Problems of environmental protection as an aspect of military conflict

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Introduction

The armed aggression of the Russian Federation against Ukraine, which began on February 24, 2022, gave rise to many problems. Many of these problems are at the solution stage, while others are extremely far from being solved. Among the latter can be attributed damage and complex negative consequences for almost all components of the environment: only preliminary estimates, voiced by experts from Ukraine and the Czech Republic (NPO "Arnica"), predict 50 years or more for the restoration of disturbed nature. According to the Minister of Environmental Protection and Natural Resources, already after seven months of armed aggression, ecological damage in Ukraine has reached one trillion hryvnias or 36 billion euros, of which 11.4 billion are estimated to be damaged to the soil, 24.6 billion are losses related to with air pollution. By the end of the year, these numbers had grown significantly, according to the minister's announcement at the "United for Justice" conference. It also became known that about a third of Ukraine's forests and 20% of the territories and objects of the nature reserve fund were damaged due to the war. Some types of damage and environmental damage are considered irreversible; significant damage was caused to biological diversity: approximately 600 species of animals and 750 species of plants were affected by the aggression of the Russian Federation.

Although environmental recovery from the consequences of war is fully available after its end and will continue for decades, the foundations for such recovery should be laid now by documenting cases of environmental damage, assessing the likely direct and indirect consequences, as well as forming plans for recovery measures the environmentю Due to the enormity of the task such plans will primarily aim to prevent the most irreversible and catastrophic consequences. They must offer the optimal procedure for eliminating all the consequences of the

armed aggression of the Russian Federation based on ecological and economic criteria.

1. Features of the classification of environmental consequences of military actions

The application of general scientific methods to modeling the effects of military actions and armed conflicts on nature and the main components of the environment faces several obstacles, some of which are outlined in. First of all, these are the difficulties of building a verified cause-and-effect relationship due to: the impossibility of conducting planned experimental studies; heterogeneity of the general population of such exposure cases, which limits the applicability of sampling methods; in general, the uniqueness of each conflict concerning the scale, a form of flow, types of natural ecosystems involved in the conflict, as well as the means and types of impact on the environment. Therefore, despite a sufficiently broad base for research (122 armed conflicts took place in the world in just 17 years from 1992 to 2008, and 163 out of 192 countries currently have and use regular armed forces), systematic study of the problem has currently received enough a limited range of recognized results and scientifically based conclusions, which are needed for forecasting and assessing the ecological consequences of wars.

First, a military conflict as an event in time and space has its framework. Thus, several scales (local, regional, global) and three stages (pre-war, war, and post-war) are distinguished in, which should be used to classify the environmental consequences of military actions and armed conflicts.

The local effect is mainly understood as the impact on specific landscapes. These can be the consequences of artillery or missile attacks, local fires caused by them, damage to the soil due to the movement of military equipment, individual facts of the death of specimens of flora and fauna, and localized pollution of water bodies and soil.

Regional consequences can be large-scale fires, including forest fires (air, flora, and fauna suffer damage, and there may be a significant impact on the soils of large areas), disruption of the hydrological regime of watercourses (from small rivers to large rivers), the death of a significant part of the population plants and animals (may result in the spread of invasive species and disruption of unique ecosystems, reduction of ecosystem diversity in a particular area), all incidents related to radiation pollution, etc.

Global consequences can result from using weapons of mass destruction, nuclear incidents, and ecosystem damage, triggering species extinction.

All consequences of military conflicts for the environment can relate directly to the stage of hostilities and accompanying activities (such as transportation of ammunition or fuel and lubricants, training, destruction of infrastructure, etc.). They also refer to the pre-war and post-war stages, no matter how strange the phrase about the consequence of the war, which took place even before the start of the armed confrontation, sounds.

War usually does not start in a vacuum. Preparatory works last for years and decades. The detonation of a plutonium charge preceded the explosions of two atomic bombs over Hiroshima and Nagasaki in the desert near Alamogordo (Trinity site); the training of a military pilot involves dozens and hundreds of hours of training flights during which vast volumes of fuel are burned; before entering the battlefield during training and exercises, a soldier shoots kilograms of ammunition, polluting the environment with their residues, affecting wildlife.

The global consequences of the military conflict associated with the aggression of the Russian Federation in Ukraine in 2022 include the phenomena and processes that some international researchers warn about. According to forecasts, a military conflict in countries that are essential food suppliers to many regions may destroy a significant portion of the land currently under the pastures and forests in those regions. Thus, a conflict in one part of the globe can have far- reaching ecological consequences in entirely different regions, and such consequences can be extremely difficult to eliminate. Also, the transfer of military

technologies to civilian use, which in many cases can have a significant impact on the environment, both positive and negative, can be a typical global consequence of waging war in wartime.

The environmental consequences of war on a regional scale in the post-war period are mainly reduced to pollution on a regional scale, degraded ecosystem services, and problems with natural resource management in conditions of an unstable economy.

When considering and classifying the ecological consequences of armed confrontations, it is also appropriate to apply the traditional classification of anthropogenic impacts on the environment, distinguishing impacts on the atmosphere and hydrosphere, plant and animal life, soils, and biodiversity the form of pollution, disruption, destruction, etc.

Finally, when studying the ecology of war, a separate and essential category should include the indirect consequences of military confrontations and their impact on the state of the environment. The following subsection will consider partial cases of the environmental effects of military confrontation. At the end of the current one, we will note one global effect associated with armed conflicts in general. The UN declared the concept of sustainable development as one of the critical goals to achieve; there is an opinion that the current conflict is a serious obstacle to its implementation.

2. Indirect consequences of military conflict

Military conflicts in the modern world are accompanied by several phenomena and processes that, in aggregate or in particular, can cause a far more significant effect on the environment than the direct conduct of military operations. These phenomena lie in different planes and can often have a hidden nature. Most are related to societal changes, the national economy, and other spheres of human life.

First of all, the war and its consequences cause changes in people's consciousness and the space of public opinion. This can directly affect the laws

that determine the impact of man on the environment. for many decades, hundreds and thousands of scientists, teachers, and managers of all levels have worked on deepening ecological knowledge, raising environmental awareness of individual strata (such as youth) and society as a whole. The war as an influential stress factor shook the consciousness of individuals and communities; it is impossible to predict with certainty the distant consequences of such an impact: whether in conditions of threat to life and health, experiencing a shortage of vital resources, a person will treat the environment as hostile, as a part of the cruel reality, and whether, having endured the horrors of the war, even more efforts will be made to preserve our typical home - the environment and the ecosystems in which it lives. We will almost certainly observe the entire range of such effects in the war and post-war society. Still, the final result will depend on the numbers and the specific share of each group and its representatives' activity. The results of processes and manifestations of the effects of this form are difficult to predict, but there are powerful tools for influencing public opinion - mass media, the Internet, etc. Therefore, when planning to restore Ukraine's environment, one should pay attention to these complex problems and emphasize the war's environmental issues.

Further, the conduct of hostilities and even their very threat is a decisive factor causing the displacement of significant masses of the population. According to various data, during the year of the war, from 7.7 million people left Ukraine (the number of people officially registered in the EU as asylum seekers) to 4.5 million people (the number of crossings of the western border was recorded during the first year; however, some returned, some crossed the border repeatedly; on the other hand, some could leave illegally or through the territory occupied by the Russian Federation); another 4.7-5.4 million are internally displaced persons.

The very life activity of the population in the modern world is a factor of anthropogenic pressure on the natural environment. A city with a population of 1 million requires more space, food and industrial products, energy, clean water, and air. It generates larger volumes of household waste, sewage, and air pollution than

a town with 10,000 inhabitants. Of course, in emergencies, a person can get by with a minimum of resources for living. Still, the military conflict in Ukraine has been going on for more than a year, and it is not easy to consider such a period as temporary.

Thus, we have a natural increase in the load on the environment in places that receive refugees and displaced persons. When a significant part of the population is moved from point A to point B, an increase in anthropogenic pressure in point B should be accompanied by a decrease in it in point A. This is usually the case. However, firstly, the war came to point A, and probably the situation, including the environmental one, is even worse there; secondly, let us assume that among the displaced persons, there are people who ensured the removal and disposal of garbage, the operation of sewage treatment plants, energy supply, and the like in point B. Without proper care, a settlement in which 10-50% of the remained population may pose an even more significant threat to the environment than in the normal functioning of all life support systems of this settlement. Some aspects of the impact on the environment, which is associated with the movement of significant numbers of people over long distances, are similar to the environmental problems of tourism and are covered in detail in the relevant scientific literature.

The movement of large numbers of the population, including weakly organized and chaotic, is a bright background for the spread of various infections and diseases. An additional risk factor may be that displaced persons' bodies may be weakened, creating a favorable environment for developing pathogenic microorganisms. In the modern world, refugees often transport pets with them, and the high intensity of their movement often makes the levels of customs and quarantine control insufficient, resulting in the risk of epizootics.

The destruction of infrastructure due to hostilities and sabotage is primarily of socio-economic importance. Still, we must recognize the ecological consequences of such destruction and the accompanying effects on the environment, some of which we will consider in more detail.

3. Environmental risks related to infrastructure destruction during war

The problems that comprise this side of the armed conflict are numerous and diverse; therefore, a thoughtful reader-researcher can complete the list below. We will briefly describe some of the consequences associated with the destruction of the infrastructure of the transport subsystem and the energy supply system.

- The main components of the energy infrastructure of Ukraine are energy-generating and energy-transmitting facilities and systems. The most extensive energy-generating facilities are nuclear and hydroelectric power plants, thermal power plants, and thermal power plants. Generating alternative energy capacities currently occupies a small share of the energy market of Ukraine. Military threats to such facilities are visible. They will be partially discussed below in the subsection devoted to typical types of environmental damage (risks of incidents at nuclear power plants associated with releasing active materials; nuclear terrorism of a broad profile; dangers of damage to dams HPP and HPP, etc.). These are direct threats to the state of the environment. The risks of indirect threats that disrupt average electrical energy generation should also be considered. Among them, we note the following:
- For the final consumer, electric energy is a relatively safe and ecological type of energy supply; the negative factors of the transmission of electricity over considerable distances and its use in everyday life and production can only be attributed to the increased level of electromagnetic radiation, which can be avoided by proper shielding. At the same time, in the event of a disruption in the supply of electricity, consumers will be forced to switch to the use of other types of energy, such as the use of fossil fuels for heating, the use of gas and gasoline generators for obtaining electrical energy, etc. (which was observed everywhere in the cities of Ukraine during periods of the limited power supply). All these types of energy are more

harmful to the environment and less efficient compared to the developed electricity supply system;

- the operation of many systems and components of production, on which the safety of the environment depends, significantly depends on the proper power supply. These are systems for cleaning gaseous emissions, equipment used at wastewater treatment plants, and safety components of ponds and sites where radioactive materials are stored. It is only sometimes possible to duplicate the energy supply of these systems from backup sources. Therefore the disruption of the average energy supply system, associated with destroying infrastructure during military operations, carries risks of environmental pollution with dangerous substances. Violation of energy supply can have consequences in the form of disruption of the regular functioning of livestock farms, chemical productions with a complex synthesis cycle, objects and structures of the nature reserve fund, etc., including harming the environment.
- Transport infrastructure is a rather complex integrated system, and in case of disruption of its links, it can continue to function by using reserve capacities and routes. At the same time, such changes may carry certain risks of increasing anthropogenic impact on the environment:
- Thus, in the event of a disruption of the power supply, electric transport will likely stop working. At the same time, transportation can be carried out at the expense of other means. However, we note that the transition from electric transport to cars with internal combustion engines (for example) will cause an additional burden on nature in the form of emissions of harmful gases and the use of fossil fuels, the resource of which is limited;
- among other things, the transport network transports environmentally hazardous goods. In the case of destroying the integrity of the transport infrastructure due to military operations, transportation safety decreases, and the risks of transporting such goods increase. An example of

ecologically dangerous incidents while transporting goods by railway is the so-called phosphorus accident near Ozhydiv. In the conditions of war, the risks of such accidents as a result of the perpetrator's actions, a decrease in the general level of security, and other poorly predicted factors increase significantly;

- such an element of the transport infrastructure of Ukraine as the Tolyatti-Odesa ammonia pipeline deserves special attention, the active functioning of which was suspended with the beginning of intensive military operations. This transport element runs in many regions of Ukraine and potentially contains significant amounts of aggressive chemicals, and therefore is dangerous from the point of view of threats to the environment, life, and health of people;
- regular functioning of the transport infrastructure is a necessary element of the response system to emergencies and artificial disasters. Proper transport connections allow the timely arrival of fire crews and teams of specialists to eliminate such situations and prevent potentially catastrophic environmental consequences. Thus, the impossibility of responding in time to a fire that has started can cause death and injury to people if the fire happens in a residential building; it can cause highly toxic emissions into the environment if a fire occurs in the buildings of the production complex; can cause the destruction of flora and fauna in large areas if a forest massif is affected by the fire. If the fire was caused by rocket fire or bombing, the corresponding damages are direct damage from the mentioned military actions. If the causes of the fire are different, but due to damage to the infrastructure, it was not possible to prevent the spread of the consequences of the emergency in time, we are dealing with indirect environmental risks of wartime caused by damage to the proper infrastructure.

4. Features of the functioning of the natural-reserve fund system in the conditions of war

The objects and territories of the nature reserve fund look vulnerable in war conditions. These objects and territories are essential for preserving biological diversity and conserving unique natural complexes. Considering the significant degree of anthropogenic transformation of the territory of our country, every corner of the preserved nature has a significant value; the value of these territories increases significantly if combined into an ecological network. At the same time, numerous factors accompanying armed aggression damage nature-protected territories.

The exact location of nature conservation areas in the war zone harms the nature of these areas. Such territories are vulnerable to fires, noise, and movement of equipment, not to mention such types of impact as shelling, explosions, digging trenches, spills of fuel and lubricants, and soil contamination with toxic materials, including rocket fuel.

Data on the objects of the Nature Reserve Fund of Ukraine, which suffered due to a full-scale invasion, are constantly updated. Already six months after the beginning of the invasion, it was known that several million hectares of Ukrainian forests had been damaged, many of which are located in protected areas. According to some data, about 44% of the reserves and national parks area are located in the temporarily occupied territories and the war zone, including extremely valuable territories, such as Askania-Nova - a reserve included in the list of reference territories of the planet by the UNESCO Council.

According to, about two hundred territories of the Emerald Network (Emerald Network) out of 377 territories that were part of it as of December 2019 for implementing the initiatives of the Berne Convention are under threat. In addition to the Askania-Nova Reserve, the Chornobyl Radiation-Ecological Biosphere Reserve, the Black Sea Biosphere Reserve, and other territories, such as the Kinburnska Kosa RLP, Tuzlivski Lymani NP, Drevliansky NR, Svyati Hory NNP, and Meotida, suffered significant damage. "Dzharylgatskyi," "Oleshkivski

sands," and others. It is only possible to objectively assess the damage's extent once these territories' occupation is completed. However, even after its completion, there will most likely be a danger of being in these territories for a long time due to a significant percentage of mined zones in the territories where hostilities occurred. The presence of mines and munitions in nature conservation territories can cause the direct death of animals and significantly limits scientists' and researchers' access to these valuable territories. This factor may become a problem for NNPs when implementing their recreational and educational function.

Protected territories are not only areas where economic and other human activity are limited to minimize the impact on natural complexes. It is also a giant laboratory for studying nature. Research has been suspended here under the threat of shelling, which is already causing significant damage to environmental science.

Among the harmful effects of armed aggression on nature conservation areas concerning the environment cases of violation of water bodies, mass death of ichthyofauna, increase in the frequency and intensity of forest fires, destruction of habitats of rare species, displacement of wild animals from territories where their peace is disturbed, and even changes in migration routes are noted—migratory birds. A typical consequence of such impacts is the loss of biodiversity at all levels: species, landscape, and ecosystem. When unique natural complexes are lost, such processes and phenomena can be interpreted as irreversible environmental losses caused by military confrontation. The risks of wind and water erosion are increasing as a result of the uncontrolled movement of the invader through the territory of the objects of the nature reserve fund.

5.

Systems and methods of documenting environmental crimes of wartime

A feature of the armed aggression of the Russian Federation, the active phase of which began on February 24, 2022, is the informational component. Unlike many past conflicts, most of the events of this confrontation are

comprehensively covered and recorded using modern information and digital technologies. Here it is important to note that to objectively evaluate events and phenomena that potentially harm the quality of the natural environment, the stability of ecosystems, and the normal functioning of biological mechanisms, one should, first of all, have complete information about these events and phenomena, their mechanisms, causes and the consequences that accompany them.

To assess the environmental consequences of military actions, information on the circumstances of such consequences should be recorded as accurately and thoroughly as possible. Therefore, accounting for the actions of the aggressor, which are criminal concerning the environment, is a primary task at this stage of the armed conflict and will play an essential role in the future. It is about implementing compensatory measures, restoring the environment, and forming mechanisms for financial support to compensate for the damage caused. Note that the estimates given in at this stage have not been fully verified regarding the calculation methodology and the complete coverage of all types of negative impacts on the environment associated with the armed aggression of the Russian Federation, including taking into account the indirect consequences described above.

It is essential to establish transparent and perfect mechanisms for detecting, recording, and documenting actions that can be interpreted as environmental crimes so that all mechanisms and the conclusions obtained on their basis are unambiguous and recognized by both the population and the international community. Various organizations and institutions work to document the environmental damage caused by the Russian invasion of Ukraine. First, these are the Ministry of Environment and subordinate state authorities. Also, because of the above, the role of international organizations is essential. Unfortunately, many international institutions still observe pro-Russian influences and neglect the true essence of events in Ukraine. Thus, the Russian Federation uses the international database of nature conservation areas WDPA. In the WDPA (World Database on Protected Areas), which is a joint project of the International Union for

Conservation of Nature (IUCN) and the United Nations Environment Program (UNEP), some occupied protected areas in Crimea (e.g., NNP "Charivna Gavan") are attributed as located in the Russian Federation (data as of 03/06/2023 according to the data of the Ukrainian nature protection group).

The Ministry of Environmental Protection and Natural Resources of Ukraine not only independently records cases of environmental violations and fixes problems of its preservation in conditions of military confrontation but also uses modern technologies to collect, process and organize access to data that are of interest in this context. One of the directions of organizing the automatic collection and recording of information about environmental threats in real-time is the site's activity and the Ecozagroza project , implemented with the participation of the European Union, USAID, UKAID, Apena2, Eura-sia Foundation, and others. As of mid-March 2023, the project involved 19,375 participants, including 27 environmental experts, four public organizations, and more than 16,000 citizens of Ukraine.

The complete coverage of ecological threats and monitoring of the impact of war on the environment by the Eco-Threat project currently requires an objective assessment because it is clear that not every citizen of the country who witnessed an environmental crime will be able to identify it clearly, and even in case of such identification will leave a corresponding message on the site using the Internet or mobile application. When reporting such a threat, users are offered to add information with or without photo/video evidence. You need to specify the location and choose one of the impact categories:

- Air (fires of petroleum products, burning of military equipment, emissions of toxic substances into the air, ignition of other objects)
- Waste (explosives, detonated military equipment, hazardous waste, other waste)
- Soils (oil spills, toxic spills)
- Water (spill of oil products, spill of poisonous substances, sunken military equipment)

- Forest and NPF (fire in forest stands, mass felling or felling of forest, negative impact on NPF objects)

In each category, details are indicated (if emissions of toxic substances - what exactly and in what volume, if burning equipment - what and how many pieces, etc.). It is also suggested to give a verbal description of the situation.

As of March 15, 2023, this project made it possible to process 2,340 appeals, verify 96.24% of them, and assess losses (calculated by the State Inspectorate according to approved methods) in the amount of UAH 1,902 billion, including UAH 988 billion in the air category, 844 billion in the waste category, UAH 12 billion – soil pollution. It is clear that the obtained picture is far from complete (for example, only 62 appeals in the category of forests and NPF were recorded, of which 22 were in the Kyiv region); however, as a component of the public database on environmental violations, this project is essential.

Among the studies of the impact of Russian aggression on the environment of Ukraine, as of the beginning of autumn 2022, the following structure of environmental crimes is distinguished: 22% - industrial accidents, 11% - impact on water resources, 15% - damage to green areas, 7% related to radiation objects, other types of crimes against the environment account for more than 36%. At the same time, such studies are often not accompanied by references to sources that can be verified; the collected information is of an episodic nature and of low value in the context of the formation of a full-fledged database on the ecological consequences of the armed aggression of the Russian Federation in Ukraine to use these data as legal justification in courts and as reliable scientific material in the study and planning of environmental restoration of Ukraine after the end of armed aggression.

The Conflict Observatory resource (https://hub.conflict observatory.org/) has been declared an information center for collecting, analyzing, and complete access to evidence of war crimes committed by Russia and other atrocities in Ukraine. The Conflict Observatory will analyze and store publicly available and commercially available information, including satellite images and information

shared via social media, following international legal standards for current and future accountability mechanisms. This includes maintaining a strict chain of custody procedures for future civil and criminal trials in the relevant jurisdictions. This is a new joint initiative of Esri, Alcis, and Quiet Professionals LLC, with research, analysis, and documentation provided by the Yale Humanities Research Laboratory, the Smithsonian Cultural Rescue Initiative, and PlanetScape Ai. In any case, the ecological problems of Ukraine, related to the armed aggression of the Russian Federation, are complex and long-lasting and require further research and development of methods for their solution.

Many researchers also draw attention to the imperfection of the international system of punishment for environmental crimes during hostilities and the need for its reorganization.

6. Separate and general types of environmental violation

Among the most impressive and noticeable facts of damage to the environment is the damage to the atmospheric air. Thus, numerous rocket and artillery attacks caused fires in all regions of Ukraine, from the contact line in the east and south to Lviv Oblast in the west. Clouds of dust, smoke, and toxic substances enveloped Ukrainian cities in the places where Russian missiles hit, drone explosions, and projectiles of rocket salvo systems, in addition to the use of equipment that intensively burns oil products, heavy flame-throwing systems that fire thermobaric and incendiary ammunition. The Russian Federation bombards not only oil product warehouses but also chemical plants; for example, in the Luhansk region, as a result of the shelling of tanks with nitric acid on the territory of a chemical plant, a large cloud of toxic fumes was released into the atmosphere, which spread to the residential quarters of Severodonetsk. Clouds of toxic smoke were recorded near Bakhmut, probably due to damage to a section of the ammonia pipeline. As a result of attacks on objects of civilian infrastructure alone, more than 680,000 tons of oil and fuel were burned with the release of combustion products into the atmosphere.

A separate and hazardous threat to the environment is connected with the irresponsible attitude of the Russian occupiers to radiation and nuclear safety, which is confirmed by their shelling of the Southern Ukrainian NPP, their behavior in the exclusion zone, and at the Chornobyl NPP. From February 24 to March 31, 2022, the occupiers of the Russian Federation held the Chornobyl NPP, preventing the normal functioning and safe storage of spent fuel. Part of the Russian military in the Chornobyl exclusion zone suffered from radiation. When moving in, the so- called Clouds of radioactive dust rose into the air from the red forest of military equipment and the construction of fortifications. According to "Kyiv-INFO," 26 occupiers were hospitalized, one occupier died of radiation sickness as of April 1, 2022, and another 73 people have damage symptoms. On February 24-25, 2022, the radiation background in the exclusion zone was exceeded by 7.6 times. Further, the connection with the exclusion zone's Automated Systems of Radiation Control data was severed.

All four operating nuclear power plants in Ukraine are in the zone of possible damage by Russian missiles. One of the NPPs, the South Ukrainian one, is physically controlled by the enemy, deploys troops there, and conducts shelling. On 04/16/2022, the flight of three cruise missiles, probably from the territory of Belarus in the direction of Mykolaiv, was recorded over the site of the Southern Ukrainian NPP. On the morning of 06/05/2022, a Russian cruise missile (probably Caliber) flew low over the South Ukrainian NPP. According to the design characteristics, the protective cap of the station can withstand the fall of an aircraft weighing about 5.7 tons. Still, the nuclear power plant is not designed to be in the center of hostilities since the penetration capacity of missile and artillery systems is higher. On September 19, 2022, at 00:20, Russian troops launched a missile attack on the SUNPP industrial zone. The shelling was probably carried out by an "Iskander" missile (data from Deutsche Welle and UkrInform). The rocket exploded 300 meters from the nuclear reactor, forming a crater with a diameter of 4 m and a depth of 2 m. The threats for the first period of February 24-March 9, 2022, are disclosed in more detail in the official notification of the Ministry of

Natural Resources. Violation of the Geneva Conventions of August 12, 1949, the 24th Principle of the Rio Declaration on Environment and Development, and other acts and agreements are emphasized.

Soil pollution and mining of a large part of the territory may become a massive problem for Ukraine. Mine pollution is primarily a danger to the health and life of the population. Still, at the same time, it threatens the environment through several mechanisms: first of all, mines can cause the death of wild animals, including those listed in the Red Book; further, the extended stay of mine structures and systems in the soil makes this soil unsuitable for several uses for many years, and in the case of destruction of the mine body, pollution of the surrounding area may occur, in addition, a half-destroyed mine is practically impossible to neutralize by standard methods, except for detonation; finally, mining limits safe access both for monitoring the state of the environment and for its protection (such as flood prevention measures, firefighting, pest and disease control in natural ecosystems, etc.).

According to the notification of the State Emergency Service from 11/18/2022, up to 30% of the territory of Ukraine (which is 170 thousand square kilometers or the area of two Austrias) is mined or may be mined. Currently, intensive demining works are being carried out in the south of Ukraine in the de-occupied areas of the Kherson and Mykolaiv regions. According to estimates, demining should be carried out in the first of them on an area of 7 thousand square km, and in the second - about 1.5 thousand square km. In many districts of Kyiv, Chernihiv, Sumy, and Kharkiv regions, the local population is advised to refrain from visiting forests and other natural landscapes where there is a danger of encountering a mine. There are facts of the poisoning of law enforcement officers of the Ternopil Region, who worked at the rocket impact site, with substances contained in rocket fuel, because the aggressor's cruise missiles use low-resource turbojet engines running on T-10 decilin. This fuel is toxic for inhalation, which irritates the skin and is probably fatal when ingested. One X-101 rocket initially carries more than a ton of this fuel.

Damage to tree vegetation is a typical environmental disturbance in areas where intense hostilities occur and in the strip adjacent to these areas. Such damage can be caused by shelling and the movement of military equipment. Numerous cases were found in the Kyiv and Sumy regions when unexploded shells were stuck in trees and soil. Such munitions significantly threaten human life, health, and the environment. Such ammunition stuck in a tree is usually the result of secondary explosions when enemy equipment explodes, and ammunition is scattered over the area. The chaotic nature of the contamination of the territory with ammunition of this type increases the difficulty of neutralizing them and restoring the territory's security.

Significant environmental risks are associated with the barbaric attitude of the occupiers to water resources in general and to reclaim land in particular. Evidence shows that the unprofessional use of water for irrigation in the southern regions (Kherson region and Crimea) can cause secondary salinization of vulnerable soils and make cultural exploitation impossible.

An eloquent example of the ecological consequences of armed conflicts on the example of the aggression of the Russian Federation in Ukraine is the damage to hydrobionts of freshwater and marine ecosystems. Yes, many dolphins have been found dead in the Black Sea; there is evidence that this may be a consequence of the Navy's use of robust sonar systems. Presumably, this effect is enhanced by the migration of animals to the shallow water zone of the northwestern part of the Black Sea, where food is scarce. Such a migration could be initiated by the alarm factor and the phenomenon of the contusion of marine mammals due to explosions and movements of the military fleet. In addition to the deaths of dolphins, in particular, mass fish deaths in the Dnieper near the Kakhovskaya HPP were recorded in the Tuzlynsky Lyman NPP.

A hazardous environmental factor is the possible use of phosphorous ammunition by the Russian troops during the assault on Azovstal and in other places of hostilities. For independent confirmation of this and other violations of the rules of war and the commission of environmental crimes, it is necessary to

continue and improve the investigation into the aggressor's actions by collecting testimony and documentary evidence at all levels.

Conclusions

A significant impact accompanies the conduct of hostilities on natural ecosystems. No single theory would explain the ecological consequences of armed conflicts.

The environmental effects of modern warfare can be divided into local, regional, and global. By time and type of impact factor, it is possible to single out the impact on the environment associated with the preparation for war, the direct impact of the conduct of hostilities, and post-war environmental impacts associated with eliminating its consequences.

It is also appropriate to highlight military actions' direct and indirect consequences on the environment. Some damages to the environment of Ukraine cannot be estimated in financial terms. In addition to destroying unique ecosystems, the war erased decades of work on environmental protection in Ukraine.

Summary

One of the aspects of military conflicts is the environmental aspect. A specific and rather intense impact accompanies the conduct of hostilities and preparations for war on the environment. Although environmental damage is not usually a goal of warfare, such damage is integral to most armed conflicts. There is no single model of how war affects the environment. At the same time, like most human activity, war changes the environment, damaging natural ecosystems and destroying human habitats. Numerous attempts to classify the environmental consequences of military confrontation boil down to the fact that it is expedient to distinguish direct and indirect consequences at different scales and stages of military confrontation.

The destruction of the natural systems of Ukraine during the armed aggression of the Russian Federation and the associated environmental challenges are numerous and diverse: the use of ammunition and damage to enterprises of various industries, including the chemical industry, the release of radioactive dust into the air due to the movement of heavy equipment in the Chornobyl zone and strikes on nuclear reactors power plants and related infrastructure facilities, destruction of gas pipelines and oil storage facilities, numerous fires in populated areas, mining of large areas and the impact of shock waves and combustion products on components of natural and anthropogenically altered ecosystems, etc. It is also clear that the consequences of hostilities will affect nature, people, and society even after these actions end. In the risk zone are, among other things, the territories and objects of the NRF.

It is essential to record and document the facts of environmental crimes and develop long-term plans to neutralize their consequences.

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