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## Consequences of the russian federation's Armed Aggression for Ukraine's Environmental Sphere

Kyryll Nesterenko  <sup>1</sup> \*

<sup>1</sup> Leonid Yuzkov Khmelnytskyi University of Management and Law (Ukraine). Postgraduate Student.

\* **Corresponding Author**, e-mail: [nesterenko-k@rada.gov.ua](mailto:nesterenko-k@rada.gov.ua)

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### ABSTRACT

The full-scale armed aggression by the russian federation against Ukraine has had a massive negative impact on the environment. Ukraine is home to a large number of industrial enterprises, critical infrastructure facilities, protected natural areas, and fertile lands. This significantly exacerbates the scale of environmental damage. At the same time, the vast extent of territories that are temporarily occupied or contaminated with mines makes it extremely difficult to conduct a comprehensive assessment of the environmental damage. The article presents a comprehensive study of the current state of Ukraine's environmental sector amidst ongoing armed aggression. Data regarding the war's adverse impact on land resources, atmospheric air, surface and groundwater, forests, the nature reserve fund, and biodiversity have been systematized. Official figures concerning environmental damage have been summarized. Attention is paid to the environmental consequences of the Kakhovka HPP destruction, widespread landmine contamination, the degradation of nature reserve areas, and the accumulation of military waste. The capabilities of modern international environmental monitoring mechanisms utilizing remote sensing and satellite technologies are examined. A classification of the war's environmental impacts is presented. It has been established that the armed aggression of the russian federation against Ukraine has created a system of long-term environmental risks, the consequences of which will persist for decades after the cessation of hostilities. It has been determined that areas within the nature reserve fund, land resources, and forests have suffered the greatest losses. It is currently impossible to fully assess the extent of the negative impact on occupied territories and marine ecosystems. The need to integrate state environmental monitoring with international information systems, improve methods for assessing environmental damage in accordance with European standards, and establish a state strategy for post-war environmental recovery is substantiated.



### KEYWORDS

armed aggression; environmental security; environmental damage; nature reserve fund; biodiversity; environmental restoration; environmental monitoring.



## Наслідки збройної агресії російської федерації для екологічної сфери України

Кирилл О. Нестеренко <sup>1</sup>\*

<sup>1</sup> Хмельницький університет управління та права імені Леоніда Юзькова (Україна). Аспірант.

\* Автор-кореспондент, e-mail: [nesterenko-k@rada.gov.ua](mailto:nesterenko-k@rada.gov.ua)

### СТАТТЯ

### АНОТАЦІЯ

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Повномасштабна збройна агресія російської федерації проти України спричинила масштабний негативний вплив на навколишнє середовище. Україна – держава, на території якої знаходиться велика кількість промислових підприємств, об'єктів критичної інфраструктури, природоохоронних територій, родючих земель. Це суттєво посилює масштаби екологічних втрат. Разом з тим, значна площа тимчасово окупованих або замінованих територій значно ускладнює здійснення комплексного оцінювання екологічних збитків. У статті здійснено комплексне дослідження сучасного стану екологічної сфери України в умовах триваючої збройної агресії. Систематизовано дані щодо негативного впливу війни на земельні ресурси, атмосферне повітря, поверхневі та підземні води, ліси, природно-заповідний фонд та біорізноманіття. Здійснено узагальнення офіційних показників екологічних збитків. Приділено увагу екологічним наслідкам руйнування Каховської ГЕС, масштабному мінному забрудненню територій, деградації природно-заповідного фонду, накопиченню військових відходів. Досліджено можливості сучасних міжнародних механізмів екологічного моніторингу з використанням дистанційного зондування та супутникових технологій. Проведено класифікацію екологічних наслідків війни для екологічної сфери. Встановлено, що збройною агресією російської федерації в Україні сформовано систему довготривалих екологічних ризиків, наслідки яких будуть проявлятися протягом десятків років після завершення бойових дій. З'ясовано, що найбільших втрат зазнали території природно-заповідного фонду, земельні ресурси та ліси. Розміри негативного впливу на окуповані території та морські екосистеми остаточно оцінити наразі неможливо. Аргументовано необхідність інтеграції державного екологічного моніторингу та міжнародних інформаційних систем, покращення методів оцінки екологічних збитків згідно з європейськими стандартами та становлення державної стратегії післявоєнного відновлення навколишнього середовища.



### КЛЮЧОВІ СЛОВА

збройна агресія; екологічна безпека; екологічні збитки; природно-заповідний фонд; біорізноманіття; відновлення довкілля; екологічний моніторинг.

## 1. Introduction

Traditionally, armed conflicts have the most devastating anthropogenic impact on the environment. The full-scale armed invasion of the Russian Federation into Ukraine on February 24, 2022, which is currently underway, covered densely populated areas with a high concentration of industrial enterprises, transport hubs, mineral deposits, critical infrastructure facilities, hydraulic structures, forest plantations and protected areas. The use of missile weapons and unmanned aerial vehicles expands the boundaries of damage far into the country. Because of this, the consequences of the war for the environmental sphere have become systemic and go far beyond local pollution.

A particular difficulty is the long-term nature and irreversibility of a significant part of the negative consequences of hostilities for the environment. At the same time, the restoration of natural processes in many cases will require a long time, significant financial resources and modern environmental technologies. An additional problem is the difficulty of quantifying environmental damage due to the temporary occupation of territories or active hostilities on them, which significantly limits the possibilities of instrumental monitoring.

## 2. Literature Review

The first scientific works on the environmental consequences of the war in Ukraine appeared after the outbreak of hostilities in the east of the country (2014). The works of G. Rudko, S. Plakhotnyi [18], I. Lychenko [16] considered environmental risks associated with hostilities in the Donbas, pollution of surface and underground waters, flooding of mines, destruction of industrial infrastructure, etc. A thorough study on the impact of hostilities on the environment was conducted by scientists with the support of the International Charitable Organization "Environment-People-Law". It became the basis for the manual "Hostilities in the East of Ukraine – Civilizational Challenges to Humanity" [12], which made the first attempts to determine the basis for assessing the damage caused to the environment as a result of hostilities. Comprehensive scientific work was also carried out by domestic researchers within the framework of the projects of the Ukrainian Helsinki Human Rights Union "Human Rights First" and the United States Agency for International Development (USAID) "Human Rights in Action", which prepared the publication "On the brink of survival: environmental destruction during the armed conflict in eastern Ukraine" [2].

In the context of the full-scale invasion (2022), the subject of research has changed significantly, as the negative impact has spread almost throughout the entire territory of the state. In the works of N. Hrynshyn [13], V. Michud [17], G. Chvalyuk [5], O. Bondar [3], the issues of calculating environmental damage, determining the amount of environmental damage and assessing the results of the impact of military operations on the environment are raised. The comprehensive work of non-governmental organizations to study the impact of the war on the environmental sphere continues, the achievements of which are the publications: "Ukraine, Environmental Damage, Environmental Consequences of the War" [1], "Waste Management from the Destruction of the War in Ukraine. Current practices and necessary changes" [19], "Environmental consequences of the war against Ukraine. Preliminary Annual Assessment" [6], "Climate Impact of the Russian War in Ukraine: February 24, 2022 – February 23, 2025. Full assessment" [11], etc. Quantitative indicators of environmental damage as a result of armed aggression are published by the State Environmental Inspectorate of Ukraine in public reports [7–10].

Despite the presence of a significant number of scientific studies confirming the negative impact of armed aggression on all components of the environment, there are a number of scientific gaps. Most of the works concern certain aspects of environmental damage: climate change, atmospheric pollution, destruction of hydraulic structures, etc. The relationships between certain types of environmental consequences and long-term environmental risks have not been sufficiently studied. Therefore, a comprehensive study is needed that would combine official data on environmental damage as a result of armed aggression and modern scientific approaches.

## 3. Problem Statement

The analysis of scientific literature has shown the existence of a number of problems in the study of the consequences of armed aggression for the environmental sphere. Most of the existing methods

for assessing environmental damage are focused mainly on determining their economic size or documenting individual facts of environmental damage. At the same time, the issues of disturbance of ecological balance and long-term changes in natural ecosystems remain insufficiently studied. In addition, the existing approaches do not sufficiently take into account the mutual influence of individual components of the environment, in which air pollution, changes in the hydrological regime, land degradation and reduction of biodiversity are a single system of interrelated ecological processes.

The problem of assessing environmental damage in the temporarily occupied territories and territories of active hostilities is also especially relevant. The impossibility or danger of free access to such places makes innovative methods of environmental monitoring relevant: remote sensing of the Earth, digital mapping, satellite monitoring, etc. Despite this, the issue of full integration of such technologies into the state environmental monitoring system of Ukraine has not yet been resolved.

The article is aimed at a comprehensive analysis of the consequences of the armed aggression of the Russian Federation for the environmental sphere of Ukraine based on the study of official statistical data and modern scientific research, identification of key patterns of environmental change.

#### **4. Methods and Materials**

The study is based on a comprehensive interdisciplinary approach that combines methods of ecology, environmental economics, geoinformation analysis, public administration and statistics. The choice of this approach is due to the multi-element nature of the environmental consequences of armed aggression, as well as the use of institutional mechanisms of public administration in the field of environmental protection to overcome such consequences.

During the analysis, the materials of state environmental monitoring, official data on the assessment of environmental damages, and thematic reports of public environmental organizations were used. In addition, scientific publications of domestic researchers devoted to the analysis of the environmental consequences of the war, methods of documenting environmental damage, and mechanisms of post-war environmental restoration have been processed.

The methodological basis of the study was a systematic approach, according to which the ecological sphere is studied as a complex system of interrelated natural, man-made and socio-economic elements. Due to this, not only individual types of environmental damage have been analyzed, but also the cause-and-effect relationships between them, the mechanisms of occurrence of complex environmental risks have been identified, and the probable strategic consequences for the functioning of natural ecosystems have been assessed.

In the process of analysis, a complex of general scientific and special methods was used. System analysis is used in the study of the relationships between individual components of the environment and the formation of the structure of the environmental consequences of the war. The comparative legal method is used to characterize the regulatory and legal support for determining environmental damage and documenting the environmental consequences of the war. The statistical method is used to generalize the official indicators of environmental damage. The generalization method is used to systematize the results obtained. When analyzing the spatial spread of the environmental consequences of the war, a geoinformational approach was used, which made it possible to assess the territorial features of the damage to natural ecosystems and identify the most affected regions of Ukraine.

It should be noted that the results of the study are characterized by certain limitations. A significant amount of environmental information is formed in the context of ongoing hostilities and occupation, which is why certain quantitative indicators may be clarified in the future.

#### **5. Results and Discussion**

After the full-scale invasion of the Russian Federation on the territory of Ukraine (2022), the issue of forming an up-to-date regulatory framework for documenting and assessing the damage caused to the environmental sphere became acute. First, the Procedure for Determining Damage and Losses Caused to Ukraine as a Result of the Armed Aggression of the Russian Federation [14] was approved, which systematized approaches to assessing damage by individual components of the environment: soils and land resources, atmospheric air, water resources, marine ecosystems, forest resources, objects and territories of the nature reserve fund. Subsequently, special methods were developed for the main components of the environment, with the help of which it became possible to quantify the damage

caused by armed aggression to form a single analytical database. These methods were approved by the orders of the relevant ministry (at that time – the Ministry of Environment) [13, p. 96]. The functions of documenting and recording the facts of environmental damage were assigned to the State Environmental Inspectorate of Ukraine, which is currently collecting data, verifying them and calculating losses.

From the beginning of the full-scale invasion until January 2026, UAH 6159.6 billion of damage was caused to the Ukrainian ecological system. The structure of environmental damage to Ukraine as a result of armed aggression by environmental components as of January 2026 is shown in Table 1.

**Table 1. Damage to the environment of Ukraine as a result of the armed aggression of the russian federation (as of 02.01.2026)**

| Components of the environmental sphere that have been affected | Type of impact on the components of the environmental sphere | Damages in kind             | Losses in monetary terms, UAH billion |
|----------------------------------------------------------------|--------------------------------------------------------------|-----------------------------|---------------------------------------|
| Atmosphere                                                     | Combustion of petroleum products                             | 4.1 million tons            | 177.5                                 |
|                                                                | Forest fires                                                 | 146.2 thousand hectares     | 799.6                                 |
|                                                                | Other fires                                                  | 3.4 million m <sup>2</sup>  | 6.3                                   |
| Water                                                          | Pollution of water bodies                                    | 36.2 thousand tons          | 75.8                                  |
|                                                                | Clogging of water bodies                                     | 42.4 million kg             | 9.8                                   |
|                                                                | Unauthorized use of water resources                          | 21.1 billion m <sup>3</sup> | 35.0                                  |
| Land                                                           | Land littering                                               | 24.8 million m <sup>2</sup> | 1280.0                                |
|                                                                | Soil pollution                                               | 1.3 million m <sup>2</sup>  | 22.2                                  |
| Nature Reserve Fund                                            | Damage to plant life                                         | 28.5 thousand hectares      | 2713.2                                |
|                                                                | Number of trees and plants destroyed and damaged             | 82.6 million                | 1040.0                                |
|                                                                | Destruction of the animal world                              | 75.2 thousand rubles IVF    | 0.16                                  |
| <b>Total</b>                                                   |                                                              |                             | 6159.6                                |

Source: Calculated by the author based on sources [7–10].

According to the data in Table 1, damage to atmospheric air is caused by the combustion of oil products (4.1 million tons), forest fires (146.2 thousand hectares) and other fires (3.4 million m<sup>3</sup>). The key reason for these losses was missile attacks and strikes by unmanned aerial vehicles on fuel and energy infrastructure facilities (fuel depots, oil depots, energy sector enterprises, etc.). Such combustion of petroleum products releases large volumes of toxic substances (nitrogen oxides, sulfur dioxide, carbon monoxide, carcinogenic compounds) into the atmosphere, which brought UAH 177.5 billion in environmental damage during the period of the full-scale invasion.

The most significant damage to the atmosphere was caused by forest fires, the economic assessment of damage from which is UAH 799.6 billion. The scale of such fires is caused by a combination of several factors: artillery shelling, falling fragments of missiles and drones, ammunition explosions, and limited opportunities for rapid fire extinguishing in mined areas. In this regard, not only forest ecosystems are destroyed (which also reduces the area of carbon dioxide absorption by forests), but also the volume of greenhouse gas and aerosol particle emissions is significantly increased. Forest fires also seriously harm forest fauna. Due to loud explosions, animals often leave their offspring. And fires due to artillery shelling led to the death of tens of thousands of vertebrates, countless invertebrates and representatives of the flora. The consequences of air pollution during hostilities are different and depend on the sources of such pollution, the main of which are given in Table 2.

The analysis of the data given in Table 2 showed that air pollution as a result of the war is uncontrolled, random, spatially mobile and of various types. Due to this, it is significantly difficult to predict the amount of environmental damage, assess health risks and determine priority response measures. Most of these sources form not only primary air pollution, but provoke secondary pollution of other environmental components.

Water resources also suffered significant losses. Pollution of water bodies is 36.2 thousand tons, which is estimated at UAH 75.8 billion (Table 1). The main sources of pollution were leaks of petroleum products, chemicals, fuels and lubricants, as well as the destruction of industrial enterprises and warehouses.

**Table 2. Pollution of the atmospheric air of Ukraine as a result of the armed aggression of the Russian Federation**

| Source of pollution                             | Main pollutants                                                                           | Impact on atmospheric air                                                                     | Secondary environmental consequences                                               |
|-------------------------------------------------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| <b>Missile strikes on industrial facilities</b> | Sulfur oxides, heavy metals, volatile organic compounds, polycyclic aromatic hydrocarbons | Large-scale air pollution by combustion products                                              | Pollution of water bodies and soils, transboundary transfer                        |
| <b>Detonation of artillery ammunition</b>       | Nitrogen oxides, carbon monoxide, particulate matter, metal aerosols                      | Local sharp increase in the concentration of toxic substances, the formation of dust aerosols | Sedimentation of heavy metals in soils, accumulation of toxic substances in plants |
| <b>Forest fires</b>                             | Carbon dioxide and carbon monoxide, nitrogen oxides, fine dust                            | Deterioration of air quality in large areas                                                   | Reducing carbon sequestration by forests, biodiversity degradation                 |
| <b>Fires at oil depots</b>                      | Soot, dioxins, furans, carbon dioxide and carbon monoxide                                 | Formation of dense toxic smoke clouds                                                         | Precipitation of carcinogenic substances on the surface of soils and water bodies  |
| <b>Destruction of residential buildings</b>     | Construction and cement dust, asbestos fibers, microplastics                              | Increase in the concentration of suspended particles                                          | Secondary dust pollution during rubble dismantling                                 |

Source: Systematized by the author on the basis of sources [1; 2; 6; 11].

There is also a litter of water bodies with fragments of building structures, metal structures, remnants of equipment and ammunition in the amount of 42.4 million kg, which caused losses of UAH 9.8 billion. We should also not forget about the unauthorized use of water resources in the amount of 21.1 billion m<sup>3</sup> (UAH 35 billion), which arose due to the violation of water use systems in the temporarily occupied territories, the destruction of hydraulic infrastructure and uncontrolled water intake. The main consequences of hostilities for water resources are shown in Table 3.

**Table 3. The impact of hostilities on Ukraine's water resources**

| Type of impact                                                         | Current consequences                                                | Long-term consequences                                                                                          |
|------------------------------------------------------------------------|---------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| <b>Damage to industrial facilities</b>                                 | Leakage of toxic substances into water bodies                       | Accumulation of persistent organic pollutants and heavy metals in sludge, groundwater                           |
| <b>Mining of water areas</b>                                           | Restrictions on the use of water bodies                             | Complications of environmental measures                                                                         |
| <b>Destruction of sewage treatment plants and water supply systems</b> | Leakage of untreated wastewater, lack of drinking water             | Decrease in the quality of surface and groundwater, deterioration of the sanitary and epidemiological situation |
| <b>Destruction of hydraulic structures</b>                             | Change of hydrological regime, flooding and drainage of territories | Degradation of river ecosystems, change of channel                                                              |

Source: Systematized by the author on the basis of sources [1; 2; 6; 11].

Judging by the data of Table 3, the degradation of river basins as a result of hostilities, damage to engineering infrastructure, and pollution of surface and groundwater cause several environmental processes, the consequences of which will determine the state of Ukraine's water resources several decades after the end of the war. Separately, it is worth mentioning the breach of the dam on the Kakhovka reservoir as a result of the actions of the aggressor in 2023. This was the largest man-made disaster in recent decades, which will have global environmental consequences for the Black Sea region. More than 80,000 hectares of the unique natural ecosystem of the Dnieper floodplain from Nova Kakhovka to the Dnieper-Bug estuary have been destroyed. In the future, the consequences of this catastrophe will be felt not only in Ukraine, but will also affect other countries of the Black Sea region. Climate change is not excluded, since the large area of water, which influenced the formation of the local climate in the region, disappears. In addition, there was a movement of fresh water into the Black Sea, which provoked changes in marine ecosystems due to desalination of the coastal strip. In addition, said water entered the sea contaminated with chemicals, household waste, and animal remains. The silt of the Kakhovka Sea was saturated with untreated emissions from industrial enterprises, heavy metals

and radioactive substances that had been deposited on the bottom for years. Now it has drifted into the Black Sea and will have consequences for all countries of the Black Sea basin.

Damage to land resources is significant. Littering of land with fragments of military equipment, ammunition residues, construction debris, and other waste from hostilities on an area of 24.8 million m<sup>2</sup> is estimated at UAH 1280 billion (Table 1). This is the second highest damage indicator among all components of the environment. It is difficult to calculate the exact area of the forest area contaminated with ammunition, since hostilities are taking place at different levels of intensity, and this directly affects the number of explosives left. Almost a third of the forests of our country have already been damaged. The most contaminated will not be able to be used for decades, because their demining will not be a priority, as it will require much more effort and time than demining similar agricultural land. This pollution is most dangerous for large animals. In the strategic perspective, an important factor influencing almost all types of living organisms (including humans) will be the frequency and intensity of forest fires due to the spontaneous detonation of ammunition and mines on hot days. The destruction of the Kakhovka hydroelectric power plant also had consequences for land resources. The drainage of a huge area of the former reservoir caused the implementation of new natural processes (wind erosion of silt, dust transfer, changes in the groundwater level, transformation of nearby landscapes).

Soil pollution (1.3 million m<sup>2</sup>) due to the ingress of heavy metals and toxic chemicals into the soil cover, leakage of fuels and lubricants, estimated at UAH 22.2 billion, stands out separately (Table 1). An important feature of soil pollution is its ability to act as a natural accumulator of toxic substances. Unlike atmospheric air, where most pollutants stay for a relatively short time, soils accumulate heavy metals, explosive residues, and other toxins, which in the future gradually migrate to groundwater and surface waters or are included in food chains through agricultural products (Table 4).

**Table 4. Factors of degradation of land resources of Ukraine as a result of hostilities**

| Factor                        | Degradation mechanism           | Environmental consequences                                              |
|-------------------------------|---------------------------------|-------------------------------------------------------------------------|
| <b>Mining territories</b>     | Impossibility of economic use   | Withdrawal of land from economic turnover until complete demining       |
| <b>Chemical pollution</b>     | Accumulation of heavy metals    | Toxic pollution for decades                                             |
| <b>Moving heavy machinery</b> | Soil compaction                 | Deterioration of aeration, water permeability and fertility for decades |
| <b>Forest fires</b>           | Destruction of vegetation cover | Soil erosion, decrease in organic matter                                |
| <b>Explosions</b>             | Topsoil destruction             | Loss of fertility for decades                                           |

Source: Systematized by the author on the basis of sources [1; 2; 6; 11].

Taking into account the data of Table 4, it should be noted that in addition to direct soil contamination, future consequences of hostilities for soil cover are inevitable. Significant damage to the soil is caused by its erosion, which during the war is caused not only by ammunition explosions, but also by direct damage to the soil by heavy equipment and the construction of fortifications and trenches. Military equipment also compacts the soil very much. The pressure on the latter tanks is almost 1 kilogram per square centimetre, which leads to a decrease in plant productivity in ecosystems [17, p. 137]. The massive construction of military bases and the use of heavy equipment damages soils and destroys vegetation. Contaminated areas will not only not recover immediately after the end of the conflict, but they can also lead to the spread of pollution to neighbouring territories. This is a significant threat not only to humans, but to flora and fauna. The degradation of land resources is one of the most long-lasting consequences of the war.

Environmental damage to the territories of the nature reserve fund reached the greatest scale. Damage to flora on an area of 28.5 thousand hectares. hectares are estimated at UAH 2713.2 billion (the largest share of total environmental damage is almost 61%) (Table 1). This amount is explained by the high conservation value of these territories, as well as the complexity of their restoration. In addition, the destruction or damage of 82.6 million trees and plants due to forest fires, ammunition explosions, mechanical damage to vegetation by military equipment, and deforestation in war zones, estimated at UAH 1040 billion, was recorded. The destruction of 75.2 thousand animals was also noted, which is estimated at UAH 0.16 billion. Although the financial valuation of this category is relatively small, the actual environmental losses are much larger, since the destruction of fauna leads to disruption of ecological chains and degradation of ecosystems.

According to official data, hostilities and temporary occupation of the territories of the nature reserve fund of Ukraine led to the destruction of natural complexes, forest fires, mining of territories and other consequences of the war, which significantly affected biodiversity. The state of natural ecosystems has deteriorated significantly and there have been threats of loss of certain rare species (Table 5).

**Table 5. Factors of the impact of hostilities on the biodiversity of Ukraine**

| Factor                                     | Events                                                | Environmental consequences                                            |
|--------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------|
| <b>Temporary occupation of territories</b> | Lack of environmental management                      | Deterioration of protected areas                                      |
| <b>Artillery shelling</b>                  | Destruction of natural habitats of animals and plants | Disturbance of the structure of ecosystems                            |
| <b>Forest fires</b>                        | Destruction of stands and undergrowth                 | Loss of habitats, reduction in the number of plant and animal species |
| <b>Mining territories</b>                  | Restriction of access to natural areas                | Death of animals, lack of environmental measures                      |
| <b>Fortification Construction</b>          | Destruction of natural landscapes                     | Disruption of migration routes                                        |

Source: Systematized by the author on the basis of sources [1; 2; 6; 11].

The results in Table 5 give grounds to assert that hostilities have led not only to the degradation of natural areas, but also to a systemic change in the ecological network of Ukraine. The destruction of natural habitats, disruption of migration processes, destruction of landscapes and the impossibility of environmental management carry long-term risks for the conservation of biodiversity in Ukraine. The greatest threat to biodiversity is not only the death of individual species, but also the danger of the existence of ecological links between the components of natural ecosystems.

The scale of the consequences of the armed aggression of the Russian Federation for the environmental sphere of Ukraine necessitated the creation of fundamentally new approaches to their assessment. Traditional environmental monitoring was based on the activities of national environmental authorities. Modern practice has shown the gradual creation of an international system for documenting environmental damage. The use of modern digital technologies: satellite systems, unmanned aerial vehicles, and geographic information systems is gaining new importance. This allows for operational monitoring of the state of natural ecosystems in the absence of physical access to territories. This combination of remote sensing, field research, and automated analysis of large amounts of data is gradually becoming the international standard for documenting the environmental consequences of war.

The prospect of using satellite technologies for the restoration of territories and integrated assessment of the state of the environment is caused by several factors: access to multi-level satellite data allows for constant updating of information on the ecological state of large areas with high resolution, which is the foundation for the formation of a national system of environmental monitoring of the environment based on reliable geospatial data [15, p. 619]. In addition, the introduction of satellite technologies makes it possible to model options for the rehabilitation of ecological systems, taking into account the real state of vegetation cover, soils, the level of man-made pollution, and the hydroelectric network. At the same time, analytical products of satellite monitoring can be used in strategic environmental assessment, spatial zoning, and development of landscape reclamation programs. Tracking the dynamics of natural regeneration or degradation of restoration areas, assessing the sustainability of changes and adjusting management decisions in real time can also be carried out using satellite systems.

## 6. Conclusions

The intensity of hostilities is the main factor in the formation of environmental damage. The longer the territories are in the zone of active hostilities, the greater environmental losses they incur. The study showed that the environmental consequences of the armed aggression of the Russian Federation cannot be eliminated only by overcoming individual man-made damage or restoring destroyed objects. The scale of environmental damage from hostilities as of 02.01.2026 is We have found that pollution of atmospheric air, soils, water resources and degradation of natural ecosystems form an

integral complex of ecological processes, where negative changes in one component of the environment cause further changes in other natural systems. Environmental measures should include the use of the ecosystem approach in public management of the environmental sphere.

Documenting environmental damage from the war is a necessary prerequisite for the involvement of the guilty party in the restoration of the environmental sphere of Ukraine in the post-war period. Given the significant scale of environmental consequences, in the future it is necessary to form a system of priority of environmental measures, since the simultaneous restoration of all damaged areas and ecosystems is almost impossible. Determination of the sequence of such environmental protection measures should be carried out based on a comprehensive assessment of environmental risks, socio-economic significance of territories, levels of threat to public health and opportunities for natural self-restoration of ecosystems. The widespread introduction of satellite and digital technologies should become part of the strategic plan for the post-war recovery of the environmental sphere. This will not only contribute to the effective assessment of environmental damage, but will also form the basis for the creation of a modern, technologically capable system of public management of the environmental sphere, focused on the principles of sustainable development and scientific validity.

## References

1. Anhurets, O., Khazan, P., Kolesnykova, K., Kushch, M., Chernokhova, M., & Havranek, M. (2023). *Ukraina: Ekolohichni zbytky ta ekolohichni naslidky viiny* [Ukraine: Environmental damage and environmental consequences of war]. Clean Air for Ukraine. <https://cleanair.org.ua/wp-content/uploads/2023/03/cleanair.org.ua-war-damages-ua-version-04-low-res.pdf> (in Ukrainian)
2. Blaha, A. B., Zahorodniuk, I. V., Korotkyi, T. R., Martynenko, O. A., Medvedieva, M. O., & Parkhomenko, V. V. (2017). *Na mezhi vyzhyvannia: Znyshchennia dovkillia pid chas zbroinoho konfliktu na skhodi Ukrainy* [On the edge of survival: Environmental destruction during the armed conflict in eastern Ukraine] (A. P. Bushchenko, Ed.). KYT. <https://www.helsinki.org.ua/wp-content/uploads/2017/06/Na-mezhi-vyzhyvannya.pdf> (in Ukrainian)
3. Bondar, O. B., Melnyk, Ye. Ye., Pohorielova, O. M., Bytsiura, L. O., & Holovatiuk, L. M. (2025). Analiz vplyvu viiskovykh dii na dovkillia ta infrastrukturu Ukrainy [Analysis of the impact of military actions on the environment and infrastructure of Ukraine]. *Naukovyi visnyk Natsionalnoho lisotekhnichnoho universytetu Ukrainy – Scientific Bulletin of Ukrainian National Forestry University*, 35(1), 60–67. <https://doi.org/10.36930/40350108> (in Ukrainian)
4. Borovyi, V., Braslavskaya, O., & Rozhi, T. (2025). Suputnykovi znimky ta BPLA yak instrumenty monitorynhu zemelnykh resursiv: Suchasni tekhnologii ta yikh zastosuvannia v Ukraini [Satellite and UAV imagery as tools for land resource monitoring: Modern technologies and their application in Ukraine]. *Tekhnichni nauky ta tekhnologii – Technical Sciences and Technologies*, 1(39), 315–327. [https://doi.org/10.25140/2411-5363-2025-1\(39\)-315-327](https://doi.org/10.25140/2411-5363-2025-1(39)-315-327) (in Ukrainian)
5. Chvaliuk, H. V., Hrubinko, V. V., & Humeniuk, H. B. (2022). Yak viina znyshchuie ekolohiiu Ukrainy [How war destroys Ukraine's environment]. *Naukovi zapysky Ternopilskoho natsionalnoho pedahohichnoho universytetu imeni Volodymyra Hnatiuka. Seriya: Biologiya – Scientific Notes of Ternopil Volodymyr Hnatiuk National Pedagogical University. Series: Biology*, 82(4), 49–64. <https://doi.org/10.25128/2078-2357.22.4.6> (in Ukrainian)
6. Conflict and Environment Observatory, & Zoï Environment Network. (2024). *Ekolohichni naslidky viiny proty Ukrainy: Poperednia richna otsinka (liutyi 2022 – liutyi 2023)* [Environmental consequences of the war against Ukraine: Preliminary annual assessment (February 2022 – February 2023)]. [https://ceobs.org/wp-content/uploads/2024/09/OSCE-Ukraine-cons\\_UKR.pdf](https://ceobs.org/wp-content/uploads/2024/09/OSCE-Ukraine-cons_UKR.pdf) (in Ukrainian)
7. Derzhavna ekolohichna inspektsiia Ukrainy. (2023). *Publichnyi zvit v. o. Holovy Derzhavnoi ekolohichnoi inspektsii Ukrainy za 2022 rik* [Public report of the Acting Head of the State Environmental Inspectorate of Ukraine for 2022]. <https://www.dei.gov.ua/post/2515> (in Ukrainian)
8. Derzhavna ekolohichna inspektsiia Ukrainy. (2024). *Publichnyi zvit v. o. Holovy Derzhavnoi ekolohichnoi inspektsii Ukrainy za 2023 rik* [Public report of the Acting Head of the State Environmental Inspectorate of Ukraine for 2023]. <https://www.dei.gov.ua/post/2834> (in Ukrainian)
9. Derzhavna ekolohichna inspektsiia Ukrainy. (2025). *Publichnyi zvit v. o. Holovy Derzhavnoi ekolohichnoi inspektsii Ukrainy za 2024 rik* [Public report of the Acting Head of the State Environmental Inspectorate of Ukraine for 2024]. <https://www.dei.gov.ua/post/3083> (in Ukrainian)

10. Derzhavna ekologichna inspektsiia Ukrainy. (2026). *Publichnyi zvit v. o. Holovy Derzhavnoi ekologichnoi inspektsii Ukrainy za 2025 rik* [Public report of the Acting Head of the State Environmental Inspectorate of Ukraine for 2025]. <https://www.dei.gov.ua/post/3455> (in Ukrainian)
11. Ecoaction. (2025). *Klimatychnyi vplyv viiny Rosii proty Ukrainy: 24 liutoho 2022 – 23 liutoho 2025 roku. Povna otsinka* [The climate impact of Russia's war in Ukraine: 24 February 2022 – 23 February 2025. Full assessment]. <https://ecoaction.org.ua/climate-damage-3years-full.html> (in Ukrainian)
12. Environment–People–Law. (2015). *Viina na skhodi Ukrainy — tsyvilizatsiini vyklyky liudstvu* [War in Eastern Ukraine – Civilizational challenges to humanity]. [https://epl.org.ua/wp-content/uploads/2015/07/1817\\_WEB\\_EPL\\_Posibnuk\\_ATO\\_Cover\\_Ukrainian.pdf](https://epl.org.ua/wp-content/uploads/2015/07/1817_WEB_EPL_Posibnuk_ATO_Cover_Ukrainian.pdf) (in Ukrainian)
13. Hrynshyn, N. M. (2026). Ekologichni zbytky, zavdani zbroinoiu ahresiieiu Rosiiskoi Federatsii, ta yikh otsinka Derzhavnoiu ekologichnoiu inspektsiieiu Ukrainy [Environmental damage caused by the armed aggression of the Russian Federation and its assessment by the State Environmental Inspectorate of Ukraine]. *Naukovyi visnyk Natsionalnoho lisotekhnichnoho universytetu Ukrainy – Scientific Bulletin of Ukrainian National Forestry University*, 36(2), 94–101. <https://nv.nltu.edu.ua/index.php/journal/article/view/2863> (in Ukrainian)
14. Kabinet Ministriv Ukrainy. (2022, March 20). *Pro zatverdzhennia Poriadku vyznachennia shkody ta zbytkiv, zavdanykh Ukraini vnaslidok zbroinoi ahresii Rosiiskoi Federatsii* [On approval of the Procedure for determining damage and losses caused to Ukraine as a result of the armed aggression of the Russian Federation] (Resolution of the Cabinet of Ministers of Ukraine No. 326). <https://zakon.rada.gov.ua/laws/show/326-2022-%D0%BF> (in Ukrainian)
15. Kalyna, T., Ostrovskiy, I., & Pidbereznykh, I. (2026). Suputnykovi tekhnologii v otsiniuvanni ekologichnykh naslidkiv viiny ta upravlinni vidnovlenniam zemel [Satellite technologies in assessing the environmental consequences of war and managing land restoration]. *Visnyk Khmelnytskoho natsionalnoho universytetu. Ekonomichni nauky – Herald of Khmelnytskyi National University. Economic Sciences*, (1), 613–620. <https://doi.org/10.31891/2307-5740-2026-350-83> (in Ukrainian)
16. Lychenko, I. O. (2016). Ekologichni problemy bezpeky tymchasovo okupovanykh terytorii Donetskoj ta Luhanskoj oblasti ta orhanizatsiino-pravovi zasady yikh vyrishennia [Environmental security problems of the temporarily occupied territories of Donetsk and Luhansk regions and organizational and legal principles for their solution]. *Visnyk Natsionalnoho universytetu "Lvivska politekhnik". Seriya: Yurydychni nauky – Bulletin of Lviv Polytechnic National University. Series: Legal Sciences*, (845), 279–284. <https://ena.lpnu.ua/server/api/core/bitstreams/21ec0793-4d50-4453-9068-2031890b0546/content> (in Ukrainian)
17. Mychuda, V. V., Volovyk, L. M., & Bondarenko, R. I. (2025). Ekologichni naslidky viiny Rosii proty Ukrainy [Environmental consequences of Russia's war against Ukraine]. *Teoriia ta metodyka navchalnoho menedzhmentu – Theory and Methods of Educational Management*, 80(1), 135–138. [https://www.innovpedagogy.od.ua/archives/2025/80/part\\_1/29.pdf](https://www.innovpedagogy.od.ua/archives/2025/80/part_1/29.pdf) (in Ukrainian)
18. Rudko, H. I., & Plakhotnyi, S. A. (2015). Hibrydna viina ta yii ekologichni naslidky dlia Donetskooho hirnycho-promyslovoho rehionu [Hybrid warfare and its environmental consequences for the Donetsk mining and industrial region]. *Ekologichni nauky – Environmental Sciences*, (10–11), 114–123. <https://ecoj.dea.kiev.ua/archives/2015/10-11/13.pdf> (in Ukrainian)
19. Zero Waste Alliance Ukraine. (2024). *Upravlinnia vidkhodamy ruinovannia, shcho utvorylysia vnaslidok viiny v Ukraini: Suchasni praktyky ta neobkhidni zminy. Analitychnyi zvit* [Management of demolition waste generated by the war in Ukraine: Current practices and necessary changes. Analytical report]. [https://zerowaste.org.ua/wp-content/uploads/2024/04/dodatok\\_1\\_zvit\\_vidhody\\_ruinacziyi\\_vijny\\_docx.pdf](https://zerowaste.org.ua/wp-content/uploads/2024/04/dodatok_1_zvit_vidhody_ruinacziyi_vijny_docx.pdf) (in Ukrainian)