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At war with nature. The impact of the Russian invasion on Ukraine's natural environment

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The Russian invasion of Ukraine, which started in February 2022, has caused not only the deaths and suffering of thousands of people, but also huge environmental damage. It has also exacerbated the enormous environmental problems of the Donbas (this region has been partially occupied since 2014) and has practically eliminated the chances for solving them in the foreseeable future. The hostilities have turned hundreds of towns and villages to ruins. The fighting was or is still taking place in industrial plants considered to be the biggest environmental polluters throughout the country, such as the Iron and Steel Works in Mariupol or the Avdiivka Coke and Chemical Plant. Trench warfare has turned hundreds of square kilometres of fields into scorched wastelands with contaminated soil and groundwater. Unique steppe and wetland ecosystems in the south and east of Ukraine, habitats of disappearing plant and animal species, were also destroyed. Russia's destruction of the Nova Kakhovka Dam resulted in the largest ecological disaster Europe has seen in many years: extensive flooding along the lower Dnipro and contamination of the waters of this river and the Black Sea.

The war may, however, become a catalyst for positive changes in the long run. The reconstruction of Ukraine may change the post-Soviet model of exploiting natural resources in the southern and eastern parts of the country which has so far been based on heavy industry and large-scale agriculture. In particular, the renaturalisation of what used to be the Dnipro River Floodplain (Great Meadow, Ukrainian: *Velykyi Luh*) provides the opportunity for the restoration of biodiversity in a region of Ukraine that has been most affected by human interference.

The prelude – Donbas in 2014

The natural environment in eastern Ukraine, which is the most industrialised part of the country, was in a bad condition even before the Russian military invasion in 2014; we could even speak of an ecological disaster in many places located in Donetsk and Luhansk oblasts. The intensive expansion of mining and heavy industry which has been underway for over a hundred years, combined with a disrespect for nature, has led to landscape degradation and permanent pollution of groundwater, soil and air. Mines and large industrial plants discharged highly mineralised water directly into rivers, and the infrastructure of sewage treatment plants was outdated and in bad condition. As a result,

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there were high levels of chemical and organic pollution in most of the rivers of the Donbas and the coastal waters of the Sea of Azov.

Mining and industry have generated huge amounts of solid waste which has been piled up to form over 1,200 heaps typical of the landscape of the Donbas. Since the heaps have not been professionally recultivated and are soaked with numerous toxic compounds, they have become a source of harmful dust and flash fires. Another problem is the degradation of the earth's surface, including ground collapses over mines as well as open-pit and bootleg mines that have a disastrous impact on the environment. Waste management was also one of the region's most serious problems before 2014. At the beginning of the 21st century, Donetsk oblast alone produced around 20–30% of the country's total hazardous industrial waste, which was stored in conditions that posed a serious risk to the environment. Since there were no garbage sorting and incineration plants, municipal waste in Donetsk and Luhansk oblasts ended up either in overflowing landfills or in illegal dumps.[1]

The hostilities in 2014 primarily resulted in increased pollution of groundwater, soil and air, caused by artillery shelling and fires of industrial plants and heaps. The industrial facilities affected by large fires include the Lysychansk Oil Refinery and the Avdiivka Coke and Chemical Plant. This raised fears of possible explosions of the most toxic chemicals (for example, ammonia and its derivatives, which were used in significant quantities at the Stirol chemical plant in Horlivka) and of a large-scale ecological disaster. Fortunately, this scenario did not play out. Damage to sewage treatment plants and water supply facilities during the fighting, as well as the lack of major overhauls and theft of metal infrastructure resulted in river pollution and serious problems with the supply of drinking water to the cities of the Donbas.

> **The armed conflict in 2014 and its political and social aftermath has further escalated the ecological problems that had already been present in the Donbas, so the region has practically no chance of systemically resolving these problems.**

The areas of the most intense clashes were additionally affected by landscape destruction as well as forest and field fires, mainly caused by artillery shelling. The Russian invasion in 2014 led to the bankruptcies of numerous mines, where saline water was no longer pumped out and began to seep into the soil and surface waters. The flooding of the mines also accelerated the process of ground collapse, which in the long run may have tragic consequences for the entire agglomeration. The armed conflict in 2014 and its political and social aftermath has further escalated the ecological problems that had already been present in Donbas; so the region has practically no chance of systemically resolving these problems.[2]

Environmental damage in the front and near-front areas

The primary destructive effect of the Russian invasion of Ukraine which started in 2022 is the degradation of the natural environment on the battlefield and its immediate rear. The areas that have been affected most of all are those where the hostilities took the form of trench warfare involving heavy use of artillery, tanks and other armoured vehicles. In the areas where manoeuvring operations were carried out in the first weeks of the invasion (Kyiv, Chernihiv and Sumy oblasts, the eastern part of Kharkiv oblast and the northern part of Luhansk oblast, and in the south: sections of Zaporizhzhia,

[1] *Воєнні дії на сході України – цивілізаційні виклики людству*, (ed. О. Кравченко), МБО «Екологія–Право–Людина», pp. 51–62, Lviv 2015, epl.org.ua.

[2] Main publications on this topic include: *Воєнні дії на сході України…*, *op. cit.*; *Environmental Assessment and Recovery Priorities for Eastern Ukraine*, Organization for Security and Co-operation in Europe, Kyiv 2017, osce.org. The issue of increasing ecological problems after 2014 in the so-called old occupied territories is not addressed in this publication.

Kherson and Mykolaiv oblasts), the losses are relatively small and – with a few exceptions – they can be self-regenerated by nature in a relatively short time span.

The territories most devastated by hostilities include: the border of Kharkiv and Luhansk oblasts along the Kupyansk-Svatove-Kreminna line, the areas along the Donets River stretching from the Russian border to the areas around Izyum, and vast areas of Donetsk oblast located on both sides of the 2014 demarcation line and further west to the current front line. In the south of Ukraine, the greatest devastation has been seen along the front line in Zaporizhzhia oblast (in and around Huliaipole, Polohy, Tokmak, Orikhiv and Vasylivka), in the western part of Kherson oblast (almost the entire area saw intense clashes from March to November 2022), on the Kinburn Peninsula and along the left bank of the Dnipro from Hola Prystan to Nova Kakhovka.

A total of 20,000–30,000 km² of Ukraine's territory is in fact the theatre of intense hostilities and their immediate rear.[3] With a few exceptions (see below), these are areas highly affected by human activity, primarily by mining, heavy industry and large-scale agriculture using a network of irrigation canals. Hundreds of places, including Mariupol, Sievierodonetsk, Lysychansk, Bakhmut and Avdiivka, have been partially or completely destroyed there. Clashes in villages and cities have led to huge amounts of garbage and construction waste being piled up, as well as the contamination of groundwater due to the damage of sewage treatment plants and infrastructure.

> **Some areas where the trench warfare was most intense may not be fit for any human activity for decades not only due to unexploded ordnance but also due to the high level of soil contamination with chemicals and metals.**

The destroyed industrial facilities include the Illich Iron and Steel Works and Azovstal in Mariupol, the Avdiivka Coke and Chemical Plant and the Azot chemical plant in Sievierodonetsk, which were known as Ukraine's worst polluters before the war. Some of the fights were taking place directly at waste storage sites, as was the case with the long clashes around the landfill in Bakhmut or near the heap at the Avdiivka plant. One of the most visible consequences of the war outside built-up areas is soil degradation caused by artillery fire and the formation of craters, the construction of field fortifications, the use of heavy armoured equipment and the penetration of harmful substances into the ground: fuels, lubricants, phosphorus from incendiary ammunition, fuel from unexploded rockets, etc. The decomposing dead bodies of people and animals from farms located in the areas affected by the clashes are another source of contamination. One more characteristic element of the trench warfare landscape are the vast amounts of garbage left by soldiers in the trenches and in the rear.

Fighting often takes place in the immediate vicinity of watercourses. The lower Dnipro as well as the Donets and its tributaries (the rivers Oskil, Zherebets and Bakhmutka) have been affected most of all. The Donets River suffered one of the worst disasters as a result of the hostilities in May 2022, when the Ukrainian army thwarted the enemy's attempt to cross the river near the villages of Serebryanka and Bilohorivka. About a hundred tanks and armoured vehicles were destroyed, and some of them remained in the river along with human corpses, ammunition, fuel and batteries.

At this point, it is difficult to assess the degree of soil and groundwater degradation caused by warfare in Ukraine, mainly because the war is still underway, and research has not been conducted on a regular basis. The clearing the area of garbage and construction waste and disposing of toxic materials on the premises of destroyed industrial plants alone will require huge resources and will

[3] Author's estimates based on the DeepState map (deepstatemap.live) taking into account changes in the route of the front line from February 2022 to November 2023 and the intensity of fighting in individual sections of the front.

take many years. Some areas (for example, around Bakhmut or Avdiivka), where the trench warfare was most intense, may not be fit for any human activity for decades not only due to unexploded ordnance but also high level of soil contamination with chemicals and metals.

Destruction of valuable ecosystems

When it comes to environmental protection and biodiversity conservation, the most tragic consequence of the Russian invasion of Ukraine is the devastation of unique ecosystems. This primarily concerns small fragments of primary steppes (mainly in the Donetsk Upland), wetlands at the mouth of the Dnipro and sections of the coastland of the Black Sea and the Sea of Azov.

Most of the theatre of war is, geographically, a steppe zone, where lush plant life has been destroyed by human activity over the past two centuries, mainly as a result of agricultural development. It is estimated that before the war, the natural vegetation of the Ukrainian steppe zone had been preserved to a maximum of 5–10% of its area. Fragments of the steppes could still be found mostly in places that are of little use for agriculture, such as ravines, steep edges of river valleys, mounds, sandy fluvial terraces, as well as in single, isolated reserves situated amidst arable fields.[4] Russia dealt them the first blow in 2014, when some of the protected areas, which are part of the Ukrainian Steppe Reserve (Donetsk Oblast) and the Luhansk Nature Reserve, were occupied, and some in the war zone.[5] The 2022 invasion brought further losses. The front line ran first through the Stanytsia-Luhanska Reserve and the Triokhizbensky Steppe Reserve, which had been established to protect fragments of floodplains and riparian forests on the Donets River and the sandy steppe.

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Steppe grasslands, natural pine forests, bairak forests and the floodplains of the Donets situated along the river from Izyum to Kreminna, including the Chalk Flora Nature Reserve near Siversk, have also been damaged. Another valuable complex largely devastated by the war is the remains of the sandy steppes situated by the lower Dnipro, which used to be partially protected as part of the Black Sea Biosphere Reserve. The Russians built a network of earth fortifications and minefields in the steppes, and part of the area burned down in fires caused by artillery shelling. If a Ukrainian offensive is launched on the left bank of the Dnipro, there is a risk of the complete destruction of this delicate ecosystem, which is home to the sandy blind mole-rat, a rodent endemic to this area which was at risk of extinction even in peacetime.[6] Additionally, since the first days of the war, the Askania-Nova Biosphere Reserve has been occupied – it is the most important area in the country protecting the remains of the chernozem steppe. Fortunately, it has not suffered any serious damage so far.[7]

Another category of valuable ecosystems significantly affected by warfare are the coastal areas and the mouth of the Dnipro River located outside the steppe proper, which are a haven for waterfowl. The shelling and wildfires led to the destruction of the pine forests, dry grasslands, salt marshes and wetlands in the Kinburn Peninsula, where the Russians had been building fortifications and artillery positions since spring 2022. The remaining part of the Black Sea Biosphere Reserve (primarily one of

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[4] See B. Sudnik-Wójcikowska, I. Moysiyenko, *Kurhany na „Dzikich Polach" – dziedzictwo kultury i ostoja ukraińskiego stepu*, Wydawnictwa Uniwersytetu Warszawskiego, Warszawa 2012, wuw.pl.

[5] *Воєнні дії на сході України…*, *op. cit.*, pp. 106–108.

[6] І. Загороднюк, 'Пріоритети в охороні природи в умовах війни: ситуація з Великим Лугом і Великим Степом', *Вісник НАН України*, no. 9/2023, p. 17.

[7] Д. Сімонов, 'Дім дикого степу. Як «Асканія-Нова» понад рік працювала в окупації під українським прапором', Українська правда, 23 April 2023, pravda.com.ua.

the largest fragments of natural sagebrush steppe and salt marshes in Ukraine in the Yahorlyk Kut peninsula) is located in the frontline zone under the control of the invaders. They turned Dzharylhach Island, one of the last fragments of wild sandy beaches on the Black Sea, into a military training ground and covered with sand the strait connecting the Dzharylhach Bay with open waters. A massive fire broke out on the island in August 2023 and destroyed the dry grasslands and the salt marshes.[8]

The contamination of the Black Sea and the impact of the Russian navy's activity on the aquatic fauna, especially dolphins, which are extremely sensitive to submarine activities and the launch of water-to-surface missiles, is a separate problem.[9] The conflict has also contributed to the increase in river pollution from the Sea of Azov catchment area (mining, industrial and municipal sewage from Donbas, including from the destroyed Mariupol). This reservoir, next to the Dnipro-Bug estuary, seems to have suffered the greatest damage as a result of the invasion.

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Another serious threat results from the disruption of animal migration routes, primarily one of the three main Ukrainian bird migration routes running along the northern coast of the Black Sea, where key breeding and feeding areas are located in the fighting zone. These are the lower Dnipro valley, including the estuary, and the Kinburn and Yahorlyk Kut peninsulas, as well as the vast wetlands of the Syvash situated on the border of Kherson oblast and Crimea, which are currently in the rear of the frontline. The war has also had an impact on land migration routes on the border of Ukraine, Belarus and Russia, where a network of fortifications with minefields was built. This may lead to a reduction in the population of large animals, such as Eurasian elks, wolves, lynxes and brown bears.

Destruction of the Nova Kakhovka Dam

On 6 June 2023, Russian troops detonated a section of the Nova Kakhovka dam. As a result, there was an uncontrolled release of water from the Kakhovka Reservoir covering an area of over 2,100 km^2 and flooding of the lower Dnipro valley. The worst disaster affected the reservoir area – its ecosystem (although artificial it had been functioning for decades) was destroyed, as a result of which thousands of tonnes of dead animals began to decompose. The flood led to the contamination of the Dnipro River and the Black Sea with fragments of buildings, human waste (there were thousands of holiday plots without sewage systems on the islands on the Dnipro), fuel and artificial fertilisers and other chemicals stored in warehouses. The seawater has not been tested due to ongoing hostilities, so it is difficult to assess the extent of contamination of the Dnipro-Bug estuary and the Black Sea. However, fears of an epidemiological disaster in southern Ukraine turned out to be unfounded: according to research carried out on the right bank of the Dnipro at the turn of August and September, sanitary standards were exceeded only in some water intakes and by no more than 10%.[10]

According to biologists, the effects of the dam's destruction are not as disastrous for the area of the former Kakhovka Reservoir as had initially appeared to be the case. The Dnipro has roughly returned to its pre-dam bed, leading to the restoration of a natural mosaic of meadows, wetlands and oxbow

[8] 'Збитки на мільярди гривень: пожежі на окупованому РФ Джарилгачі на Херсонщині знищили екосистему заповідної зони острова', Суспільне Новини, 10 August 2023, suspilne.media.

[9] Д. Сімонов, 'Море катастроф і надій. Як війна ставить небувалий експеримент над природою Чорного моря', Українська правда, 11 December 2022, pravda.com.ua. The cruiser Moskva was sunk near Zernov's Phyllophora Field marine botanical reserve, where the remains of a colony of red algae that were huge several decades ago are protected over an area of 4,025 km^2. Since there is no access to this place, it is impossible to estimate the impact of the ship's sinking on this valuable ecosystem, which had been at risk of complete destruction until the reserve was created in 2008.

[10] Л. Ільченко, 'Україна ліквідувала наслідки теракту на Каховській ГЕС: вдалося уникнути найгіршого', Економічна правда, 4 September 2023, epravda.com.ua.

lakes stretching from Khortytsia island in Zaporizhzhia to the vicinity of Nova Kakhovka, which were known as the Great Meadow (Ukrainian: *Velykyi Luh*) before the flooding. It seems that all fish species previously living in the reservoir survived the outflow of water in the depressions, which will allow for a quick and natural restoration of the ichthyofauna. Most importantly, the dry bottom of the reservoir began to quickly become overgrown with native flora, especially willow and poplar. Due to this, the fears about dust storms and the release of harmful substances from the factories and sewage systems of large cities, which had been deposited at the bottom of the reservoir for the last few decades, turned out to be unfounded.

There is every reason to believe that the restoration of the riparian forests and meadows will accelerate the natural process of soil cleansing. This positive turn is primarily the result of a fortunate coincidence: the dam was breached at the beginning of June, so tree and grass seeds could germinate and grow, and the warm summer accelerated the process of decomposition of dead animal mass.[11]

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Prospects

Given the fact that life scientists are unable to conduct research in the occupied territories and areas of direct hostilities, and that we should not expect the war to end in the coming months, it is difficult at this point to fully assess the negative impact of the war on the natural environment of Ukraine. Some consequences will be long-term and their scale will only be known years later (for example, the flooding of mines in the Donbas is causing land subsidence and the salinisation of soil and surface water). Other potential long-term threats are related to the expansion of the so-called dead water zones in the Black Sea, the destruction of endemic populations of plants and animals (including insects and steppe rodents) and the reduction of the population of some animal species as a result of the disruption of migration corridors.

The Russian invasion may also, surprisingly, have positive consequences for nature in the long run. It led to the destruction of some large industrial plants which had a reputation of being the worst polluters in Europe due to the outdated technologies they used. These companies will either cease to function altogether or they will have to be rebuilt from scratch, using modern solutions, including so-called green technologies. The destruction of the Nova Kakhovka Dam has created the opportunity to improve the sustainability of water management and agriculture in southern Ukraine. In other words, the war may become a catalyst for at least a partial departure from the legacy of the Soviet economy, symbolised by smoking factory chimneys, field drainage systems and the Nova Kakhovka Dam, one of the ‘great construction projects of communism’ dating back to the 1950s.[12]

Much depends on the vision for the country’s reconstruction that will be developed and adopted by the Ukrainian government. So far, representatives of the government and the Office of the President have been eager to speak on this topic, emphasising the scale of destruction that the Russian invasion has brought to Ukraine’s natural environment, and often using the term ‘ecocide’ in this context.[13]

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[11] *Интервью на дне Каховского моря. Каким будет Днепр?*, Латвийские общественные СМИ, 23 October 2023, rus.lsm.lv.

[12] One of the greatest absurdities linked to building the network of irrigation canals in the south of Ukraine that were fed from the Nova Kakhovka Reservoir was the creation of rice fields in the previously waterless areas of Skadovsk and northern Crimea.

[13] The term ‘ecocide’ was coined in the 1970s to refer to serious crimes against the natural environment. It was also introduced in the Ukrainian Criminal Code of 2001, but not a single verdict was issued on this account until 2022.

Although it is absolutely justified to condemn the aggressor and demand reparations, still no comprehensive state-financed plan for natural research has been presented since 2014. The research which is currently being conducted, for example on sea pollution and fauna or the destruction of the steppes, is usually the result of the initiative of individual scientists or non-governmental organisations.[14]

All this taken into account, the discussion concerning the plan to rebuild the Nova Kakhovka Dam is particularly disturbing. It goes beyond the issue of ecological catastrophe and brings together the most important problems regarding the approach to the use of natural resources. The main lobbyist for the reconstruction of the dam and artificial reservoir is the state-owned company Ukrhydroenergo.[15] All biologists agree that, if these plans are implemented, this area will suffer from an ecological disaster for a third time, after the destruction of the original *Velykyi Luh* in the 1950s and the tragedy of 2023. When the war is over, the government needs to take into account the needs of the natural environment and people, and step away from Soviet projects dating back to the early 20th century. The renaturalisation of the *Velykyi Luh* will have a great impact on restoring biodiversity in southern Ukraine. This does not have to mean a complete economic collapse in Kherson and Dnipropetrovsk oblasts and their depopulation (this vision is often presented by the bureaucratic and industrial lobby that opts for the reconstruction of the dam). It will still be possible to draw water for nearby towns, industry in the Kryvyi Rih Basin, the Zaporizhzhia Nuclear Power Plant and for the local irrigation of fields and gardens from the Dnipro. To enable this, it will be necessary to build new intakes and pipelines, as well as small retention reservoirs. This infrastructure will be built, at least partially, in the next few years anyway, because local communities will have to supply water without waiting for the hypothetical reconstruction of the artificial reservoir in the distant future.

The only problem that cannot be solved without rebuilding the dam is the irrigation of distant fields. This does not necessarily mean that land cultivation will be abandoned completely. A large part of the area in Kherson oblast was not artificially irrigated before the dam was destroyed, and yet it was cultivated binging yields only slightly lower than in the areas served by the canal network.[16] As long as the war continues and the south of the country is under Russian occupation, discussions of this type are only theoretical. However, they show the dilemmas Ukraine will have to face in the future.

[14] Д. Сімонов, 'Екоцид, каховська гребля та розмінування. Про кого забули на «United for Justice. United for Nature"', Українська правда, 23 October 2023, pravda.com.ua.

[15] І. Орел, 'Україна вирішила будувати нову Каховську ГЕС за $1 млрд. Чи дійсно вона потрібна? Пояснює керівник «Укргідроенерго» Ігор Сирота', Forbes, 24 July 2023, forbes.ua.

[16] І. Загороднюк, 'Пріоритети в охороні природи в умовах війни…', *op. cit.*; conversation with Professor Ivan Moysiyenko from Kherson State University.