

ECOCIDE IN UKRAINE AS A RESULT OF TARGETED RUSSIA'S WAR CRIMES

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The full-scale Russian invasion of Ukraine in February 2022 and the ongoing Russian-Ukrainian war have a dramatic impact on every aspect of life in Ukraine and beyond. Russia continues to commit innumerable war crimes. To make the perpetrator responsible for all its crimes requires painstaking recording, which by itself demands careful counting, estimations and forecasts highlighted in relevant internationally renowned publications. So far, only a handful of scientific reports have been published, mostly in Ukrainian language, with limited availability to the international community. A substantial category of war crimes is ecocide, a purposeful devastation of ecosystems with a potential to trigger environmental disasters. Up to now almost 5.3 thousand facts of the damage to the environment as a result of Russian aggression have been documented. Over 100 million tons of pollutants and 110 tons of poisonous substances were released into the air due to fires at industrial facilities and forests. About 860 thousand m² of land was contaminated and almost 20 million m² was clogged. Tens of thousands of tons of foreign objects were dumped into the land water bodies. Seawater also badly suffered. One of the most atrocious single-event damage to the environment was the destruction of the dam of the Kakhovka Reservoir on Dnipro River in June 2023. As a result, 61 settlements were flooded, 465 tons of oil most likely got into the Dnipro River, 333 biotic species were at risk of death.

The total damage caused to the environment in Ukraine by Russian invaders is more than EUR 57 billion. Here we present a report on the environmental crimes of Russian invaders to support the international efforts to stop the aggressor and to lay ground to holding the Russian regime responsible and getting full compensations for its crimes.

Keywords: ecocide in Ukraine, Russian invasion, environmental damage, war crimes, environmental devastation

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Introduction

Russian aggression against Ukraine is a gross violation of the fundamental principles of international laws. The war began back in 2014, when Russian troops occupied Crimea, and then invaded Donbas region in Eastern Ukraine. For eight years, thousands of Ukrainian soldiers and tens of thousands of civilians were killed by the enemy, often brutally attacking Ukrainian territory from behind the Russian border. On February 24, 2022, Russia started a new wave of its colonial war, which we now call as full-scale invasion, and the war crimes spread over the entire territory of Ukraine. Ukrainian army bravely resisted the aggressor and made them to pay high costs for their brutal actions. However, Russia has abundant resources and morbid imperial ambitions, which is very unfortunate not only to Ukraine but to the whole world.

Waging the war against Ukraine, Russia committed innumerable war crimes. The whole complex of such crimes can be divided into eight classes (Stakhiv & Demydenko, 2023a):

- war crimes against the civilian population (torture, rape, ill-treatment, executions);
- war crimes against military personnel;
- intentional destruction of civil infrastructure;
- socio-economic damages (deprivation of income, business, agriculture, industrial production, housing, schooling, destroyed networks of social services and poverty);
- chronic damage to health (military and civilian);
- damage to cultural objects (museums, libraries, historical buildings);
- damage to public welfare and mental health and mental trauma associated with bloody fighting, terror and everyday stress due to hostilities – for example, fear of bombing, loss of home, loss of livelihood, deportation, rape, robbery, torture, starvation or imprisonment;
- ecosystem degradation (for example, destruction and pollution of water bodies, damage to endangered species, fires in protected areas, unexploded mines).

Thus, environmental degradation is one of the classes of war crimes. The term *ecocide* is used in this analysis to describe the current Russian war crimes related to the environment. According to the Article 441 of the Criminal Code of Ukraine (VRU, 2001), ecocide includes mass destruction of flora and fauna, poisoning of air or water resources, and any other actions that may cause an environmental disaster, and shall be punishable by imprisonment for a term of eight to fifteen years.

Since the start of the full-scale invasion, an enormous amount of Russian military acts falling under the category of ecocide have already been documented (Kozachok, 2022). Moreover, during the previous eight years of the Russian-Ukrainian war and occupation, the invaders also committed countless acts of ecocide (forest fires, destruction of protected areas, planting of mines into vast territories, etc.).

Ecocide is more dangerous than just harming the environment. It destroys the possibility of restoring nature. Living organisms and their habitats get destroyed. That is, the components of inanimate nature (soil, surface and underground waters, atmospheric air, rocks) and their characteristics (relief, macro- and microclimate, etc.) are also subjects to the destructive influence of war.

Devastation of the environment has a very strong negative impact on human health. Indeed, people, like the other living creatures, depend on the state of the environment, including clean air, drinking water, healthy food, etc. In addition, the very sight of dead or wounded animals, burnt forests, soil damaged by shell explosions and other acts of ecocide causes irreparable damage to the mental health of the population.

Moreover, ecocide causes considerable damage to agriculture and food production, forestry and other sectors of the economy. Many of these sectors are highly dependent on free *ecosystem services* that cannot be provided by the destroyed environment. Thus, ecocide has a complex destructive effect both on the natural environment and on humans.

Methodology for assessment of the war damage to the environment

The State Environmental Inspectorate of Ukraine has developed a methodology for calculating damage due to emergency situations and/or under martial law. Damages caused by Russia's aggressive war estimated using this methodology exceed EUR 57 billion by August 2024 (EcoZagroza, 2024a). These damages were calculated based on US and EU standard practice methods

covering forestry, agriculture, water quality, soil and air pollution. Costs are calculated based on the principle of lost productivity, i.e. replacement cost of burned forests (cost of timber), lost production on contaminated agricultural land, costs of remediation of contaminated soil, air or water by conventional methods, etc. (Stakhiv & Demydenko, 2023a). The Ukrainian government uses a methodology based on forgone revenues from fees, taxes and other regulatory payments for pollution caused by municipal and industrial emissions. This figure is then multiplied by several factors to reflect the estimated damage caused by military destruction (Stakhiv & Demydenko, 2023a). As a result, the specified amount of losses is obtained, which is already approaching sixty billion euros. This figure is well out of line with the recent estimate of the *Second Rapid Damage and Needs Assessment (RDNA2)* carried out by the World Bank, which covered the first year of war, from February 24, 2022 till February 24, 2023. The RDNA2 estimated environment and forestry damages in the order of USD 2 billion. Damages estimated for the same time according to the methodology of Ukrainian government amounted to USD 27 billion (Stakhiv & Demydenko, 2023b).

The *RDNA2* methodology used definitions for damage as direct costs of destroyed or damaged physical assets and infrastructure valued in monetary terms with costs estimated based on replacing or repairing physical assets and infrastructure, considering the replacement price prevailing before the war. It means that the *RDNA2* analysis assesses only the costs of physical assets and infrastructure restoration. It does not consider the costs of pollution of the environment due to the destruction and non-functioning of many facilities, such as wastewater treatment plants and other industrial sites, nor for restoration of degraded ecosystem services or compensation for their impairment. Thus, for example, if a forest was destroyed, *RDNA* considers the cost of replacing the forest, but not for the loss of its ecological functions and services during the period it takes to regrow/replant the forest. Ukraine's damage assessment may be an overestimate but is likely closer to a full accounting of total environmental damages that should include all quantified degradation of terrestrial and aquatic ecosystems, soils, and forests (Stakhiv & Demydenko, 2023b).

The principles and methods of damage assessment that apply to the environment and ecosystems serve as the foundation for the financial compensation of war damages, and they are no different from those that apply to private property, commercial businesses, and public infrastructure. For example, compensation should include the valuation of all components of assets (read species, habitat) and company (ecosystem) value that were affected by the war, directly or indirectly. The *International Valuation Standards (IVS 2022)* have long been applied globally to determine asset and company value within numerous compensation adjudications. There are comparable valuation standards and methods for the environment, ecosystems and valued ecological resources developed by the UN, EU, USAID and the *U.S. National Strategy for Natural Capital Accounting* (Stakhiv & Demydenko, 2023b).

Various techniques for valuing ecosystem services are documented in the literature that are based on the use of remote sensing, satellite imagery, and geographic information systems (GIS) to estimate damage remotely (Markandya, 2019; Bartkowski & Massenberg, 2023; Laurans et al., 2013). For Ukraine, where the war has not ended yet, this is especially crucial.

Acts of ecocide recorded during the Russian aggression

During the full-scale war, 5 298 facts of causing damage and losses to the environment because of the Russian armed aggression have been documented up to now (August 2024)

(EcoZagroza, 2024a). That is, on average, more than six new facts are recorded every day. The number of such facts is constantly increasing.

Damage to atmospheric air

Air is the most dynamic component of the ecosystem. Atmospheric pollution, including those caused by the war, spreads the fastest and causes great damage to both the environment and human health.

Millions of tons of oil products were burned in Ukraine due to Russian attacks. This caused nearly 57 million tons of pollutants to enter the atmosphere. In addition, more than 49 million tons of pollutants entered the atmosphere due to forest fires caused by Russian invaders. Almost 70 000 hectares of forests were destroyed due to intentional and unintentional fires by Russian invaders (EcoZagroza, 2024b). Such an area is equivalent to the territories of Andorra and Malta combined.

About 2 million m^2 of other objects were destroyed by fires from Russian attacks. As a result, more than 290 000 tons of pollutants got into the atmospheric air. In addition to the above, emissions of poisonous substances into the air are equal to about 110 tons. The total damage caused to the air pollution exceeded 26.5 billion euros (EcoZagroza, 2024b):

- EUR 3.13 billion – due to the burning of oil products;
- EUR 23.2 billion – owing to the burning of forests;
- EUR 138.6 million – because of the burning of other objects.

Damage to soil and land resources

The southern and eastern regions of Ukraine became the biggest battlefields of the current war. These regions belong to the steppe natural zone of the country. In the conditions of an arid climate, the most fertile soils in the world, namely *black soils*, were formed here under the grassy vegetation. It is known that Ukraine is one of the world's largest producers and exporters of food thanks to its black soils. According to the *U.S. International Trade Administration* (ITA, 2020), Ukraine is one of the most fertile places in the world, containing 25-30 % of the world's black soil reserves with more than 40 million hectares of agricultural lands. Ukraine accounts for 6 per cent of all calories traded on the global market (HALO, 2024). Around 400 million people worldwide rely on Ukraine for their food supply, according to the *United Nations World Food Programme* (Yang, 2024). Four hundred million people – this is without taking into account the Ukrainians themselves.

More than 858,000 square meters were contaminated with chemicals by the Russian invaders. Much more land is littered with physical objects, almost 20 million m^2 . The total damage caused to the soil component exceeded EUR 25.8 billion (EcoZagroza, 2024d):

- EUR 25.45 billion – owing to soil contamination;
- EUR 375.2 million – due to soil litteration.

Ukraine, being one of the breadbaskets of the world, currently has its agricultural land badly decimated by landmines and other explosives. HALO (*Hazardous Area Life-support Organization*; a humanitarian non-government organization which primarily works to clear landmines and other explosive devices left behind by conflicts) estimates that up to 2 million landmines may have been laid since February 2022 in Ukraine. In Mykolaiv and Kharkiv regions, over 70 % of minefields or battle areas assessed by HALO for clearance contain tripwire devices, magnetic influence mines (which can be activated by the presence of metallic objects and by a change in the magnetic field around the mine), or seismic influence mines (activated by vibrations in the earth) (Ukraine, 2024).

As of July, 2024, more than 144 thousand km^2 of Ukraine are considered potentially mined. For complete demining of Ukraine, 37 billion dollars and more than 10,000 sappers are needed. To this, currently there are only 3 000 demining specialists available in the country (Kuzmenko, 2024).

Damage to aquatic ecosystems and resources

Ukraine shares the 32nd place among 40 countries in terms of drinking water provision in Europe and is one of the countries threatened by water scarcity. Importantly, 75 % of the water supplied to Ukrainian consumers is taken from surface sources. The existing problems with the outdated water supply stations and sewage treatment plants, which are unable to cope with the current loads and do not meet modern requirements for water and wastewater treatment, were worsened by the destruction and damage to water infrastructure, caused by the full-scale war (WAREG, 2023).

Due to Russian aggression, 36.4 thousand tons of foreign objects, materials, waste and/or other substances fell into land water bodies. Furthermore, almost 3 000 tons of contaminants were discharged into surface water. Additionally, the Russian occupiers arbitrarily collected and/or used almost 21 billion cubic meters of fresh water resources. Sea waters were also negatively affected. About 66 800 tons of pollutants were dumped into the waters of the Black Sea and the Sea of Azov. The total damage caused to the aquatic resources exceeded 1.9 billion euros (EcoZagroza, 2024c):

- EUR 199.8 million – due to the foreign objects, materials, waste and/or other substances;
- EUR 929.5 million – because of the contaminants;
- EUR 608.4 million – as a result of arbitrary collection/use of fresh water resources by Russian invaders.

In the report on the results of the *14th Meeting of the Conference of the Contracting Parties to the Ramsar Convention on Wetlands* (COP14, 2022), the following was noted: Russia's ongoing attack on Ukraine is a blatant breach of the UN Charter and fundamental principles of international law with acute environmental ramifications. Some 30 percent of the country's protected areas have been bombed, polluted, burned, or hit by military maneuvers. As a result, 33 % of our wetlands have been occupied or adversely affected. Around 600 000 hectares are suspected of being damaged. Moreover, 16 sites still remain under threat of direct military action (COP14, 2022).

If the specified 600 thousand hectares of wetlands of Ukraine lost at least 10 % of the potential of ecosystem services, Ukraine will lose more than USD 2.9 billion dollars in damages every year due to these reasons alone. These are losses calculated on the basis only of direct military damage to the wetland ecosystems, the area of which in Ukraine is much smaller than the area of cultivated lands damaged by enemy actions.

In the war, it is difficult to assess the damage caused to marine ecosystems. Due to their low salinity and seclusion, the Black Sea and Sea of Azov are considered natural riches with abundant biodiversity and uncommon biotopes (Sadogurska, 2023). In the sea, the first cases of the harmful impact of military activity were recorded back in 2014. After the seizure of the Ukrainian territories, marine ecosystems have systematically experienced negative impacts throughout the period of occupation, particularly as a result of construction of clandestine infrastructure, extraction of building materials, conducting military exercises, and changes in the status of protected natural areas. The most vivid example is the Crimean Bridge. Not only were the unique ecosystems and lake on Tuzla Island got destroyed as a result of the bridge's construction, but the migration routes of fish and cetaceans in the Kerch Strait were also cut off (Sadogurska, 2023). Consequently, the Sea of Azov became even more isolated and substantially deteriorated.

At least 2 500 dead dolphins, the Black Sea bottlenose dolphins: short-beaked common dolphins and harbour porpoises, had been washed up on shores between 24 February when the full-scale invasion started, and May 2022 (Barsukova, 2022). However, this figure is in fact significantly larger. Doctor Ivan Rusev, a Head of the Scientific Department of the *Tuzly Estuaries National Park*, has said that the sea normally washes up only about 5 % of all dead animals, while the remaining 95 % go to the bottom and can not be register. “Therefore, probably up to 50 000 dolphins have already died” (Barsukova, 2022). This is the fifth part of their total number in the Black Sea.

Damage due to destroyed military equipment

During the full-scale war, the Ukrainian army destroyed a large amount of enemy military equipment (Figure 1).



Figure 1. Destroyed Russian military equipment by August 10, 2024
(EcoZagroza, 2024e)

In total, 74 691 units of Russian military equipment were destroyed. This number is growing every day. As a result, around 1 210 600 tons of waste were generated. Furthermore, pollutants totaling to 111 000 tons were discharged into the atmosphere (EcoZagroza, 2024e). Up to 29 Russian Black Sea navy units were sunk in open waters or destroyed in ports, with all harmful pollutants, possibly even radioactive ones, found their way into the sea.

Environmental damage is also caused by the operating equipment. A vehicle weighing 10 tons compacts the soil to a depth of 60 cm. A tank can weigh over 40 tons. Consequently, in addition to releasing harmful plumes, burning, and killing, tanks and other armored vehicles spoil agricultural land, destroy biological cycles in ecological systems, and trigger a chain of vicious changes in the environment. Soil compaction causes a decrease in plant productivity in agroecosystems, with yields on compacted soils diminished by 40-60 % (Baziv, 2024). The damage caused by soil compaction by Russian tanks alone amounts to EUR 4.145 billion. In the long-term, given that soil recovery from heavy compaction takes many years, the losses can increase tenfold and reach EUR 41.45 billion (Baziv, 2024). Moreover, other military equipment has a similar destructive effect on various components of ecosystems and on the environment in general.

Thus, *the environmental devastation* inflicted upon Ukraine by Russian ecocide is dramatically large. Environmental damages in Ukraine due to Russian war crimes calculated by the State Environmental Inspection of Ukraine in accordance with internationally approved methods are, as already mentioned, more than 57 billion euros (EcoZagroza, 2024a). These days the ecocide in Ukraine due to Russian aggression goes on. For comparison, the revenues of the state budget of Ukraine in 2021 (before the destruction of the Ukrainian economy by the war) amounted to about 42 billion euros (MinFin, 2024).

The greatest one-time damage of Ukrainian environment caused by Russian terrorists

One of Russian war crimes with the worst one-time damage to the environment was the destruction of the dam of the Kakhovka Reservoir on the Dnipro River. The invaders took control over Kakhovka HPP already on February 24, 2022, during the first day of the invasion. Afterwards, it was mined and on June 6, 2023 detonated (EcoZagroza, 2024f). In a short time after the destruction of the Kakhovka HPP, more than 75 thousand hectares of land were flooded, which led to the dramatic degradation of the soil cover. Compounds of nitrogen, calcium and other nutrients were washed away from the ground by a destructive wave, as a result of which the fertile soil layer badly suffered (EcoZagroza, 2024f).

The area of flooded forests was 64.4 thousand hectares, with 4 big forestry enterprises affected in the Kherson and Mykolaiv regions. For comparison, 64.4 thousand hectares is more than twice the territory of Malta. Water from the reservoir arrived incredibly quickly downstream the Dnipro River. 61 settlements were flooded (EcoZagroza, 2024f): 30 settlements (3 801 houses) in Kherson region and 31 settlements (540 houses) in Mykolaiv region. Furthermore, 856 gardens were inundated, and 6.34 km² of agricultural land were flooded. More than two thousand people were evacuated from the flooded settlements, including 120 children and 38 people with reduced mobility (EcoZagroza, 2024f). A large number of homes, hospitals, kindergartens, and businesses were left without a centralized source of energy and water, as well as without access to transportation.

The equipment of the Kakhovka power plant and the oil storage before the explosion contained 465 tons of oil, which most likely got into the natural environment. The flooding zone also included the territories of the Kherson oil depot, river and sea ports, which are also places of concentration of oil products and hazardous wastes (EcoZagroza, 2024f).

In total, 333 species of animals and plants with various conservation statuses, as well as 25 types of habitats, are currently at risk of destruction. Nine *Emerald Network* sites are potentially affected (EcoZagroza, 2024f). The Emerald Network is a European-wide protected area network established to protect species and habitats that are threatened to extinction on a continental scale. This network is designed to comply with the Bern Convention requirements. Currently, the Network consists of 271 sites, covering 10 % of Ukraine (Emerald Network, 2024).

The following territories of the Emerald network are in the zone of influence of the destruction of the Kakhovka HPP dam (EcoZagroza, 2024f):

- UA0000037 – *Velykyi Luh National Nature Park*;
- UA0000192 – *Lower Dnipro*;
- UA0000109 – *Dniprovsko-Buzkyi Lyman*;
- UA0000215 – *Kinburnska Kosa*;
- UA0000017 – *Black Sea Biosphere Reserve*;
- UA0000097 – *Biloberezhzhia Sviatoslava National Nature Park*;

- UA0000207 – *Berezanskyi*;
- UA0000107 – *Oleshkivski Pisky*.

The Kakhovka reservoir itself was also an object of the Emerald Network – UA0000106 *Kakhovske Reservoir* – with an area of 218 119 hectares, recognized by the Council of Europe's *Convention on the Conservation of European Wildlife and Natural Habitats* (EcoZagroza, 2024f). This nature conservation object has been barbarically destroyed. The fauna of the Kakhovka Reservoir included more than 150 species of zooplankton and 55 species of fish. The wetlands associated with this reservoir were the habitat of more than 150 species of wild birds at various stages of their life cycle, including those protected by international treaties of Ukraine. On June 7, 2023, a mass death of aquatic biological resources was recorded, namely, 28 500 silver crucians (*Carassius gibelio*), as a result of a rapid decrease in the water level (8-10 cm per hour) in the water area of the Maryana Bay of the Kakhovka Reservoir (EcoZagroza, 2024f). In this way, the fishing industry also suffered dramatic financial losses.

A few *Ramsar* sites are potentially affected. *Ramsar* sites refer to sites listed on the List of Wetlands of International Importance (also known as the *Ramsar* List). These sites are designated because they meet the Criteria for identifying Wetlands of International Importance. The first criterion refers to sites containing representatives of rare or unique wetland types, and the other eight cover sites of international importance for conserving biodiversity (*Ramsar* site, 2024). The destruction of the dam and the sharp descent of large volumes of water from the Kakhovka reservoir led to a change in the ecological character of the *Ramsar* sites (EcoZagroza, 2024f):

- flooding of the *Dnipro River Delta* – resulted in the death of all mammals and other animals and the destruction of nesting birds;
- a radical change in the hydrological regime and the drainage of the *Archipelago Velyki and Mali Kuchugury* and *Sim Maiakiv Floodplain* – resulted in the death of a large number of ichthyofauna and other hydrobionts (mainly benthic organisms).

In the Kherson region, nine hunting grounds on an area of 395.03 thousand hectares were affected. On the territory of these hunting grounds, taking into account that the crime of ecocide was committed during the season of mass reproduction, the number of hunting animals was approximately: ungulates – 1 059 individuals; fur – 22 085 individuals; birds – 160 000 individuals. Another 8 hunting grounds on an area of 8 285 hectares were partially damaged in the Mykolaiv region (EcoZagroza, 2024f). So the total area of the affected hunting grounds exceeds 4 000 km². This significantly exceeds the territory of Luxembourg, Andorra, Malta, Liechtenstein and San Marino combined.

The destruction of the Kakhovka Dam by the Russian forces was also a catastrophe for the Black Sea. Dramatically large volumes of fresh water, contaminated with fuel and lubricants, fertilizers and sewage from flooded settlements and fields, entered the sea and spread over large areas (Figure 2).

Figure 2, compiled on the basis of satellite images, shows that in less than 10 days, the waters of the Kakhovka Reservoir spread by currents along the entire western coast of Ukraine in a strip with an area of more than 7 300 square kilometers. Certain ecosystems and species were in danger of going extinct. Already on June 15, 2023, polluted waters reached the mouth of the Danube and spread beyond the borders of Ukraine.

A salinity of seawater dropped from 14 to 4 ppm off the coast of Odesa in the early days following the demolition of the Kakhovka HPP dam, which caused many hydrobionts in shallow

waters to perish (Sadogurska, 2023). Scientists have observed acute toxicity in seawater in certain coastal sectors, with exceptionally high nitrogen concentrations at specific periods, which may be a sign of direct sewage pollution. The abrupt introduction of a significant amount of organic and mineral substances into the marine ecosystem caused phytoplankton to develop in massive quantities, which in turn caused a water bloom that, at its height, covered more than 70 % of the northwest Black Sea (Sadogurska, 2023). The estimated amount of damage caused to the environment as a result of the armed aggression of Russia in connection with the explosion of the Kakhovka HPP is EUR 1.27 billion (EcoZagroza, 2024f). The exact calculations of the damages still require further investigations, while currently it is impossible to carry out an accurate assessment of losses in the temporarily occupied territories.

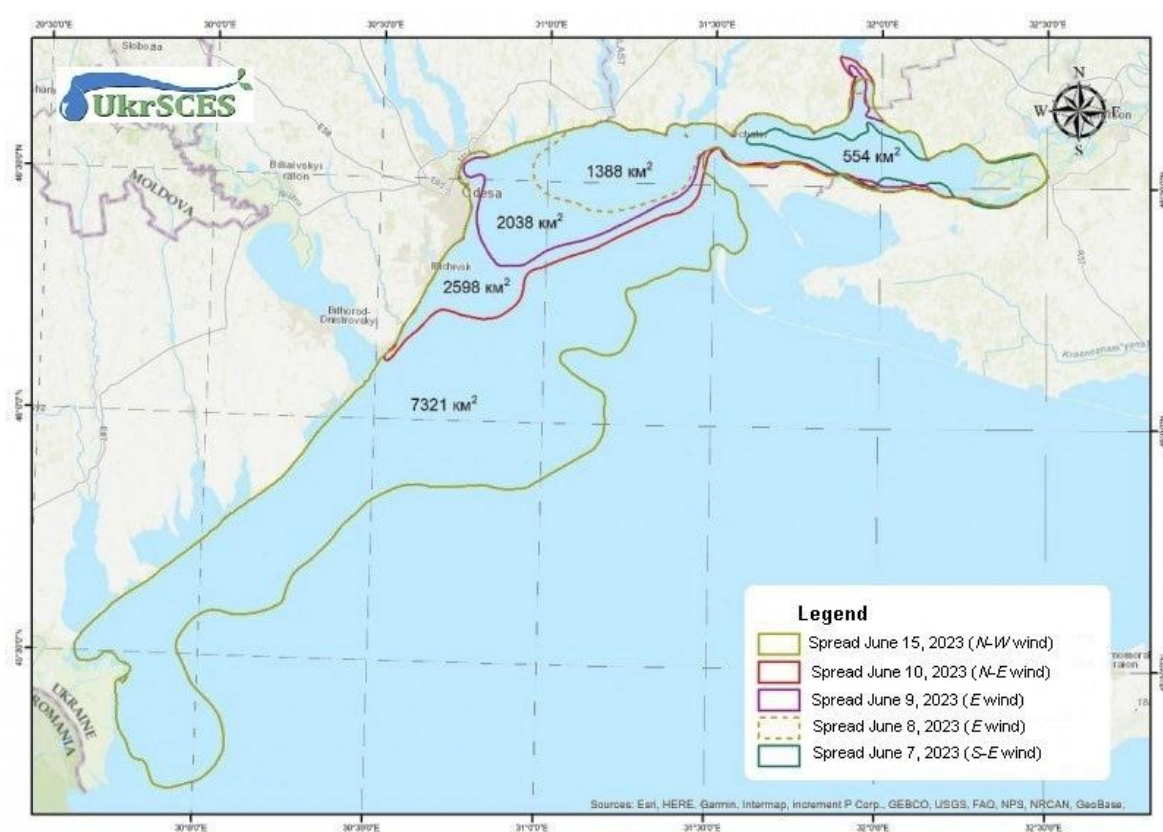


Figure 2. The spread of polluted river waters after the explosion of the Kakhovka HPP dam (USCES, 2023)

Conclusions

The Russian unprovoked war against Ukraine is a gross violation of the UN Charter and fundamental principles of international law with acute environmental consequences. Russia is employing war crimes tactics, including ecocide in its aggression against Ukraine. This essentially amounts to using nature as a weapon for purposeful devastation of ecosystems leading to environmental disasters. Over 5 thousand cases of environmental damage and losses caused by Russian invaders during the full-scale war have been already documented.

The damage caused to the environment in Ukraine due to Russian war crimes currently exceeds EUR 57 billion, which is comparable to the revenues of the state budget of Ukraine before

the war. The aggressor continues committing war crimes. It is still impossible to accurately calculate the damage caused to the environment in the temporarily occupied territories of Ukraine. In addition, the applied by the State Environmental Inspection of Ukraine damage assessment methodology does not take into account the costs of restoring degraded ecosystem services or compensation for their impairment. The scale of environmental crimes of Russian invaders in Ukraine is already unprecedented. It is in the best interests of the international community to take all possible measures to stop the aggressor and to force it to fully compensate the incurred damages.

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Conflict of interest

The authors state no conflict of interest.

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