CHAPTER 3

ENVIRONMENTAL PRINCIPLES IN THE DEVELOPMENT OF SCIENTIFIC STRATEGIES FOR THE CONSERVATION AND RESTORATION OF NATURAL ECOSYSTEMS UNDER ANTHROPOGENIC PRESSURE

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INTRODUCTION

In the 21st century, the problem of preserving and restoring natural ecosystems has become a global and key challenge for sustainable human development. The rapid growth of anthropogenic pressure caused by urbanization, industrialization, the transformation of agricultural landscapes, excessive exploitation of natural resources, and climate change has led to a significant disruption of the natural self-regulating mechanisms of ecosystems. This leads to land degradation, reduced biodiversity, disruption of the hydrological regime in these areas, and a decrease in the ability of ecosystems to provide vital ecosystem services.

The issue of environmental principles underlying the development of scientific strategies for the conservation and restoration of natural ecosystems is particularly relevant in the context of increasing anthropogenic pressure, when traditional approaches to nature conservation prove insufficiently effective. Modern environmental science is shifting its focus towards integrated, interdisciplinary solutions combining ecosystem-based approaches, adaptive management principles, and innovative environmental monitoring methods. The development of such strategies requires a deep scientific understanding of the patterns governing the functioning of natural systems, the limits of their stability, and their capacity for recovery.

The development of scientific strategies for ecosystem conservation is based on an environmental approach that involves a comprehensive analysis of the interaction between biotic and abiotic components of the environment, as well as an assessment of the anthropogenic impact on the structural and functional organization of ecosystems. The preservation of natural systems is impossible without considering the spatial integrity of landscapes,

preserving ecological corridors, maintaining natural succession processes, and protecting key biotopes. Simultaneously, the role of scientifically substantiated forecasting of environmental changes is growing, enabling the prevention of critical ecosystem disturbances and the minimization of negative consequences from economic activity.

Restoring degraded natural ecosystems is a complex and multifaceted process requiring a combined approach of passive and active environmental restoration methods. Passive approaches are based on reducing or eliminating anthropogenic pressure and creating conditions for the natural restoration of ecosystem functions. Active methods involve targeted measures to recultivate disturbed land, restore water bodies, regenerate vegetation cover, and reintroduce native species. Selecting the optimal restoration strategy should be based on the ecological characteristics of a specific ecosystem, the degree of its degradation, and the socio-economic conditions prevailing in the region[1].

In the context of global and regional environmental challenges, especially for countries with transitional economies, it is critically important to integrate ecological principles into strategic planning and natural resource management systems. Scientific strategies for the conservation and restoration of ecosystems must be consistent with the goals of sustainable development, environmental safety, and improving the living standards for the population. In this context, the formation of ecological culture, the development of environmental education and the involvement of the public in environmental decision-making processes play an important role.

Therefore, the study of the ecological principles forming scientific strategies for the conservation and restoration of natural ecosystems under anthropogenic pressure is scientifically and practically significant. It is aimed at substantiating effective approaches to preserving natural potential, increasing the sustainability of ecosystems and ensuring the balanced development of society. The results of such studies can be used in the development of national and regional environmental programs, natural resource management strategies, and practical measures for environmental restoration[2].

1. Ecological prerequisites for the formation of scientific strategies for the conservation of natural ecosystems

The formation of scientific strategies for the preservation of natural ecosystems is based on a deep understanding of the ecological patterns in

[1] Bochevska M. E. Restoration of degraded ecosystems in the context of post-war transformation of nature management. *Academic visions*. 2025. Issue 43. DOI: https://doi.org/10.5281/zenodo.15585538

[2] Argenti P. Reputation and corporate brand. *Review of corporate reputation.* 2004. No. 6. P. 371.

the functioning of the natural environment and its ability to self-regulate. Melnykovych M., Nijnik M., Zibtsov S. et al. conducted a comprehensive analysis of the impact of hostilities on the socio-ecological systems of Ukraine's forest ecosystems and outlined possible directions for their further restoration in their studies[3]. Researchers emphasize the advisability of introducing nature-oriented solutions into the process of forming policies for the restoration of forest ecosystems. At the same time, Mirzabaev A. and Wuepper D. focused on the economic dimensions of the restoration of degraded ecosystems, emphasizing that investing in environmental restoration can provide tangible economic benefits, in particular by creating new jobs and improving the well-being of local communities[4].

Natural ecosystems are complex dynamic systems whose stability is determined by the level of biodiversity, trophic structure, and the intensity of energy and matter exchange between their components. The increase in anthropogenic load disrupts these connections, which leads to a decrease in environmental resilience and an increase in the risk of degradation processes.

Scientific approaches to ecosystem conservation involve the application of ecosystem and landscape approaches, allowing the assessment of anthropogenic factors in a spatial-temporal dimension. Defining ecologically acceptable limits for the economic use of natural resources and establishing critical thresholds for anthropogenic pressure are important elements. In this context, the role of environmental monitoring, bioindication, and forecasting of changes in the condition of ecosystems is growing, providing a scientific basis for management decisions in the sphere of environmental protection. Scientists note that the limited maturity of the sustainable investment market, the insufficient level of institutional support for environmentally oriented business models and limited tax incentives prevent the scaling of environmentally oriented solutions that could serve as synergies between economic development and environmental protection[5].

In such conditions, local communities are often forced to rely on their own resources and initiatives, which limits the scale and speed of implementation of environmentally friendly technologies and renewable energy projects. At the same time, the lack of proper financing of instruments, grant programs and

[3] Melnykovych M., Nijnik M., Zibtsev S., et al. Pathways for Ukraine's Post-War Recovery: Forest Socio-Ecological System in the Focus. *Preprints.org.* 2025. DOI: https://doi.org/10.20944/preprints202502.1736.v1

[4] Mirzabaev A., Wuepper D. Economics of Ecosystem Restoration. *Annual Review of Resource Economics*. 2023. Vol. 15. P. 329–350. DOI: https://doi.org/10.1146/annurevresource-101422-085414

[5] Bochevska M. E. Restoration of degraded ecosystems in the context of post-war transformation of nature management. *Academic visions.* 2025. Issue 43. DOI: https://doi.org/10.5281/zenodo.15585538

state support mechanisms hinders the development of the "green" economy, reduces the attractiveness of environmental investments for business and makes it impossible to comprehensively restore degraded ecosystems. This is especially relevant for the post-war reconstruction of Ukraine, where the scale of destruction and land degradation requires significant resources, systematic planning and integration of nature-oriented solutions. At the same time, initiatives aimed at supporting environmentally sustainable community development are already in place at the national level, in particular, the state programs "Energy Modernization in the Community"[6] and "Clean Air for Ukraine[7]," which provide grants and loans for building insulation, installation of energy-efficient technologies, and modernization of heat generation capacities in accordance with environmental standards.

Institutional support is also intensified through the implementation of the provisions of the National Recovery Plan of Ukraine and relevant local development programs, where the environmental component is included as a priority. For example, under the Green Reconstruction program,[8] community and municipal initiatives receive funding for the reclamation of degraded land, the cleanup of water bodies, and the restoration of green areas, which is implemented in cooperation with international partners: UNDP, UNEP, the European Investment Bank, and EU funds. Similar initiatives have already supported energy efficiency and environmental improvement projects in communities of Lviv, Kyiv and Kharkiv regions, demonstrating the potential of combining state, local and international support for large-scale implementation of environmental innovations. In the long term, such approaches could form the basis for a national model of post-war recovery, combining the environmental, economic, and social aspects of sustainable development in local communities.

2. Scientific approaches to ecosystem restoration under anthropogenic pressure

Restoring natural ecosystems that have been damaged by long-term human activity is one of the key areas of focus in modern environmental science. Scientific strategies for restoration are based on a combination of

[6] State program "Energy modernization in the community". URL: https://www.kmu.gov.ua/news/zatverdzheno-derzhavnu-tsilovu-prohramu-enerhetychnoi-modernizatsii-pidpryiemstv-teplopostachannia-do-2030-roku

[7] State program "Clean Air for Ukraine". URL: https://liubym.otg.dp.gov.ua/novini-ta-podiyi/novini/prohrama-chyste-povitria-dlia-ukrainy

[8] Post-war green reconstruction of Ukraine: processes, stakeholders, public participation analytical report January – February 2024. URL: https://racse-report_2024-5-13-1_ukr.pdf

passive and active methods of environmental restoration, which are selected depending on the type of ecosystem, the degree of its degradation, and the environmental conditions in the region. Passive restoration involves reducing the intensity of anthropogenic pressure and creating favorable conditions for natural succession, while active measures include targeted intervention to restore key ecosystem functions.

The position of the OECD in terms of overcoming institutional and economic barriers in Ukraine's environmental recovery policy is to increase institutional capacity and implement the principles of good governance, in particular through improving the judicial system and strengthening anti-corruption mechanisms, as well as adapting the environmental taxation system to the standards and requirements of the European Union[9].

The principle of prioritizing the restoration of natural processes over man-made solutions is particularly important in the formation of scientific restoration strategies. UNIDO emphasizes the need to formulate and implement a green industrial reconstruction program for 2024–2028, aimed at stimulating the introduction of environmentally friendly technologies and compliance with modern environmental standards[10].

A systematic analysis of current scientific sources[11] has shown that among the existing approaches to ecosystem restoration, the leading ones are socio-ecological, economic, legal, and nature-oriented approaches. At the same time, the methodologies of international organizations such as OECD, UNEP, UNDP, UNIDO and the World Bank are highly structured and scientifically sound, which makes them suitable for the application in the Ukrainian context.

Restoration of hydrological regimes, soil cover, plant communities and food chains contributes to increasing the environmental sustainability of ecosystems and reducing the need for further intervention. At the same time, the application of modern scientific methods, namely ecological modeling, geographic information systems, and ecosystem services assessment, can improve the effectiveness of restoration measures and ensure their long-term effectiveness.

[9] OECD. *Ukraine – OECD*. URL: https://www.oecd.org/en/countries/ukraine.html

[10] United Nations Industrial Development Organization. Green Recovery Vision for Ukraine. URL: https://www.unido.org/green-recovery-vision-ukraine

[11] UNECE, UNEP, OECD. Platform for Action on the Green Recovery of Ukraine URL: https://ukraine.un.org/en/271424-unece-unep-and-oecd-launch-platform-action-green-recoveryukraine

3. Features of developing scientific strategies for the conservation and restoration of ecosystems in Ukraine

For Ukraine, the issue of preserving and restoring natural ecosystems is particularly important because of the combination of traditional anthropogenic factors and the consequences of military action and technogenic pressure. Significant plundering of the territory, intensive use of land and water resources, urbanization and industrial pollution for a long time formed a high level of environmental vulnerability of natural systems. The hostilities additionally caused the destruction of landscapes, pollution of soils and waters, degradation of forest and steppe ecosystems, which significantly complicates the processes of their natural restoration. Today, the ecological state of land in Ukraine is extremely critical as a result of the military aggression of the Russian Federation. A significant portion of the land has suffered degradation, mechanical damage, and pollution, leading to widespread erosion. Hostilities cause the accumulation of toxic chemicals and heavy metals in the soil, while explosions from mines, rockets, and bombs create craters, disrupting the landscape and soil structure. In addition, there is a total violation of the basic land law principles that guarantee rational use and protection of land, as well as disregard for the priority of environmental safety requirements at the national level. Such a complex of negative impacts creates serious obstacles to the restoration of land resources and requires the development of evidence-based strategies for their rehabilitation and protection.

It should be noted that the problems of soil fertility preservation in Ukraine took place before the war. Thus, almost 26 % (about 16 million hectares) of soil cover was already eroded, and more than 15 % of this land needed to be withdrawn from cultivation and conservation activities[12].

Restoration of degraded lands in Ukraine under conditions of constant anthropogenic and military influence requires an integrated scientific approach. Priority strategies include reclamation of damaged areas, stabilization of erosion processes, cleaning of soils from toxic substances and heavy metals, as well as restoration of the landscape structure of the territories. An effective approach is to combine passive methods, which involve limiting anthropogenic impact and supporting natural succession, with active measures such as planting adapted plant communities, restoring water regimes, and creating ecological corridors. The integration of these measures into state programs for post-war reconstruction and land resource management, taking

[12] Novakovska I. O., Skrypnyk L. R., Slavin I. V. Economic incentives for the implementation of measures for the land use and protection. *Problems of the systemic approach in the economy*. No. 2 (82). 2021. P. 150–161.

into account the priority of environmental safety, plays an important role. The application of scientifically sound restoration strategies not only stabilizes the condition of land resources but also creates conditions for the further sustainable development of Ukraine's agricultural and environmental sectors, ensuring the restoration of ecological balance in the affected areas.

Scientific strategies for the conservation and restoration of ecosystems in Ukraine should take into account the regional specifics of natural and climatic conditions, the level of anthropogenic load and socio-economic challenges. In particular, in the east and south of Ukraine, where a significant part of the territories has been destroyed as a result of hostilities, the priority is the restoration of degraded lands, the purification of water bodies and the reclamation of industrial zones. In the western and central regions, the conservation of forests, the development of green corridors and the integration of environmental elements into urban planning and agricultural plans are important. Scientific strategies should provide a comprehensive approach integrating scientifically sound methods for monitoring and assessing the health of ecosystems, effective management decisions for local communities, financial and institutional mechanisms to support restoration, and the integration of international standards and programs such as the UN Decade on Ecosystem Restoration and the European Green Deal. This approach allows not only to restore ecosystems, but also to increase the resilience of communities to climate and anthropogenic risks, forming the prerequisites for the sustainable development of Ukraine.

Priority areas are the restoration of degraded lands, rehabilitation of water bodies, conservation of biodiversity and the formation of a national ecological network, which involves the restoration of natural landscapes, ensuring the spatial integrity of ecosystems and maintaining ecological corridors. The implementation of these areas should be based on the application of the ecosystem approach, the integration of nature-oriented solutions and the introduction of modern environmental monitoring tools. Coordinating environmental protection measures with regional socio-economic development and post-crisis recovery programs is an important aspect.

One of the prerequisites for land reclamation and conservation in Ukraine in the post-war period is the development and legislative approval of a national program for land protection and restoration. This program should include a detailed plan for land restoration involving international organizations, investors, and foreign scientists in the field of soil protection and restoration, as well as the use of innovative technologies and approaches. In addition, the document needs to identify the sources of funding and procedures for land

management, since these issues remain insufficiently regulated at the current legislative level[13]. The nationwide program for the protection and restoration of Ukraine's land in the post-war period will serve as a strategic guideline for the state, defining priority measures for land restoration, in particular conservation and recultivation. The[14] program will provide for comprehensive planning of restoration work, taking into account soil types, the degree of their degradation, and local natural conditions, as well as the integration of modern scientific methods for monitoring and assessing the condition of land. Particular attention will be paid to coordination between national and local authorities, involving local communities in planning and implementation, and drawing on international experience and financial support, including grants and technical assistance from UNDP, UNEP, and the European Investment Bank. Such integrated management will not only restore soil fertility and stabilize ecosystems, but also ensure sustainable development of territories, increase environmental safety and integrate environmental principles into local development strategies.

Table 1

The main directions and measures of the National Program for the Protection and Restoration of Lands of Ukraine (post-war period)

Direction of the program	Specific activities	Executors / Responsible persons	Financing sources	Expected effect
1	2	3	4	5
Land conservation	Temporary withdrawal of degraded areas from cultivation, erosion prevention measures, and protection against pollution	Ministry of Agrarian Policy and Food, territorial communities	State budget, local budgets, international grants	Preservation of soil fertility, reduction of land degradation
Land Remediation	Restoration of industrial, military and contaminated areas, restoration of soil structure, landscape rehabilitation	Local authorities, private contractors, academic institutions	State subventions, international programs (UNDP, UNEP, EIB)	Restoring ecosystems, improving environmental safety, increasing land productivity

[13] Agriculture of Ukraine under martial law: lessons for society and politicians. URL: https://www.nas.gov.ua/UA/Messages/Pages/View.aspx?MessageID=9288

[14] National Academy of Agrarian Sciences of Ukraine. Scientific, methodological, and coordination center for scientific issues related to the development of Ukraine's agro-industrial complex. URL: http://naas.gov.ua/content/ publichna-informaciya/ogoloshennya/7393/

Continuation of Table 2

1	2	3	4	5
Monitoring and assessment of land condition	Regular assessment of soil degradation, pollution monitoring, and geoinformation database management	Ukraine State Service of Geodesy, Cartography and Cadastre, scientific institutes	State budget, grant funding	Scientifically based planning of activities, control over the program implementation
Institutional support and management	Coordination between national and local authorities, integration of environmental principles into local strategies	Cabinet of Ministers, Ministry of Economy, Environment and Agriculture of Ukraine, territorial communities	State budget and international technical assistance	Improving management efficiency, shaping environmental culture and community responsibility
Supporting the green economy	Stimulation of environmentally safe land use, introduction of energy-efficient and nature-oriented technologies	Local authorities, business, international partners	Government grants, loans from international financial organizations	Sustainable development of territories, synergy of economic growth and environmental protection

This approach will contribute to increasing the resilience of natural systems, reducing environmental risks and ensuring long-term environmental safety. The integration of scientific environmental approaches into state environmental policy, spatial planning systems, and post-war land restoration programs plays an important role in this process, ensuring the coordination of environmental, economic, and social measures. Such integration contributes to improving the effectiveness of restoration measures, strengthening the environmental sustainability of regions and creates prerequisites for sustainable development and long-term conservation of natural ecosystems.

Thus, the implementation of scientifically sound environmental strategies in Ukraine is a prerequisite for ensuring environmental safety and sustainable development of the state. The combination of fundamental environmental knowledge, innovative technologies and effective management of natural resources creates the prerequisites for preserving the country's natural potential and increasing the sustainability of its ecosystems in the long term.

CONCLUSIONS

The study found that the increase in anthropogenic pressure is a determining factor in the degradation of natural ecosystems, which manifests itself in a violation of their structural integrity, a decrease in biodiversity and a weakening of the ability to self-regulation. Under such conditions, the conservation and restoration of ecosystems requires a shift from fragmented conservation measures to comprehensive, scientifically sound strategies based on ecosystem and interdisciplinary approaches.

It has been proven that the environmental principles underlying scientific strategies for the conservation of natural ecosystems must be based on consideration of the interaction between biotic and abiotic components of the environment, determination of the limits of acceptable anthropogenic pressure, and assessment of the ecological stability of natural systems. Environmental monitoring, bioindication, and forecasting tools play an important role in this process, ensuring the timely detection of negative changes and providing scientific justification for management decisions.

It has been established that effective restoration of degraded ecosystems is possible provided that passive and active methods of environmental restoration are combined, with priority given to the restoration of natural processes. Specific restoration measures should be selected, taking into account the type of ecosystems, the degree of their disturbance, and regional natural and climatic characteristics. This approach contributes to increasing the resilience of ecosystems and reducing the risks of repeated degradation.

The study pays particular attention to the specifics of developing scientific strategies for the conservation and restoration of natural ecosystems in Ukraine, where traditional anthropogenic factors are exacerbated by the consequences of hostilities. The necessity of integrating environmental strategies into the system of state policy, spatial planning, and post-war reconstruction programs is justified in order to ensure environmental safety and sustainable development of territories.

Consequently, the implementation of scientifically sound strategies for the conservation and restoration of natural ecosystems is a key prerequisite for preserving natural potential, improving the quality of life of the population, and achieving sustainable development goals. Further scientific research should be aimed at improving methods for assessing ecosystem services, developing nature-based solutions, and strengthening institutional mechanisms for environmental management in the context of growing anthropogenic pressure.

SUMMARY

The paper examines the environmental principles underlying the development of scientific strategies for the conservation and restoration of natural ecosystems in the context of increasing anthropogenic pressure. The main factors of ecosystem degradation and their impact on the structural and functional organization of the natural environment are analyzed. The importance of the ecosystem approach as a methodological basis for the development of effective environmental strategies is substantiated. Scientific approaches to assessing the environmental sustainability and resilience of ecosystems are considered. The role of environmental monitoring, bioindication and forecasting in the management decision-making process is determined. Passive and active methods of restoring degraded ecosystems are characterized. Particular attention is paid to the integration of nature-oriented solutions in the strategy of environmental restoration. The specifics of forming scientific strategies for preserving ecosystems in the context of wartime and post-war challenges are analyzed. The importance of combining environmental, economic and social aspects in the process of restoring natural systems is emphasized. It is concluded that it is necessary to implement comprehensive science-based strategies to ensure environmental safety and sustainable development.

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