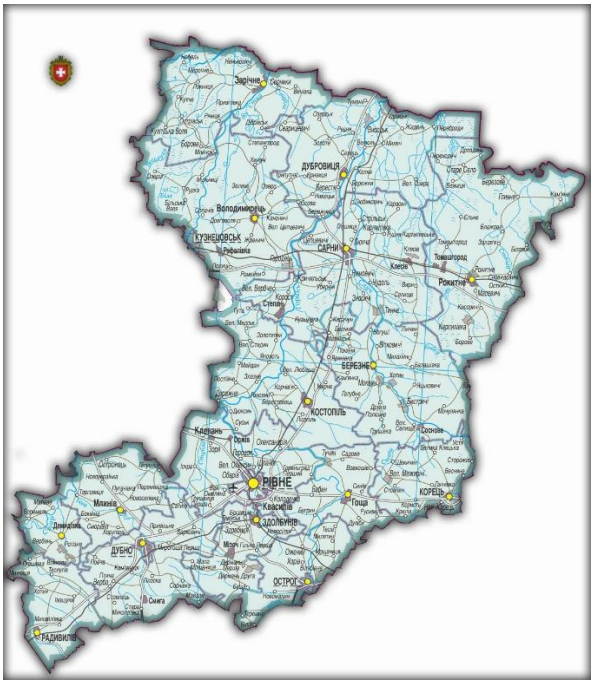

Fig. 3 Map of the Rivne region

2.2. Typical ecosystems of the oblast

The Rivne oblast in western Ukraine is known for its diverse ecosystems, encompassing forests, wetlands, meadows, and more. Here are some typical ecosystems found in the Rivne oblast:

- Forest Ecosystems: The region is characterized by extensive forests (Fig 3.), which cover a significant portion of its area. These forests include a mix of coniferous and deciduous tree species such as pine, oak, birch, beech, and spruce. The forest ecosystems provide habitats for a wide range of flora and fauna, including deer, wild boars, foxes, wolves, various bird species, and smaller mammals like squirrels and hedgehogs.
- Wetland Ecosystems: The Rivne oblast is home to several important wetland areas, such as the Prypiat River floodplain and the Sarny marshes. These wetlands include floodplains, marshes, and bogs. They provide critical habitats for diverse plant and animal species, including waterfowl, amphibians, reptiles, and fish. The wetlands are known for their rich biodiversity and serve as important breeding grounds for migratory birds.

- Grassland and Meadow Ecosystems: Open grasslands and meadows can be found in areas where forests are less dominant. These ecosystems are characterized by a variety of grasses, wildflowers, and herbs. They provide important foraging grounds for herbivores like deer and support a diverse range of insects, birds, and small mammals.
- Peatland Ecosystems: The Rivne oblast is known for its extensive peatlands, including bogs and fens (Fig. 3). Peatlands are wetland ecosystems characterized by the accumulation of partially decayed organic matter. They are home to unique plant species like sphagnum mosses, insectivorous plants, and rare orchids. Peatlands play a crucial role in carbon storage and water regulation. The region's peatlands provide habitats for unique plant species, including sphagnum mosses and insectivorous plants like sundews and bladderworts.
- Bogs: Bogs are another important wetland type found in the Rivne oblast. These acidic and nutrient-poor wetlands are characterized by the growth of sphagnum mosses and other specialized plant species. Bogs provide unique habitats for rare and endangered species, including insectivorous plants like the round-leaved sundew and the large white-faced dragonfly.
- Sand Dunes: In the southern part of the Rivne oblast, particularly near the town of Dubno, there are sand dunes formed during the Ice Age. These dunes are covered with grasses, shrubs, and rare plant species adapted to sandy environments. They provide a distinct ecosystem and are of ecological importance.
- Aquatic Ecosystems: The region's numerous lakes, rivers, and streams support diverse aquatic ecosystems (Fig. 3). These habitats are home to various fish species, including pike, perch, carp, and catfish. Aquatic ecosystems also provide nesting and feeding areas for water birds and support aquatic plants and invertebrates.
- Riparian Ecosystems: The region's rivers and streams are flanked by riparian ecosystems, which are transitional zones between aquatic and terrestrial habitats. These areas are characterized by diverse vegetation, including trees like willows, alders, and poplars. Riparian ecosystems provide habitat for a variety of birds, mammals, and insects and contribute to the overall health of the riverine ecosystem.

These ecosystems in the Rivne oblast contribute to its ecological diversity and provide valuable habitats for a wide range of plant and animal species. Efforts are being made to protect and conserve these ecosystems to maintain their ecological balance and ensure their sustainability for future generations.

Fig. 4 Forest ecosystems typical for Rivne oblast - pine, oak, and birch

Fig. 5- Swamp ecosystem – typical associations of Rivne oblast

Fig. 6 - Lake ecosystems are numerous in oblast, including Lake Svityaz, which is the largest lake in Ukraine

2.3. Sources of anthropogenic pressure

The Rivne oblast, like many other regions, experiences various anthropogenic pressures resulting from human activities. Some of the significant sources of anthropogenic pressure in the Rivne oblast include:

- Agriculture: Intensive agricultural practices, such as the use of fertilizers, pesticides, and irrigation, can lead to water pollution and soil degradation. Excessive use of chemicals can contaminate water bodies and affect the health of aquatic ecosystems. Agricultural expansion can also result in deforestation and habitat loss.
- Industrial Activities: Industrial development, including manufacturing, mining, and energy production, can contribute to air and water pollution. Emissions from factories and power plants release pollutants into the air, while industrial waste can contaminate water sources if not properly managed. These activities can have detrimental effects on both human health and the environment.
- Urbanization and Infrastructure Development: The growth of urban areas and infrastructure development can result in habitat fragmentation and loss, as well as increased pressure on natural resources. Construction projects, road networks, and urban expansion can lead to deforestation, loss of wetlands, and disruption of wildlife habitats.
- Pollution: Discharge of untreated or poorly treated wastewater, industrial effluents, and solid waste can contaminate water bodies and soil, posing risks to human health and ecosystems. Pollution from sources such as household waste, improper disposal of hazardous materials, and improper handling of agricultural waste can degrade the environment and impact biodiversity.
- Overexploitation of Natural Resources: Unsustainable practices related to logging, hunting, fishing, and collection of non-timber forest products can lead to the depletion of natural resources. Overfishing, for example, can disrupt aquatic ecosystems and negatively impact fish populations. Illegal logging and unsustainable hunting practices can also result in habitat destruction and threaten wildlife populations.

- Hunting and poaching: Hunting and poaching are also problems in the Rivne oblast, and are contributing to the decline of many species. Hunting regulations and enforcement efforts are not always effective in preventing illegal hunting and poaching.
- Infrastructure Development and Land Conversion: Construction of infrastructure, including roads, buildings, and agricultural expansion, often requires the conversion of natural habitats. This process can result in habitat loss, fragmentation, and the displacement of wildlife.
- Climate Change: While not directly caused by local activities, climate change is a global issue that affects the Rivne oblast. Rising temperatures, changing precipitation patterns, and extreme weather events can impact ecosystems, agriculture, and water resources. Climate change can also exacerbate the effects of other anthropogenic pressures.
- Deforestation: Uncontrolled logging and deforestation for timber, agriculture, and urbanization can lead to the loss of forests and natural habitats. Deforestation disrupts ecosystems, reduces biodiversity, and contributes to climate change by releasing stored carbon into the atmosphere.
- Water Management: The alteration of natural water flows through the construction of dams, drainage systems, and irrigation canals can disrupt aquatic ecosystems. It can impact the natural hydrological cycles, reduce water availability downstream, and affect the migration patterns of fish and other aquatic species.
- Mining Activities: Mining operations, including coal mining and extraction of minerals, can release pollutants into the environment. Discharge of toxic substances, such as heavy metals and acids, from mining activities can contaminate water sources and soil, leading to long-term environmental degradation.
- Tourism and Recreation: While tourism can bring economic benefits, unregulated tourism and recreational activities can put pressure on fragile ecosystems. Overcrowding, pollution, improper waste disposal, and habitat disturbance associated with tourism can harm natural areas and wildlife.
- Invasive Species: Introduction of non-native species, either intentionally or unintentionally, can disrupt local ecosystems and threaten native species. Invasive plants

and animals can outcompete native species for resources, alter habitats, and reduce biodiversity.

- Air Pollution: Emissions from industrial facilities, vehicles, and residential sources contribute to air pollution. Particulate matter, nitrogen oxides, sulfur dioxide, and other pollutants can have adverse effects on human health, vegetation, and air quality.

Among the most important causes of environment degradation are illegal amber mining, intensive mining of industrial minerals and deforestation. These result in a variety of negative trends in ecosystems, including degradation of zonal soils and underlying parent rocks, destruction of the fertile humus-eluvial horizon of podzolic soils and tree root systems, as well as changes in groundwater levels, which causes opposite phenomena, like waterlogging and reduction of water levels in rivers and lakes. The destruction of forest resources leads to changes in diversity, abundance AND migration processes of fauna of the region.

As it is seen from the analysis, the key challenges facing the Rivne oblast is the loss of natural habitats, which can be caused by activities such as deforestation, urbanization, and agricultural expansion. This loss of habitat can have a significant impact on the biodiversity of the region, which is known to be diverse and include many rare and even unique species.

2.4. Climate change effects in Rivne oblast

Another notable issue, previously not considered very much relevant to the Rivne oblast is climate change. The Rivne oblast, like many other regions around the world, is facing a range of climate-related problems that can impact biodiversity.

1. Temperature changes: Climate change is causing global temperatures to rise, which can have a range of impacts on biodiversity. For example, species that are adapted to specific temperature ranges may be negatively impacted if temperatures exceed their tolerance limits. This can lead to changes in the timing of seasonal events, such as breeding and migration, and can also result in the loss of habitat as species are forced to move to find suitable conditions.

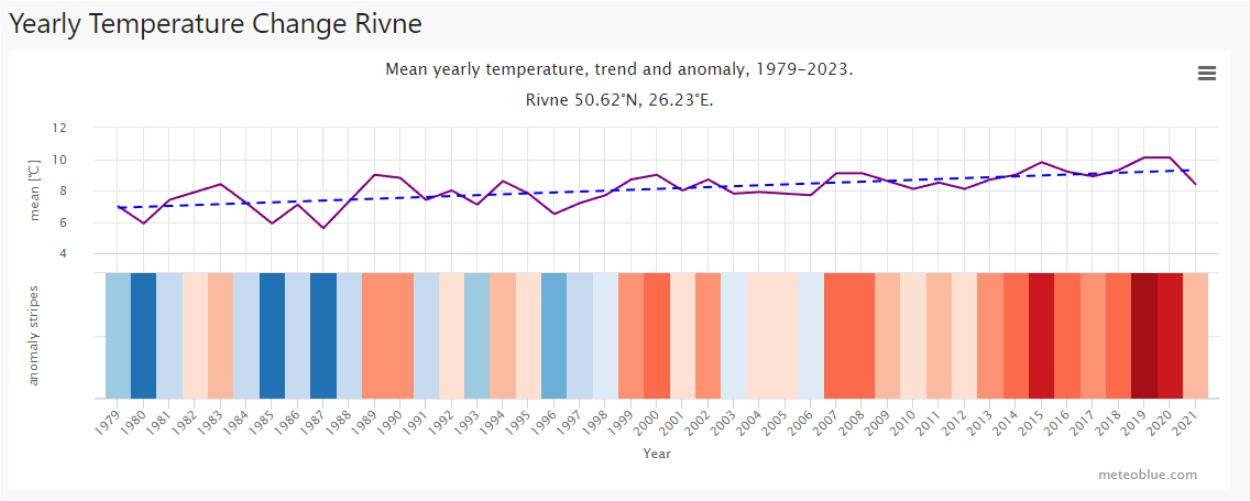

Fig. 7 Yearly temperature change in Rivne region

The top graph shows an estimate of the mean annual temperature for the larger region of Rivne. The dashed blue line is the linear climate change trend. If the trend line is going up from left to right, the temperature trend is positive and it is getting warmer in Rivne due to climate change. If it is horizontal, no clear trend is seen, and if it is going down, conditions in Rivne are becoming colder over time.

In the lower part the graph shows the so called warming stripes. Each colored stripe represents the average temperature for a year - blue for colder and red for warmer years.

2. Changing precipitation patterns: Climate change is also leading to changes in precipitation patterns, with some regions experiencing more frequent and intense droughts, while others experience more frequent and intense rainfall. These changes can impact biodiversity by altering the availability of water and food resources, as well as affecting the timing of seasonal events.

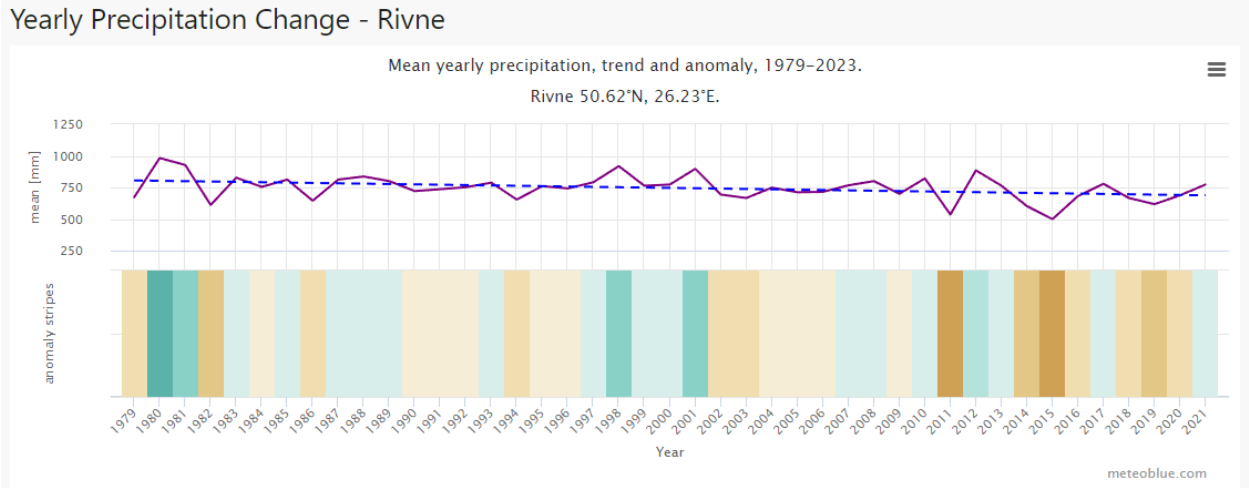

Fig. 8 Yearly precipitation change in Rivne region

The top graph shows an estimate of mean total precipitation for the larger region of Rivne. The dashed blue line is the linear climate change trend. If the trend line is going up from left to right, the precipitation trend is positive and it is getting wetter in Rivne due to climate change. If it is horizontal, no clear trend is seen and if it is going down conditions are becoming drier in Rivne over time.

In the lower part the graph shows the so called precipitation stripes. Each coloured stripe represents the total precipitation of a year - green for wetter and brown for drier years.

3. Extreme weather events: Climate change is causing more frequent and intense extreme weather events, such as hurricanes, heatwaves, and wildfires. These events can have devastating impacts on biodiversity, causing the loss of habitats, the death of individuals, and changes in the composition of ecosystems.

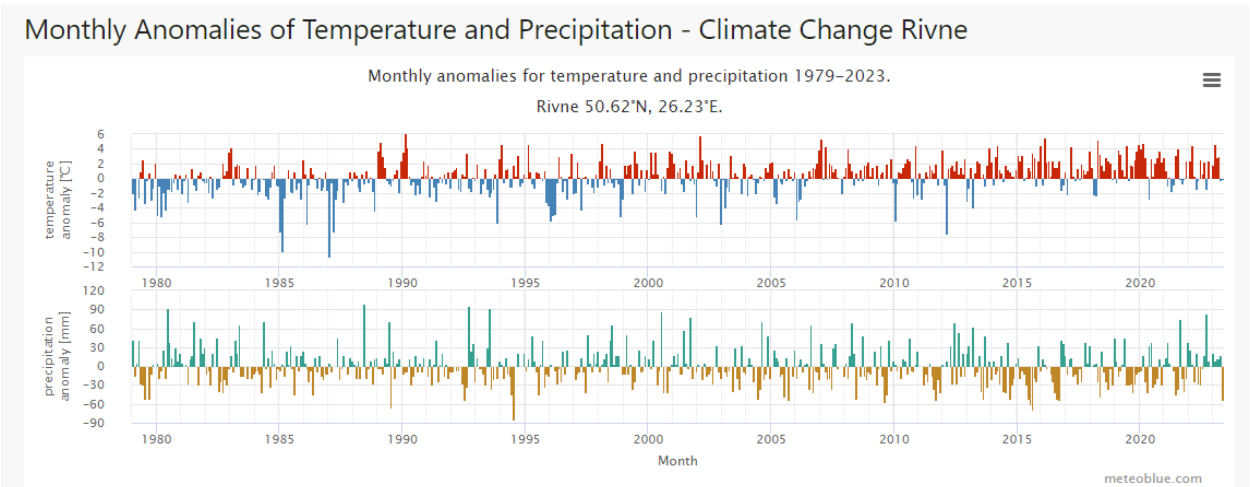

Fig. 9 Monthly anomalies of temperature and precipitation

The top graph shows the temperature anomaly for every month since 1979 up to now. The anomaly tells you by how much it was warmer or colder than the 30 year climate mean of 1980-2010. Thus, red months were warmer and blue months were colder than normal. In most locations, you will find an increase of warmer months over the years, which reflects the global warming associated with climate change.

The lower graph shows the precipitation anomaly for every month since 1979 up to now. The anomaly tells you if a month had more or less precipitation than the 30 year climate mean of 1980-2010. Thus, green months were wetter and brown months were drier than normal.

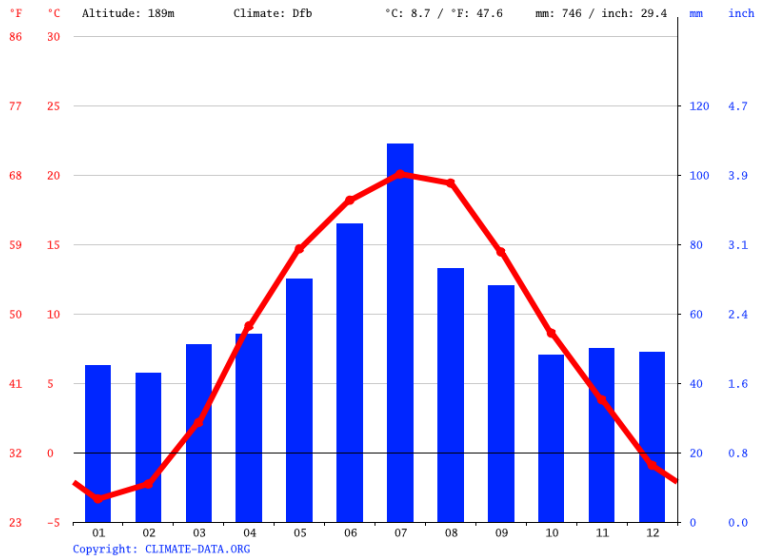

Fig. 10 Temperature and precipitation patterns in Rivne oblast

Thus, climate change is a serious threat to the Rivne oblast. The region is already experiencing the impacts of climate change, such as increased frequency and intensity of extreme weather events, changes in precipitation patterns, and shifts in plant and animal ranges. These impacts are expected to worsen in the future, posing a significant challenge to the region's economy, environment, and people.

The Rivne oblast is taking steps to adapt to climate change, but more needs to be done. The region needs to continue to invest in green infrastructure, promote energy efficiency, and develop a comprehensive climate change adaptation plan. By taking these steps, the Rivne oblast can build a more resilient future and protect its people and environment from the impacts of climate change.

Here are some asctions that can be done to address climate change in the Rivne oblast:

- Reduce greenhouse gas emissions: The region can reduce greenhouse gas emissions by investing in renewable energy, improving energy efficiency, and switching to low-carbon transportation options.
- Support sustainable agriculture: The region can support sustainable agriculture by promoting practices that reduce greenhouse gas emissions, such as no-till farming and cover cropping.
- Protect forests: Forests play an important role in mitigating climate change by absorbing carbon dioxide. The region can protect forests by reducing deforestation and promoting sustainable forest management.
- Educate the public: The region can educate the public about climate change and the importance of taking action. This can be done through school programs, public awareness campaigns, and other initiatives.

By taking these steps, the Rivne oblast can make a significant contribution to the fight against climate change.

These climate change effects are major threats to biodiversity, and the impacts are expected to intensify in the coming decades. To address this threat, it is important to take action at local levels to reduce greenhouse gas emissions, protect natural habitats, and promote sustainable land use practices. It is important that these efforts continue and are supported by policy makers, stakeholders, and the general public to ensure that the region's unique biodiversity is preserved for future generations.

Overall, the Rivne oblast faces many challenges related to biodiversity loss and habitat degradation. Addressing these problems will require a combination of efforts, including protecting remaining natural habitats, promoting sustainable land use practices, addressing climate change, and effectively enforcing hunting and poaching regulations.

Despite these challenges, there are efforts underway to support biodiversity in the Rivne oblast. For example, local conservation organizations are working to protect and restore key habitats, such as wetlands and forests. Additionally, some farmers are adopting sustainable agricultural practices that minimize the impact of their activities on local ecosystems.

Conclusion to Section 2

The Rivne region in Ukraine faces several significant ecological problems. These issues include deforestation and habitat loss due to agricultural expansion and urbanization, leading to the fragmentation of natural landscapes. Pollution from industrial activities, agricultural practices, and transportation contributes to air, water, and soil contamination, affecting both human health and ecosystem integrity. The region also experiences biodiversity loss, with declining populations of certain plant and animal species due to habitat degradation and human disturbances. Additionally, inadequate waste management practices and the presence of illegal dumps pose further environmental challenges. Urgent measures are needed to address these ecological problems, including sustainable land use practices, improved pollution control, conservation efforts, and the promotion of environmental awareness and education in the region.

CHAPTER 3 - ASSESSMENT OF ECOSYSTEMS FUNCTIONING

The territory of Rivne region is a part of Eastern European province of deciduous forests of European broadleaf zone. In the direction from north to south within the region, three geobotanical districts should be distinguished: West Polissya, Volyn Forest-steppe and Malopolissya.

The Polissya part of the region is characterized by considerable forest and waterlogging. Meadows are common in large areas. Forests occupy 40% of the territory, meadows -25-30%, swamps -10-20%.

Among the forests, the largest areas fall on pure pine forests. Smaller areas are occupied by mixed forests, broad-leaved pine and pine-deciduous (subory). Even smaller areas under mixed oak-hornbeam-pine and hornbeam-pine forests. In place of felled pine and oak-pine forests, birch forests are quite common

In the south of the Polissya part of the region, broad-leaved oak-hornbeam forests have been preserved on small areas, and in the northern part of the region spruce forests have been preserved in places. Everywhere along the depressions and marshy tracts grow black alder forests.

Among the meadow vegetation in Polissya, the most common are interfluve, continental meadows (upland, on the site of felled forests, and lowland). Large areas are occupied by floodplain meadows, especially along the valleys of larger rivers (Goryn, Styr).

Marshes are distributed both along river valleys and between rivers. The valleys of small rivers are completely swampy. Lowland meadows prevail, but are also known, especially in the north of Rivne Polissia, in particular in the basins of Lviv and Stvyha, transitional and upland bogs.

Within the boundaries of the Volyn Forest-Steppe, natural vegetation has been preserved less. The forested area is only 10.8%. Forests are concentrated mainly on the northern and southern outskirts of the district. The middle band is treeless. Deciduous and mixed forests of oak, hornbeam and scots pine prevail.

Like Rivne Polissia, Lesser Polissia is marked by significant forest. Meadows and swamps are also common in large spaces. Among the forests, the most common are dry pine and deciduous-pine forests (subory). Among meadow vegetation, lowland and upland meadows prevail, floodplain meadows occupy smaller areas. The bulk of the swamps are concentrated mainly in the valleys of small rivers.

A large territory of Rivne region is occupied by forests. Only the forests of the State Forest Fund cover about 550 thousand hectares. hectare. Of these, under coniferous forests – 69%, under hard-leaved forests – 12% and under soft-leaved forests – 20% of the total area. The largest areas are occupied by pine (69% of the forested area), common oak (about 10%), birch (10%) and black alder (9%). The main part of forests is concentrated in the Polissya part of the region, where they account for about 40% of the territory. In the Forest-steppe, forests have been preserved only on 10% of the area.

3.1. Transformation of ecosystems in the oblast

The Rivne oblast is home to diverse ecosystems that have undergone significant transformations in recent years. The interplay of human activities and natural processes has led to profound changes in the region's ecosystems. The most serious transformative processes are deforestation, wetland drainage, mining operations and agriculture. A separate concern is degradation of aquatic ecosystems due to pollution.

3.3.1. Deforestation trends

Deforestation is a serious problem in the Rivne oblast. The region has lost about 20% of its forest cover since 1990. This deforestation is due to a number of factors, including:

- Logging: Logging is the main cause of deforestation in the Rivne oblast. Logging is done for a variety of reasons, including to provide timber for construction and furniture, to clear land for agriculture, and to make way for infrastructure development.
- Agriculture: Agriculture is another major cause of deforestation in the Rivne oblast. Forests are cleared to make way for cropland and livestock grazing.
- Fires: Forest fires are a common occurrence in the Rivne oblast. These fires can be caused by a number of factors, including lightning, human carelessness, and deliberate arson.
- Urbanization: The Rivne oblast is experiencing rapid urbanization. As the population grows, more land is being converted from forest to urban use.

Deforestation has a number of negative impacts on the Rivne oblast. These impacts include:

- Loss of biodiversity: Forests are home to a wide variety of plants and animals. Deforestation can lead to the loss of these species.
- Water pollution: Deforestation can lead to water pollution. When forests are cleared, the soil is exposed to erosion. This eroded soil can wash into streams and rivers, carrying with it pollutants such as sediment, fertilizers, and pesticides.

- Climate change: Deforestation contributes to climate change. Forests absorb carbon dioxide from the atmosphere. When forests are cleared, this carbon dioxide is released into the atmosphere, contributing to global warming.

Forested areas have been cleared for agricultural expansion and infrastructure development, resulting in habitat fragmentation and the displacement of numerous plant and animal species. In 2010, **Rivne** had **783 thousand ha** of tree cover, extending over **39%** of its land area. In **2021**, it lost **5.56 thousand ha** of tree cover (Fig. 11).

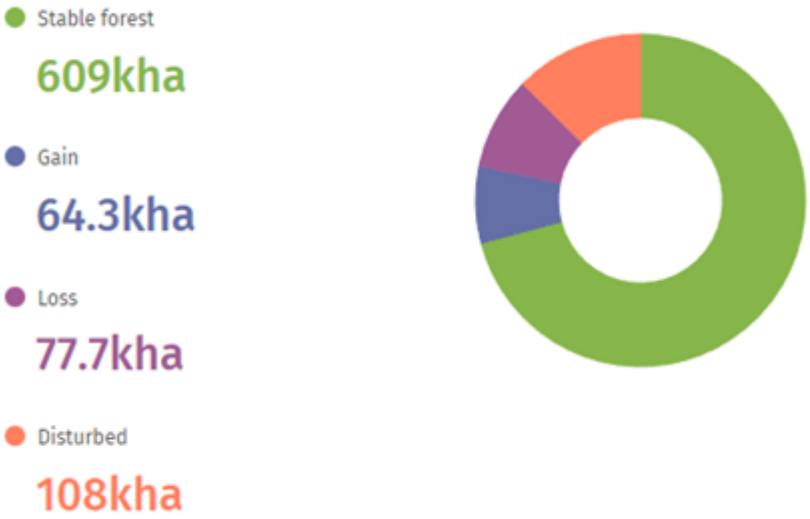

Fig. 11 – Components of net change in tree cover in Rivne oblast (based on Global Forest watch data)

From 2001 to 2021, Rivne lost 154 thousand ha of tree cover, equivalent to a 19% decrease in tree cover since 2000. This trend is quite high as compared to the neighbouring areas (Fig. 11)

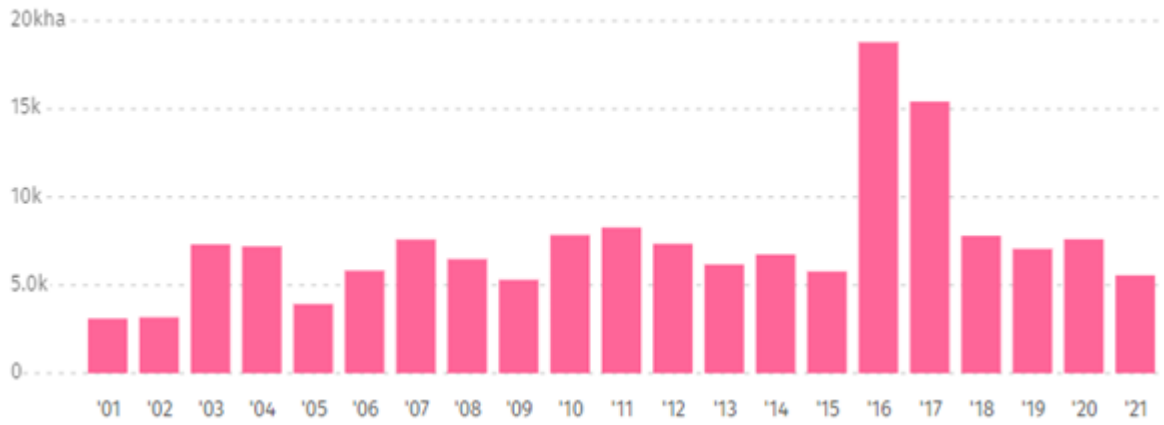

Fig. 12 – Dynamics of forest loss by Rivne oblast

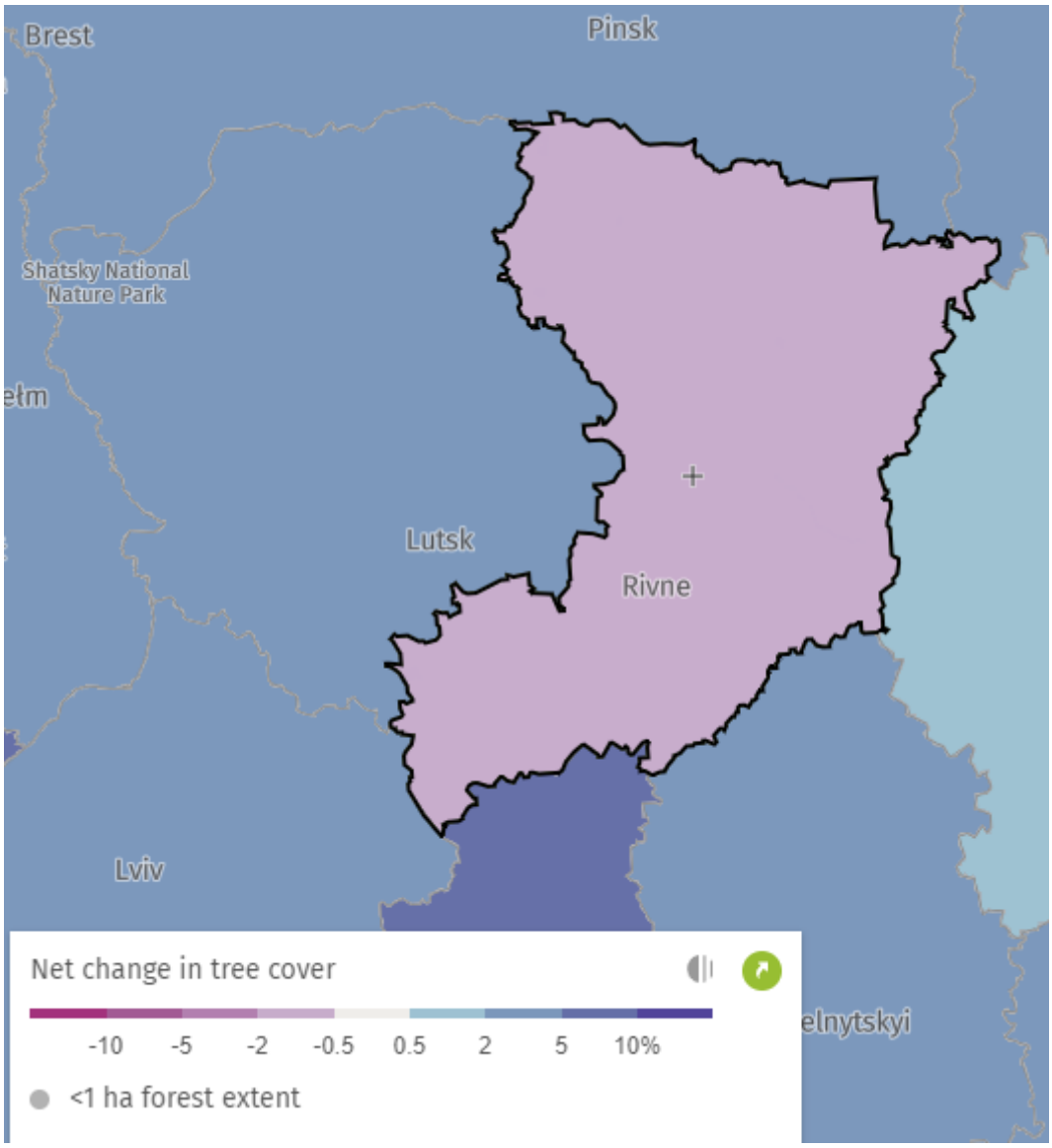

Fig. 13 – Net change in tree cover

3.3.2. Wetlands degradation

Wetlands degradation in the Rivne oblast is a serious problem. The region has lost over 50% of its wetlands since 1990. This degradation is due to a number of factors, including:

- Drainage: Wetlands are drained for agriculture, aquaculture, and other development. Drainage removes water from the wetland, which can lead to soil erosion, water pollution, and loss of habitat for plants and animals.
- Pollution: Wetlands are polluted by agricultural runoff, industrial waste, and sewage. Pollution can kill plants and animals, and it can make the water in wetlands unsafe for drinking and swimming.
- Invasive species: Invasive species are plants and animals that are not native to a wetland. Invasive species can outcompete native plants and animals for food and habitat, which can lead to the degradation of the wetland ecosystem.
- Climate change: Climate change is causing wetlands to dry up and become more acidic. This can lead to the loss of plant and animal species, and it can make wetlands less able to provide flood control and other important services.

The degradation of wetlands in the Rivne oblast is having a number of negative impacts, including:

- Increased flooding: Wetlands help to prevent flooding by absorbing excess water during heavy rains and snowmelt. When wetlands are degraded, this water can flow more quickly into rivers and streams, increasing the risk of flooding.
- Water pollution: Wetlands filter pollutants from water, such as sediment, nutrients, and pesticides. When wetlands are degraded, these pollutants can flow into rivers and streams, harming fish and other aquatic life.
- Loss of wildlife habitat: Wetlands are home to a variety of plants and animals, including waterfowl, amphibians, and fish. When wetlands are degraded, these animals lose their habitat and may be forced to move to other areas.

- Economic losses: The degradation of wetlands can lead to economic losses in a number of ways. For example, degraded wetlands can increase the risk of flooding, which can damage property and infrastructure. Degraded wetlands can also reduce the amount of fish and other aquatic life, which can harm the fishing and tourism industries.

3.3.3. Effects of mining operations

Damage to forest resources and soils due to unauthorized extraction of raw amber in the northern part of the oblast remains a complex and unsolved problem.

In the forest, where amber diggers have already visited, in a few years all the trees dry up, because the hydrological regime is disturbed by pits and pumps. There are also problems for animals that fall into the pits and cannot get out of there. Very often, amber is mined in valuable natural areas and does not take into account the regime of territories, which leads to the impossibility of the existence of many rare species of animals from the Red Book, such as lynx or black stork.

According to experts from the State Forestry Agency of Ukraine, 3.5 thousand ha have already been damaged in this region due to illegal amber mining. This is due to the fact that amber stones are washed out by motor pumps, which leads to the destruction of groundwater drainage channels.

Mining operations in the Rivne oblast have had a number of negative environmental impacts, including:

- Water pollution: Mining operations can pollute water with heavy metals, acids, and other pollutants. This can contaminate drinking water, harm fish and other aquatic life, and make swimming and other water recreation activities unsafe.
- Air pollution: Mining operations can pollute the air with dust, fumes, and other pollutants. This can cause respiratory problems in people and animals, and it can contribute to climate change.
- Land degradation: Mining operations can degrade land by creating large pits and mounds, and by removing topsoil. This can make the land less productive for agriculture and other uses.

- Noise pollution: Mining operations can be noisy, which can disrupt people's sleep and peace of mind.
- Social impacts: Mining operations can have a negative impact on the social fabric of communities. This can include increased crime, alcoholism, and other social problems.

There are a number of things that can be done to mitigate the environmental impacts of mining operations. These include:

- Reclamation: Mining companies should reclaim mined land to the extent possible. This can involve filling in pits, grading the land, and planting vegetation.
- Pollution control: Mining companies should install pollution control devices to reduce the amount of pollution from their operations.
- Community engagement: Mining companies should engage with local communities to address their concerns about the environmental impacts of mining operations.

3.3.4. Land use changes due to agriculture

Wetlands, crucial for biodiversity and water regulation, have also been drained for agricultural purposes, further exacerbating the degradation of these vital ecosystems.

The expansion of agriculture has intensified in the recent years, leading to the increased use of chemical inputs, such as fertilizers and pesticides. While enhancing productivity, these practices have resulted in soil erosion, nutrient runoff, and a decline in soil fertility. Consequently, agricultural intensification has negatively impacted the health and functioning of ecosystems in the region.

3.3.5. Negative processes in aquatic ecosystems

Industrial activities, urbanization, and agricultural practices have contributed to water pollution, with untreated or inadequately treated wastewater, industrial effluents, and

agricultural runoff contaminating water bodies. This pollution has had detrimental effects on aquatic ecosystems, reducing water quality and posing risks to the survival of aquatic species.

Water pollution and degradation have had far-reaching consequences for aquatic ecosystems. Contaminated water bodies suffer from reduced biodiversity, impaired water quality, and disruptions in the food chain. Fish populations have been particularly affected, with declines in abundance and diversity, negatively impacting both the ecological balance and the livelihoods of communities reliant on fisheries.

The impacts of these ecosystem transformations have been significant. The loss of habitat and fragmentation have resulted in the decline of biodiversity in the Rivne oblast. The construction of infrastructure, including roads and settlements, has severed wildlife corridors and impeded the movement of species. Fragmented habitats limit the gene flow between populations and increase the vulnerability of species to environmental changes, diminishing the overall resilience of ecosystems.

Species dependent on specific ecosystems, such as forest-dwelling plants and animals or wetland-dependent species, have experienced population declines or local extinctions. The disruption of ecological processes, such as pollination and seed dispersal, has further compromised the functioning of ecosystems and reduced their ability to provide essential services.

Furthermore, the degradation of ecosystems has resulted in a loss of ecosystem services. The region has experienced a decline in services such as clean water, air purification, and soil fertility. These services are vital for human well-being, agriculture, and the overall health of ecosystems. The diminishing provision of these services poses challenges for sustainable development and the long-term resilience of the Rivne oblast.

3.2. Biodiversity levels along a temporal scale

The Rivne oblast has with rich biodiversity, harboring a diverse array of species within its ecosystems.

The region boasts a remarkable diversity of plant species. According to approximate data, the flora of the Rivne oblast includes about 1,600 species of higher spore and seed plants, which belong to 500 genera and 100 families.

Within its forests, one can find a mosaic of deciduous and coniferous trees, including oak, beech, pine, spruce, and birch. The understory is formed with hazel, elderberry, and hawthorn, along with a diverse array of herbaceous plants, including wildflowers, grasses, and ferns. Wetland areas are characterized by a variety of aquatic and marsh plants, including reeds, sedges, water lilies, and iris.

Among the specific plant groups of the region, we should mention the peculiar "chalk forests" (pine and oak-pine associations on chalk outcrops), fragments of which are found in the forest-steppe part of the region, as well as the neighboring plant groups of "rock steppes" (steppe cherry, hairy hemlock, low sedge, broad-leaved alfalfa, and others).

Old oaks over 250 years old grow on an area of 54 hectares in the tract "Ostrozh chin" of the Ostroh district, on an area of 14 hectares in the tract "Olexandrivka" of the Duben district. Oak plantations have been preserved in the "Netreba" tract of Rokytniv district on an area of 52 hectares.

81 species of vascular plants and mushrooms of the region are listed in the Red Book of Ukraine. Species with interesting biology - orchids and insectivores, taken under protection in many countries of the world - form a significant group among protected plants.

Tundra and taiga species in the flora of Ukraine are remnants of the times when the northern part of its territory was covered by a glacier. There are about two dozen such species in the flora of the Rivne oblast.

After analyzing the data on biodiversity dynamics, we see a rather negative trend in preserving of the forests of the Rivne region. It cannot be said that measures are not being taken, because the trend has a controlled pace, and in some cases demonstrates improvement [https://mepr.gov.ua/wp-content/uploads/2022/10/Regionalna-dopovid-Rivnenska-ODA-2021.pdf]. Also, in general, I would like to note the trend of increasing the number of reserves in the territory of the region, which gives positive results in terms of biodiversity and its preservation.

It is also important to note that in the process of introducing new ideas and rules, many previously unsuitable areas were planted with various types of trees and vegetation, which will contribute to the restoration and creation of new ecosystems, and the expansion of existing ones.

Most of the rare species are present within the territory of national natural parks . For example, according to the 3rd edition of the Red Book of Ukraine on the territory of Rivne nature reserve, as of 01.01.2022, 51 species of plants and 3 types of mushrooms listed in the Red Book. Among them 20 species of vascular plants are listed the European Red List (according to the IUCN Red List of Threatened Species, Version 2021), 4 species are included into Appendix 1 of the Berne Convention. The regionally rare species include 52 species according to the "List of regionally rare and such that are under threat of extinction, plant species on the territory Rivne oblast" (2018).

Table 3.1

Protected plant and fungal species in 2020

Indicators	*Rivne Nature Reserve*	*NNP "Dermansko-Ostrogsky"*	*Nobelsky NPP*
Total number of species of plants and fungi	1389	1112	384
Species of plants and fungi listed in the Red Data Book of Ukraine	54	51	12
Species of plants and fungi listed in the annexes to the Convention on Conservation of Wild Flora and Fauna and Natural Habitats in Europe	4	8	1
Species of plants and fungi listed in the annexes to the Convention on International Trade in Endangered	13	18	1

Species of Wild Fauna and Flora (CITES)			

Also, 303 species of vertebrates are registered in the region, among which mammals, birds, reptiles, amphibians, roundmouths and fish are widely represented. In general, the fauna of the region is not much different from neighboring regions located in similar physical and geographical conditions, primarily Volyn and Zhytomyr. We can only talk about the absence in the Rivne oblast of certain species of vertebrates common in Volyn (river eel, copperhead, reed frog) with the simultaneous increase of some species of birds and mammals (stone thrush, little white heron, garden wolf, black rat, etc.).

Intra-regional faunal differences due to the difference in the natural complexes of the Polish and forest-steppe parts of the region are more clearly visible. The forest is characterized by a greater diversity of fauna, among whose representatives there are sometimes representatives of vertebrates that are rare in modern Ukraine, typical for the northern forest regions of the East European Plain (brown bear, elk, lynx, capercaillie, grouse, grouse, beaver, etc.). In the forest-steppe zone of the region, the number of hares, foxes, mouse-like rodents and shrews is increasing, but the species composition of the forest fauna here is much poorer than in the forests of Polissya (only squirrels, wood martens are more common, wolves, wild boars and some other animals are less common). At the same time, there are many species of vertebrates that are distributed throughout the territory of the region, without specific regional ranges. Among them, we should first mention representatives of the avifauna - waterfowl, marsh and meadow birds (ducks, waders, quails, etc.). It should be borne in mind that the modern fauna of the region, especially in its forest-steppe part, bears the traces of a significant anthropogenic transformation, which manifested itself mainly in the reduction of the quantitative and species composition of the animal world, although attempts to restore the natural fauna are successfully carried out in some nature conservation localities. and even its species expansion.

The Rivne oblast provides habitat for numerous avian species. The diverse landscapes, including forests, wetlands, and open fields, attract a wide range of bird species. Common species include woodpeckers, warblers, finches, sparrows, and thrushes. Wetland

areas are particularly important for water-associated bird species, including herons, ducks, grebes, and rails. Raptors such as eagles, hawks, and owls soar through the skies, adding to the region's avian diversity.

The region is home to various mammal species, both large and small. Forested areas provide habitat for mammals such as roe deer, wild boar, red foxes, and badgers. The presence of wetlands supports populations of European beavers and water voles. Additionally, the region hosts elusive predators like lynx and martens, adding a touch of wilderness to its diverse mammalian community.

The Rivne oblast accommodates a variety of reptiles and amphibians. Various snake species, including grass snakes and smooth snakes, inhabit the region's grasslands and forests. Wetlands serve as breeding grounds for numerous amphibians, such as common frogs, common toads, and various newt species. These cold-blooded creatures contribute to the ecological balance and add to the region's biodiversity.

The abundance of invertebrate life, including insects, spiders, mollusks, and others is also high. Butterflies, beetles, dragonflies, and bees flit through meadows and gardens, performing vital pollination services. Diverse moth species contribute to the region's nighttime biodiversity. Aquatic ecosystems are home to a wide range of aquatic invertebrates, crucial for nutrient cycling and maintaining the health of water bodies.

When analyzing the current state of the animal world in the region, a comparison of the "background" species composition of the fauna with modern data shows a generally negative trend. As it is seen from the data (Table 3.2) the number of endangered species is growing every year.

Table 3.2

Dynamics of the endangered species of fauna

Systematic group of animals	*Number of endangered species*					
	2000	*2017*	*2018*	*2019*	*2020*	*2021*
Insects	32	34	35	35	39	
Other invertebrates	-			1	1	2
Bone fish	1			3	3	6
Amphibians	1			1	1	2
Creepy	2			1	1	1
Birds	95	97	42	42	45	
Mammals	58	25	28	31	32	

Thus, within the zoocenoses of pine-birch forests, which dominate the Polish part of the region and are characterized by reduced fodder and protective potential, a relative impoverishment of the vertebrate fauna is noted. There is a clear dependence of the species composition of the fauna and the density of individual populations on the age and composition of stands, as well as on the seasons. Young pine-birch forests (up to 10 years old), especially in the spring and summer period, are dominated by certain species of reptiles and amphibians (toads, quacks, sometimes water lizards, spinids, common snakes, vipers), as well as nesting birds (grouse, Marsh owl, night owl, etc.). Grouse, finches, titmice, flycatchers and other birds that nest mainly in older forests often feed in young forests. With the development of pine-birch forests, their crowns are increasingly closed, which increases the protective capabilities of the forest and contributes to the spread of foxes, wild boars, roe deer, raccoon dogs, etc. At the same time, in 25-30-year-old forests, the number of birds

decreases, amphibians and reptiles almost disappear. In old (50-60 years) pine forests, the undergrowth is intensively developing, which has a favorable effect on the species diversity and density of the animal world, especially birds and mouse-like rodents. In recent years, the population of moose in the pine-birch forests of the Rivne Polyssia has grown significantly.

The zoocenoses of oak-pine forests, distributed mainly in the southern part of the region (they are found fragmentarily in Polissia), are characterized by a greater species diversity and density of feathered and mouse-like rodents (forest voles, yellow-throated mice), which is especially noticeable in the warm seasons. At the same time, the number of predatory birds and animals trophically related to them is increasing here, primarily martens, weasels, foxes, and ferrets.

Cultivated land zoocenoses were formed on areas of natural, reclaimed and reclaimed agricultural land significantly transformed by human economic activity (arable land, hayfields and cultural pastures, vegetable gardens, etc.). Considering the relentless expansion of anthropogenic landscapes, we can talk about the offensive nature of the specific vertebrate fauna that dominates cultivated lands. Among the reptiles, the pond lizard and common snake are quite common here. Amphibians are represented by toads, grass frog, common garlic, etc. The avifauna is quite widely represented, with the highest density of quail, turtledove, woodpecker, jackdaw, starling, and skylark. In general, the biological role of the main representatives of amphibians, reptiles and birds in the zoocenosis of cultivated lands is evaluated positively, as they restrain the development of harmful insects and mouse-like rodents. Among the mammals in the zoocenosis of cultivated lands, both harmful (hamsters, voles, mice) and beneficial species that destroy insect pests (white tooth, mole, bats) or mouse-like rodents (fox, ferret, weasel) are widespread.

Nevertheless, the intensive human presence on the territory of the region is constantly increasing, and the zones of influence of human activity are growing significantly from year to year. This leads to the disappearance of numerous specific ecotopes, which are habitats of a small number of species. As a result, the list of species of fauna that are protected in the Rivne oblast is quite significant.

Table 3.3

Species of fauna that are protected in 2021

Indicators	*Rivne Nature Reserve*	*NPP Dermansko-Ostrogskiy*	*Nobelsky NPP*
The total number of species of fauna, units.	1843	259	*229*
Species of fauna listed in the Red Book of Ukraine	93	65	23
Fauna species listed in the annexes to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	34	28	11
Fauna species listed in the annexes to the Convention on the Conservation of European Wild Flora and Fauna and Natural Habitats (Berne Convention)	217	236	98
Species listed in the annexes to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)	119	89	35
Species protected under the Agreement on the Conservation of Afro-Eurasian Migratory Waterbirds (AEWA)	31	32	22
Species protected under the Agreement on the Conservation of Bats	16	15	-

in Europe (EUROBATS)			
Species of fauna listed in the European Red List	40	40	-
Fauna species listed in the Red List of the International Union for Conservation of Nature	30	30	-

Aquatic ecosystems are of particular concern. Over the past 30-40 years, the main fish populations in the reservoirs of the region have been completely rebuilt. The trophic level is dominated by predators, plantophages and partially benthophages. As a result of hydromelioration and hydrotechnical regulation of the basins of the main rivers of the region, the disappearance of typical rheophilic fish species, which have very small populations or are absent at all, are on the red lists of international and national importance.

Regarding the biodiversity of animals – if we consider specifically trophic chains and methods of their preservation, - they are not very effective, because there is a tendency to decline. In order to prevent the destruction of trophic chains, increased attention to this problem is required. For example, as one of the ways to solve this crisis, I see an increase in the number of foresters who will control the pace of animal hunting, prevent poaching, etc.

3.3. Conservation Challenges and Efforts:

In order to preserve typical and unique natural complexes with everything the totality of their components, including biological and landscape diversity objects of the nature reserve fund of the region were created.

The Rivne region of Ukraine has several protected areas, including natural reserves, which are established to conserve natural habitats and their biodiversity. The largest of them are Rivne Nature Reserve, Dermansko-Ostrozki National Nature Park and Nobel National Nature Park. Here are some examples of natural reserves and their support in the territory of the Rivne region:

1. Kostopilsky Forest is a nature reserve located in the northern part of the Rivne region. The reserve covers an area of over 18,000 hectares and is home to a range of habitats, including forests, wetlands, and lakes. The reserve supports a diverse range of flora and fauna, including several endangered and rare species such as the white-tailed eagle, otter, and black stork. The reserve is managed by the Ukrainian State Agency for Protected Areas, which is responsible for protecting and managing the reserve.

2. Zvanets is a nature reserve located in the southwestern part of the Rivne region. The reserve covers an area of over 6,000 hectares and is home to a range of habitats, including forests, wetlands, and grasslands. The reserve supports a diverse range of flora and fauna, including several endangered and rare species such as the European bison, lynx, and black grouse. The reserve is managed by the Ukrainian State Agency for Protected Areas, which is responsible for protecting and managing the reserve.

3. Bereznevytsya is a nature reserve located in the eastern part of the Rivne region. The reserve covers an area of over 1,400 hectares and is home to a range of habitats, including forests, meadows, and wetlands. The reserve supports a diverse range of flora and fauna, including several endangered and rare species such as the European pond turtle, white-tailed eagle, and beaver. The reserve is managed by the Ukrainian State Agency for Protected Areas, which is responsible for protecting and managing the reserve.

4. Ostriv Yatsevycha Reserve focuses on protecting and restoring the nesting sites of the white-tailed eagle. These reserves contribute to the preservation of the region's biodiversity and provide opportunities for research and environmental education. It's important to note that the Rivne region's natural ecosystems are interconnected and provide valuable ecological services, such as water purification, soil fertility, and climate regulation.

These are just a few examples of natural reserves and their support in the territory of the Rivne oblast. These reserves play an important role in conserving natural habitats and their biodiversity, and are managed to ensure their long-term protection. Through the establishment and support of these reserves, the Rivne oblast is taking an important step towards the conservation of its natural heritage for future generations. The state of populations of most species, included into protection lists, is characterized as stable, the reserves maintain proper conditions for their growth.

Despite the remarkable biodiversity, the Rivne oblast faces conservation challenges. Habitat loss, fragmentation, pollution, and invasive species pose threats to the delicate balance of ecosystems and the species they support. However, various conservation initiatives and protected areas have been established to safeguard the region's biodiversity. National parks, nature reserves, and wildlife sanctuaries promote habitat preservation, restoration, and species conservation.

To increase the number of animals in the forests of the region, the work aimed at increasing the efficiency of biotechnical measures and, improving the protection of hunting grounds from poaching. In 2021 employees of all inspecting services (fish protection patrol, hunting farms, forestry and hunting management, public organizations) during systematic raids to prevent illegal hunting detected 1,321 cases of poaching. So, the problem is still urgent for the oblast.

Another important issue is the protection of ecosystem diversity. The usual approach to nature protection is usually focused on protecting species, while the community level is also diverse and valuable, but often left outside the conservation efforts.

The next step of the work was to define the sufficiency of protection of typical and unique ecosystems. For each ecosystem the protected areas of Rivne oblast, covering them, were defined and the conclusion about the need to expand them was made.

Table 3.4

Conservation of ecosystem diversity

Type of ecosystem	List of protected areas, which include given types of ecosystems	Conclusion

Forest Ecosystems: - "Chalk forests"	"Veliki Berestovitsy", "Galuschyna", "Lyubomlskyi", "Sasovsky" Reserves	There are few of them in the region, and they are covered almost completely
- (pine and oak-pine)	"Dvirsky", "Mankivskyi" "Rivnensky", "Kuznetsovsky" Reserves	The most important forest stands of this type are protected
- Deciduous forests of Polissya	"Galuschyna", "Kuznetsovsky", "Montenegro", "Dvirsky" Reserves	The most important forest stands of this type are protected
- Deciduous forests of forest-steppe	"Dvirsky", "Polisky", "Kuznetsovsky", "Montenegro" Reserves	These forests are often the main target of felling, so they are not sufficiently protected
- Spruce forests	"Holosiivskyi", "Galuschyna", "Sasovsky", "Mankivskyi" Reserves	Spruce forests are partially protected
- Black alder forests	"Peresopnytskyi" "Sarnensky" "Montenegro", "Lyubomlskyi" "Mankivskyi" Reserves	These communities have limited distribution and represent habitat for red book species, so they need more extensive protection
Wetland Ecosystems	"Polisky" "Rivnensky" "Sasovsky", "Montenegro",	Exposed to extremely high human

	"Peresopnytskyi", "Montenegro" Reserves	influence and need much more protection
Grassland Ecosystems (steppe and lowland herbaceous associations)	"Krasnoshorsky" "Lyubomlskyi" "Mankivskyi", "Peresopnytskyi" "Sarnensky" Reserves	These natural areas are the least affected and sufficiently protected
Meadow Ecosystems (floodplain and lowland meadows)	"Mankivskyi" "Polisky", "Dvirsky" "Krasnoshorsky" Reserves	These ecosystems are the most protected in this area
Peatland Ecosystems	"Sarnensky" "Montenegro" "Veliki Berestovitsy", "Dubrovytskyi" "Kuznetsovsky" Reserves	They are quite well protected, although their exploitation is very intensive
Sand Dunes	"Lyubomlskyi" "Mankivskyi" "Polisky" Reserves	These ecosystems are few in the territory of the Rivne oblast
Aquatic Ecosystems	"Veliki Berestovitsy", "Galuschyna" "Dvirsky" "Krasnoshorsky"	the Rivne oblast is rich in rivers, so these ecosystems are widespread, and protected area is currently sufficient

	"Lyubomlskyi" Reserves	
Riparian Ecosystems	"Dubrovytskyi" "Kuznetsovsky" Reserves	similarly to the previous point

As it is seen from the table, a large number of ecosystems are under the protection. Many reserves are combined - they contain several types of ecosystems that organically coexist with each other, thus, increasing diversity of protected communities.

Of course, not all ecosystems can be covered by reserves, but new forest massives are included in nature reserves from time to time, and this guarantees their preservation and the maintenance of their biodiversity in these locations.

The Rivne oblast has high diversity of life in Ukraine. Its forests, wetlands, and open landscapes host a remarkable range of plant and animal species. From the towering trees to the smallest invertebrates, the region's biodiversity paints a vibrant picture of interconnectedness and ecological vitality.

I would like to point out that the measures implemented to correct these problems are not enough, and the problems are rather underestimated. And high biodiversity can decrease over time, as the current trends are negative. So, it is important to draw the attention of the masses to these problems in order to correct them.

3.4. Ecosystem functional ability assessment

In this section, the ecosystems functional ability was evaluated.

The evaluation was made based on two parameters - Level of transformation and Level of anthropogenic pressure. Both parameters were rated by special scales. The rating was derived from the information, collected from open data sources.

The Level of anthropogenic pressure was evaluated by the scale from 0 to 14, depending on the number of the sources of pressure, known to have effect on the area of an

ecosystem under consideration. The complete list of typical pressures is given in subsection 2.3.

The Level of transformation was also rated based on data, available from research data on the topic. The scale applied in this case ranged from 0 to 10, which has the following meaning:

2 - not changed

4 - minimal - less than 10%

6 - moderate 10-25%

8 - considerable – 25-50%

10 - massive – over 50%

The Functional ability of ecosystems was finally derived as a product of scores by two scales – Level of transformation and Level of anthropogenic pressure (Table).

Table 3.5

Functional ability of ecosystems

Type of ecosystem	Level of transformation	Level of anthropogenic pressure	Functional ability of ecosystems
Forest Ecosystems: - "Chalk forests"	4	3	12
- (pine and oak-pine)	6	3	18
- Deciduous forests of Polissya	8	3	24
- Deciduous forests of forest-steppe	4	2	8

- Spruce forests	8	2	16
- Black alder forests	6	2	12
Wetland Ecosystems	8	4	32
Grassland Ecosystems	4	4	16
Meadow Ecosystems	6	4	24
Peatland Ecosystems	8	5	40
Sand Dunes	2	1	2
Aquatic Ecosystems	4	2	8
Riparian Ecosystems	4	2	8

Having analyzed the data presented in the table, we can draw a conclusion - most of the Rivne oblast ecosystems are subject to a rather different levels of human influence. Many ecosystems are affected by soil, air, and water pollution and are heavilily transformed, which leads to reduced functional ability. This is the case of sand dunes, aquatic and riparian ecosystems. The highest level of functional ability was still attributed to wetlands and peatlands, but their total areas is constantly shrinking. Meadows and deciduous forests of Polissya are relatively functional, while other types of forests didn't demonstrate high level of resilience. Possible ways to solve these problems are to protect these ecosystems as much as possible via limiting access physically, fences, etc. It is also necessary to invest in modernization of emission control and sewage treatment systems.

So, after conducting an ecosystem assessment, some problems of the Rivne region can be identified. First of all, I would like to point out right away that all forest ecosystems

suffer and are affected the most, because due to deforestation and illegal amber mining, they are affected the most. These problems can be remedied - with the help of general publicity and directing the influence of law enforcement agencies on the problem of illegal logging.

Marshes are also greatly affected - land reclamation, burning, reduction of the total territory of marshlands have a negative impact on the diversity of biological diversity. The key to correcting this situation is reducing the human impact on this type of ecosystem: switching to alternative types of fuel, reducing the rate of land reclamation.

Next, I would like to note that a large part of the ecosystems of the Rivne region is protected by various nature reserves. This provides an additional layer of protection for these ecosystems, as these areas are officially protected.

Aquatic ecosystems are least affected. In this area, they are exposed to the least influence, although the problem of water pollution and driving territories still exists, and it is quite large. Water purification, etc., is actively being carried out in the territory of the Rivne region. It is also important to note that a large number of these ecosystems are located on the territory of nature reserves.

Also, based on the results of the analysis, the main conclusion can be drawn: reducing the anthropogenic impact on ecosystems is the key to their prosperous existence. At least a reduction, because we are not even talking about its complete exclusion.

3.4. Prognosis and recommendation

There are several ways in which biodiversity can be supported in the Rivne region. Here are some examples:

1. Habitat restoration: One of the most effective ways to support biodiversity is by restoring degraded or damaged habitats. This can involve activities such as reforestation, wetland restoration, or creating pollinator-friendly habitats.

2. Sustainable land-use practices: Encouraging sustainable land-use practices such as agroforestry, sustainable farming, and responsible tourism can help to reduce habitat destruction and pollution, and support the conservation of natural habitats and species.

3. Protected areas: Establishing protected areas such as national parks or wildlife reserves can help to conserve biodiversity by preserving critical habitats and providing safe havens for endangered or threatened species.

4. Awareness raising and education: Increasing awareness about the importance of biodiversity and the impacts of human activities on ecosystems can help to promote a culture of conservation and encourage individuals and communities to take action to support biodiversity.

5. Monitoring and research: Regular monitoring and research can help to track changes in biodiversity over time and identify areas that require conservation interventions. This can also help to inform conservation strategies and provide insights into the effectiveness of different interventions.

These are just some examples of the ways in which biodiversity can be supported in the Rivne region. It is important to note that effective conservation efforts often require collaboration between multiple stakeholders, including government agencies, NGOs, local communities, and individuals. By working together, it is possible to support and conserve the unique biodiversity of the Rivne region for future generations.

Conclusion to Section 3

The ecosystems in the Rivne region have undergone significant transformations over the past three decades, primarily due to human activities and natural processes. Habitat loss, fragmentation, water pollution, and the disruption of ecological processes have severely impacted biodiversity, ecosystem functioning, and the provision of vital services. However, it is crucial to recognize the importance of conservation efforts, restoration initiatives, and sustainable land management practices in mitigating these adverse effects.

CONCLUSIONS

1) Ecosystem functioning refers to the processes and interactions that occur within an ecosystem, such as energy flow, nutrient cycling, and biodiversity. It is crucial for maintaining the health, productivity, and resilience of ecosystems. However, ecosystem functioning is threatened by various factors, including habitat loss, pollution, climate change, invasive species, overexploitation, and human disturbance. Protecting and restoring ecosystems, promoting sustainable practices, and raising environmental awareness are essential for safeguarding ecosystem functioning and the valuable services they provide to both nature and humanity.

2) The overview of the Rivne oblast ecosystems, their problems and perspectives was conducted. The main ecosystems of the Rivne oblast were shown to have diverse levels of degradation due to anthropogenic pressure. A special attention is devoted to climatic changes, because their impact on the region as a whole is very large.

3) The condition of the Rivne oblast biota was considered in terms of diversity and its dynamics. The trends of protection efforts and their visible results were studied, as well as the sufficiency of ecosystem diversity protection with the already established protected areas.

4) The analytical work was carried out regarding the assessment of the functional capacity of the oblast ecosystems. This was done based on the level of ecosystems transformation and level of anthropogenic pressure, typical for them. Despite the considerable decline in the area wetland and peatland ecosystems, while sand dunes and most of forests experience reduced functional ability. The main problems regarding the functionality were defined, as well as the factors of influence and possible approaches to the improvement of the situation.

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