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5 WIDE-RANGING ENVIRONMENTAL EFFECTS OF THE ACTIVE CONFLICT IN UKRAINE

Brief overview of the conflict. – 2013 may have been the year when the root of the ongoing invasion of Ukraine by the Russian Federation was first unveiled. That year, Viktor Yanukovych, the President of Ukraine at the time, decided to shift the country's international alliances from a deepening connection with the European Union (EU) to a renewed one with the Russian Federation. When this new strategy became public, large protests erupted on the streets of Kyiv and across Ukraine. Known as the Euromaidan protests, these peaceful demonstrations against the government reached a breaking point on January 22, the day of Ukraine's unification, when several protesters were shot, and one was found beaten by authorities in the woods outside Kyiv.

In mid-March 2014, the President of the Russian Federation, Vladimir Putin, declared the annexation of Crimea. Although Crimea was part of the sovereign territory of Ukraine, for the President of Russia, the country, and the pro-Russian populations of both Russia and Ukraine, this territory was now considered part of Russia by all means. This act followed armed intervention by forces of the Russian Federation, a referendum, and a declaration of independence in Crimea. «Outside the context of decolonization, few claims of annexation following the use of force have been made during the United Nations era; this is the first by a permanent member of the Security Council against a United Nations member» (Grant, 2015).

Armed conflict erupted in eastern Ukraine after Crimea's annexation, centered in Donetsk and Luhansk. Pro-Russian separatists, backed by Russia, declared independence, leading to prolonged clashes with Ukrainian government forces. President Petro Poroshenko initiated military operations to reclaim these areas, resulting in a protracted armed confrontation. The conflict caused severe humanitarian devastation, with thousands dead and hundreds of thousands displaced. Both sides faced accusations of human rights abuses, including targeting civilians and using landmines.

The conflict that began in 2014 and continued until 2022, culminating

in a full-scale invasion of Ukraine by Russian forces, can be characterized as a mixed-intensity conflict. The intensity of such conflicts is typically assessed based on factors such as the frequency of violence, the use of heavy weaponry, and the level of casualties incurred.

Since the invasion in February 2022, the conflict in Ukraine has intensified, marked by heavy fighting, significant civilian casualties, and widespread displacement. Russian forces have advanced into Ukrainian territory, triggering a humanitarian crisis and drawing international condemnation and support for Ukraine's defence. Multiple attempts at negotiation have been proposed by various international actors, albeit in a somewhat tentative manner. Efforts to encourage negotiations, like economic sanctions imposed by the Western world on Russia, have seen limited success in quelling the conflict.

Meanwhile, the European Union, its member states, the US Congress, and other Western allies have strongly supported Ukraine financially and militarily. Conversely, Russia has diversified its commercial partnerships, shifting to China and North Korea to other *BRICS* countries, focusing increasingly on military assistance rather than just economic ties.

According to Antony Blinken Secretary of State of the United States of America, interviewed by the BBC: «China has become a key partner for Russia amid sanctions over the Ukraine conflict. While denying direct arms supply, China provides critical components essential for Russia's military production, including machine tools and microelectronics» (Ng, Ma, 2024).

Although with a different approach also North Korea and Russia tightened their cooperation. As reported by the New York Times: Mr. Putin and North Korea's leader, Kim Jong-un, agreed that if one country found itself in a state of war, then the other would provide "military and other assistance with all means in its possession without delay," according to the text of the agreement released Thursday by the North's official Korean Central News Agency (Motoko, Sang-Hun, 2024).

How is the environmnet influenced by armed conflicts? – Armed conflicts have impacted the environment for many decades, if not centuries. Since the beginning of the 20th century, this impact has grown substantially due to several factors: the deployment of larger troops, the expansion of conflicts to a global scale, the use of increasingly polluting vehicles and equipment, the introduction of more destructive explosives and ammunition, the

deployment of bigger arms, the use of airstrikes and long-distance missiles, and the resulting greater devastation, deforestation, and destruction of infrastructure. Additionally, the nature of the present ecosystem, biodiversity, and the duration and intensity of conflicts further exacerbate the environmental impact.

According to the Council of Europe: Environmental damage resulting from armed conflicts can be multifaceted, severe, long-lasting and mostly irreversible. It not only harms natural habitats and ecosystems but can also affect human health well beyond the conflict area and long after the conflict is over. The human rights to life and to a healthy environment are thus undermined.

Furthermore, it is worth mentioning that the causes of environmental consequences can be subdivided into three categories: pre-conflict, intra-conflict, and post-conflict. Pre-conflict emissions and the destruction caused by military activities prior to "boots on the ground" are often overlooked but can be very costly to the environment. These emissions include the environmental costs of producing and maintaining equipment, vehicles, aircraft, vessels, and arms, as well as training and maintaining troops. Additionally, the use of explosives and arms during training contributes significantly to environmental degradation. It is important to note that calculating the precise emissions and effects of military activity is often very complicated. This complexity arises from the widespread distribution of troops, vehicles, vessels, aircrafts and bases, as well as the difficulty in accessing this information, which is usually classified.

A significant portion of emissions from military activity pollutes the earth even before conflicts begin. The Conflict and Environment Observatory notes how military activities, from building and maintaining forces to training, consume vast resources, including metals and oil, and contribute to 5.5% of global greenhouse gas emissions. They also occupy significant land and sea areas, often disrupting ecologically important regions. In The Netherlands, for instance the military sector accounts for approximately 2 to 5% of the national energy consumption. Additionally, the military uses various toxic and rare elements like thallium, thorium, copper, beryllium, cadmium, zinc, and lead, which make up about 10 to 40% of their national consumption of these elements (Vertegaal, 1989).

Though, the largest portion of environmental damage associated with armed conflicts occurs during the actual conflict, leaving long-lasting

effects that can persist for centuries. The extent and severity of this damage can vary greatly from one conflict to another. Several factors influence the environmental impact of military activities, including the duration and intensity of the conflict, the geographical area affected, the infrastructure involved and targeted, the size of the population, and the nature of its displacement.

The most common and direct environmental consequences of wars during the ongoing fightings are: CO2 emissions, air pollution caused by pulverisation of building materials in urban areas, damage to landscapes, large scale pollution incidents caused by targeted infrastructure, deforestation, toxic, polluting and/or radioactive elements contained and released by abandoned military scrap and/or explosions.

A significant cause of environmental damage is the disposal of weaponry and other military equipment at the end of their lifecycle, even if they have never been used in battle. The lack of effective national regulations on the proper disposal of this equipment often leads to the use of unsafe and environmentally harmful methods. As a result, burning or detonation is frequently employed as the primary disposal technique.

Most of us recall shocking environmental damage in global conflicts, like Agent Orange in Vietnam used in the 70's and Kuwait's burning oil wells in the 90's. Sadly, such conflicts still harm people and the environment through pollution, infrastructure damage, and governance collapse worldwide. In Kabul, the capital of Afghanistan where conflicts have been going on since 1978, almost 3,000 people died in 2018 from diseases attributable to air pollution. That's more victims than the war provoked in the same year. Among the main causes of this phenomenon, writes the specialist portal Lifegate, is the conflict itself (Dumčiūtė, Tecleme, 2023).

In post-conflict scenarios, according to the Conflict and Environment Observatory: land rights disputes and environmental pressures often arise due to returning populations, causing increased deforestation rates. Additionally, military presence during and after conflicts can lead to pollution issues, including hazardous pollution from practices like burn pits and soil degradation during landmine clearance efforts, impacting both veterans and local communities.

How is the war in Ukraine affecting the environment? – Since the beginning of the war, the infrastructure of Ukraine has suffered significant damage as a

result of the conflict, impairing essential services like energy, water, food, waste management, health care, education, housing, transportation, and the manufacturing of industrial and agricultural products. The presence of 15 reactors at four operational nuclear power plants and numerous radioactive sources at other locations in Ukraine have raised concerns about nuclear hazards as a result of this destruction, which has also resulted in environmental contamination, including toxic chemical releases from damaged industrial facilities (Raccioppi, 2022).

This paragraph aims to review the existing research on the environmental consequences of the Russo-Ukrainian war and further deepen this research by providing additional insights. Our goal is to identify the key aspects most pertinent to our paper. We will achieve this by carefully selecting relevant findings, avoiding redundancy, and maximizing the utilization of valuable insights from prior studies. Additionally, it is crucial to reemphasize the inherent challenges in conducting research during an ongoing conflict. Obtaining unrestricted access to non-classified information, particularly military data, is limited and discouraged by the involved parties. Furthermore, access to the conflict zone for researchers, international organizations, and non-governmental organizations (NGOs) is hindered due to safety concerns. Significant and reliable sources for obtaining on-ground environmental data are the Ministry of Environmental Protection and Natural Resources of Ukraine and the Ukraine War Environmental Consequences Work Group.

The Ministry calculated that up to September 2023 the environmental cost of the war in Ukraine is about 57 billion US dollars. According to the State Emergency Service of Ukraine (SESU), from February 24, 2022, to September 22, 2023, a total of 433 270 explosive items were neutralized on the territory of Ukraine. An area of 967 square kilometres has been surveyed.

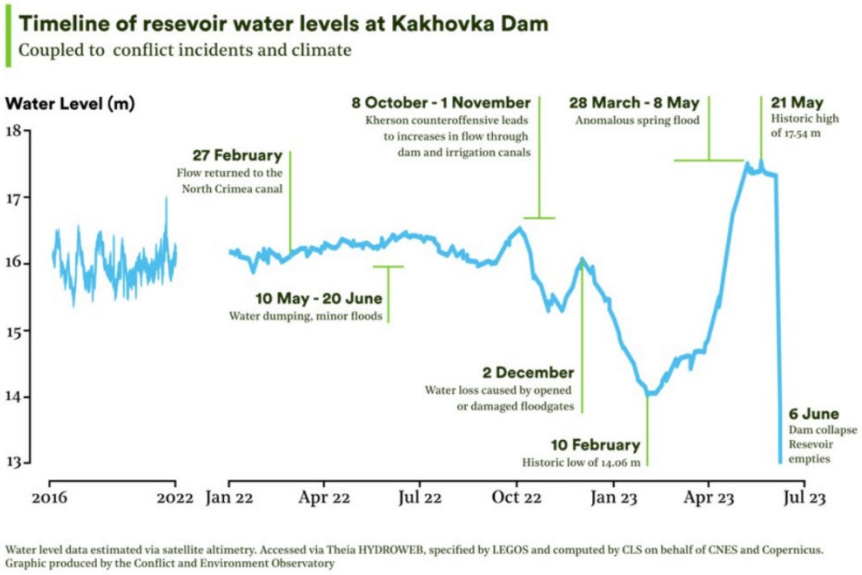
Direct environmental impacts include emissions from bombarded oil refineries, gas pipelines, and damaged water and sewage treatment facilities. Indirect environmental problems are significant, and the ongoing war could worsen the situation and harm global climate policy. Sanctions and global condemnation affect critical climate research collaborations in Russia. The war has also led to relaxed environmental regulations, prioritizing defense and economic needs over conservation.

One of the major environmental disruptions since the beginning of the Russia-Ukraine War occurred on June 6, 2023. The Kakhovka hydropower

plant on the Dnipro River in Ukraine, along with its spillway dam and adjacent structures, was completely destroyed. This caused extensive flooding in four cities and several dozen villages downstream, resulting in numerous fatalities and significant damage to industrial and urban infrastructure. Additionally, bacteriological and chemical pollution has been detected in the lower Dnipro River and the north-western Black Sea. The destruction also disrupted water supplies for large agricultural areas, several cities, and major energy facilities, including the Zaporizhzhia nuclear power plant (Vyshnevsky, 2023).

The Ministry of Environmental Protection and Natural Resources of Ukraine estimated that the economic cost of environmental damage from the Russian destruction of the Kakhovskaya HPP dam is approximately €3.66 billion. The flooding affected 1,144 populated areas, reduced the water volume by 14.395 billion cubic kilometers, and inundated 263,447 hectares of forests.

Fig. 1 – *Water level in the Kakhovka Reservoir prior and at the moment of the breach of the dam*



Source: water information is acquired via satellite images by Theia HYDROWEB Conflict and Environment Observatory, 2024

Further consequences include:

- At least 150 tons of oil leaked into the Dnipro River, potentially reaching the Black Sea.
- Destruction debris may also end up in the Black Sea.
- Over 80 settlements are at risk of flooding from the dam, which held 18 cubic kilometres of water.
- 333 species of animals and plants, along with 25 habitats, are threatened.
- Critical ecosystems, including several national parks and protected areas, face potential permanent loss.
- 9 Emerald Network sites and 5 Ramsar sites are potentially affected.
- Water supply from the Dnipro River to Crimea is disrupted due to critically low reservoir levels.

Assesment of water resources. – Water is essential for all forms of life on Earth and plays a crucial role in various aspects of our daily existence, Water is vital for human survival but is also crucial for the environment. It sustains ecosystems, helps plants and trees grow, and supports the habitats of countless species. It is essential for the survival of both aquatic and terrestrial life. Similarly, also agriculture is heavily reliant on water. Crops require water for growth, and efficient irrigation systems are crucial for maintaining food production. Adequate water supply is necessary for food security. Ukraine is one of the world's major grain producers. The country mainly grows and exports, wheat, corn and barley. According to the European Commission, Ukraine accounts for 10% of the world wheat market, 15% of the corn market, and 13% of the barley market. With more than 50% of world trade, it is also the main player on the sunflower oil market (Eisele, 2022).

At the same time, water resources within Ukraine are not as diffused, making water supply relatively scarce, compared to the necessity and size of the area. Ukraine's main river catchments are the Dnieper (with Desna and Pripyat tributaries), Siverskyi Donets, Southern Bug, Dniester, Tisza (a Danube River tributary), and Western Bug, are experiencing widespread water shortages, particularly in the Lower Dnieper, Siverskyi Donets, Southern Bug, Ingul, and Azov basins due to scarce water resources (Kitowski, 2023). Furthermore, a study published on the journal Nature by Shumilova et al, which researched the impact of the conflict on water

resources found out that only in the first three months of the war the impacts on water infrastructure in the region included: 17 resulting from direct attacks, 13 due to power-supply cut-offs, 8 as a combination of both, and 4 instances of pollution of surface waters from sunken military objects. Additionally, there were 15 potential threats, including flooding due to damage to dams, threats to nuclear power plants, flooded underground mines, and potential explosions of hazardous materials in wastewater treatment plants and nautical mines in the Danube River delta (Shumilova, 2023). On this same note the United Nations Environmental Program points out how: water infrastructure, including pumping stations, purification plants and sewage facilities, has also suffered significant damage, and multiple industrial facilities, warehouses and factories have been damaged, some storing a range of hazardous substances ranging from solvents to ammonia and plastics.

In general is important to mention how during conflicts water is both used as a weapon, but it can also be a casualty of it. During a battle near Novomykhaylivka, Donetsk a farm's area and a power transmission line are destroyed, resulting in blackouts in communities and the absence of water for Novomykhaylivka hamlet (casualty). In fact, the importance of water can also be perceived by the fact that during the initial days of the Russian Federation Army's invasion of Ukraine on February 24, 2022, a significant action resulted in the demolition of a dam on the North Crimean Canal in the Kherson region, which has been obstructing water access since 2021 [weapon]. This move aimed to restore water flows and improve the water balance on the Crimean Peninsula, although it falls short of meeting its full needs (Kitowski, 2023). Moreover the conflict in Ukraine disrupts wastewater treatment, polluting water in communities. The Kakhovka Reservoir received contaminated wastewater due to a plant closure. Rivers and irrigation channels now contain buried military equipment, causing long-term environmental harm. Underwater ammunition decay pollutes water with toxic compounds and heavy metals, affecting irrigation areas. The Siverkyi Donets River basin shows pollution with oil products, high mercury levels, and other contaminants. Donbass power outages heighten the risk of mine water contamination, worsening water quality (Shumilova, 2023).

A study commissioned by the UNEP and carried out by the Conflict and Environment Observatory found out that 86.54 km2 of urban areas on both

riverbanks saw extensive flooding; owing to terrain, the Russian-occupied side was more severely affected. It is worrisome when household pollutants leak chemicals and oils. Furthermore, concerns regarding fibre dispersion from damaged structures are heightened by the asbestos present in 60% of Ukrainian roofs (Moreland, 2023). The effects of the war in Ukraine on water contamination are complex and provide serious obstacles to human life as well as environmental protection. Important water infrastructure has been affected by the fighting, which has resulted in direct attacks, power outages, and pollution from submerged military equipment. The deliberate collapse of a canal and the destruction of dams demonstrate how water may be used as both a weapon and be a victim in armed conflicts. This has serious ramifications for both the general well-being of the populace and agriculture, a vital sector for Ukraine's economy. The situation is made worse by widespread water shortages in large river catchments, which lead to long-term environmental damage from contaminated rivers, reservoirs, and irrigation canals. The disturbance of wastewater treatment plants results in an additional pollutant layer that affects communities and puts public health at danger. The extent of environmental harm described in the Shumilova et al, study and the UNEP's observations highlight the pressing need for international action to alleviate the Ukraine water crisis and lessen its far-reaching effects.

Analysis of air quality and pollution.– In this paragraph, the paper transitions from discussing water resources to focusing on air quality and pollution resulting from the war in Ukraine. The causes triggering pollution, including the movement of heavy military vehicles and explosions, are highlighted, along with the effects of decreased air quality on the environment. Factors affecting air quality during wartime, such as industrial and transport disruptions, fossil fuel burning, and infrastructure damage, are outlined. The conflict in Ukraine is shown to have impacted air quality by altering concentrations of sulphur and nitrogen dioxide. Research comparing the effects of war and COVID-19 lockdowns on air pollution is presented, revealing complex interactions. Concerns about depleted uranium in Russian tanks and its potential health risks are discussed, with studies suggesting a low risk of cancer.

Smoke from fires is identified as a major cause of air pollution, affecting both urban and rural areas. The continuous environmental devastation is

indicated by the 46,286 fires per year on average in the examined areas during the conflict. An important change in hostilities is the rise in flames in built-up regions, which went from 11% in 2022 to 28% in the first part of 2023.

In conclusion, the analysis of air quality and pollution in Ukraine during the war indicates a multifaceted environmental challenge. Military activities, including heavy vehicle movement and explosions, significantly increase the release of toxic elements, deteriorating air quality. While the conflict has lowered sulphur and nitrogen dioxide concentrations, the interconnectedness of events, such as the war and COVID-19 lockdowns, has led to a complex impact on air pollution. Concerns about depleted uranium in Russian tanks add additional risks, though studies suggest a low risk of cancer. Smoke from fires, a major contributor to pollution, poses risks to both urban and rural areas. The overall findings underscore the urgent need for comprehensive environmental management and international collaboration to address the lasting impacts on air quality and public health in the region.

Impact on biodiversity and ecosystems. – By examining air and water pollution, soil contamination, the impacts of fires, and the use of depleted uranium in military weaponry, it becomes evident that the biodiversity and ecosystems in Ukraine have suffered significant damage as a result of wartime activities. These kinds of activities impact biodiversity and the health of ecosystems in several ways.

The most evident and logical impact is the movement of large military vehicles through the territory, which often comes at the cost of forest integrity and its inhabitants -plants and animals. The severe destruction of forests in Donbas and Crimea during the war- more than 70% according to ecologists- has critically impacted the ecological balance. These forests, integral to Ukraine's natural environment, serve as vital resources for various species and act as a primary oxygen source for local inhabitants (Levchenko, 2023).

As mentioned, deforestation is commonly caused by military vehicle mobility, explosions, fires, and uncontrolled wood consumption. As a result, animals are forced to relocate, leaving their native habitats behind and ultimately leading to the long-term extinction of the local fauna. Furthermore, many species' migratory paths are disturbed by the

degradation of natural habitats, especially those that depend on particular routes for feeding or reproducing. This disruption may have an effect on ecosystem health overall and contribute to population decreases. Another often overlooked aspect of war is landmines and unexploded ordnance. Besides posing a threat to human life, the explosion of this kind of weaponry poses a huge threat to wildlife. The detonation by unaware wildlife of landmines placed by one of the parties fighting in the war poses a significant risk. Even worse is the fact that after the end of the war, many of the natural areas that previously constituted battle zones remain dangerously not demined for decades. Similarly, the same fact of the natural habitats of many species being battle zones for years, as is the case for Ukraine, puts wildlife under immense stress, often causing the complete loss of certain species from that particular area for many years if not forever.

Moreover, as a consequence of conflict, soil and water are contaminated. This pollution endangers aquatic habitats, damages plant life, and upsets food chains. Furthermore, the disorder caused by conflict causes conservation initiatives to fail, which in turn encourages illicit activities like poaching and logging, hastening the loss of biodiversity in the impacted areas.

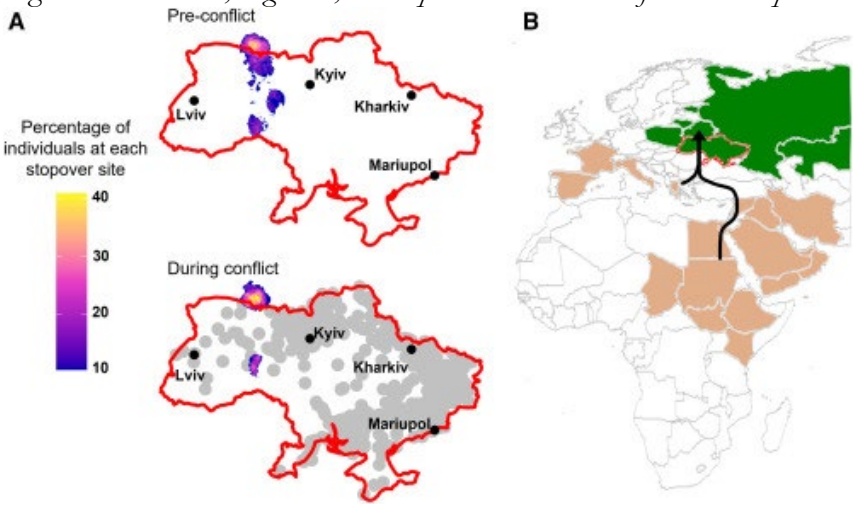
More concretely, with respect to the loss of biodiversity in Ukraine, the International Fund for Animal Welfare (IFAW) has put together some data. The battle had an influence on 750 plant and mushroom species, 600 animal species, and 20% of protected areas. Since February 2022, mines and sonar have caused dolphins to strand ashore on Black Sea shores. Four lion cubs, a black leopard cub, bears, bats, caracals, and other confined creatures are being rescued and evacuated from zoos and sanctuaries by the IFAW.

The impact of war on wildlife is particularly pronounced for three crucial species: the Eurasian Brown Bears, the Eurasian Lynx, and the European Bison. These species, existing in low numbers, primarily inhabit the Carpathian Region, where extensive conservation efforts and the establishment of forest corridors between Ukraine, Romania, and Poland have been undertaken to facilitate their growth and reproduction. Unfortunately, the ongoing conflict introduces heightened risks, including increased threats from deforestation and poaching, jeopardizing the progress made in the conservation of these vulnerable species (Howell, 2022).

A recent study published in Current Biology by researchers from the University of East Anglia, the British Trust for Ornithology, and the Estonian University of Life Sciences highlights the impact of conflict not

only on terrestrial life but also on bird populations. The researchers, who were studying several Greater Spotted Eagles before the war, observed that the eagles altered their migration routes and stopover sites due to the conflict, with these changes all cross-checked against meteorological conditions. By March 3rd, as the first of 19 tagged Greater Spotted Eagles entered Ukraine, the conflict had spread widely. Using GPS tracking and data from the Armed Conflict Location and Event Data (ACLED) project, researchers found that eagles deviated more (~10%), migrated more slowly (females, ~20%; males, ~30%), made fewer stopovers (~60%), and took longer to migrate (females, ~25%; males, ~50%) through Ukraine than in previous years.

Fig. 2 – *Distribution, migration, and stopover use in Ukraine for Greater Spotted Eagles*



Source: Russell, 2024

In the context of war's impact on flora, the Ukrainian Nature Conservation Group has highlighted 20 rare herbaceous plant species, like thyme, thistle, geranium, figwort, rattle, aster, and cock's-head. These lesser-known but crucial species are listed in Ukraine's Red Book and legally protected. Their disappearance not only represents a loss for nature but also hinders scientific understanding (Russell, 2024).

In summary, wartime activities in Ukraine have severely impacted biodiversity and ecosystems. Large military vehicles, deforestation, landmines, and contamination of soil and water disrupt habitats, forcing

wildlife relocation and contributing to long-term extinction risks. Migratory paths are disturbed, ecosystem health is compromised, and illicit activities like poaching thrive. The International Fund for Animal Welfare (IFAW) notes significant impacts on 750 plant and mushroom species, 600 animal species, and 20% of protected areas since February 2022. The conflict poses heightened risks to iconic species like Eurasian Brown Bears, Eurasian Lynx, and European Bison, jeopardizing conservation efforts. The war not only leads to biodiversity loss but also challenges future conservation endeavors and scientific understanding.

Examination of infrastructure damage. – In addition to the readily apparent environmental consequences of the ongoing war, there exists a less conspicuous yet significant impact: the substantial emissions that will inevitably result during the eventual reconstruction phase. The extensive damage inflicted upon Ukrainian infrastructure over the past year and a half is staggering.

A stroll through numerous villages, towns, and even major cities - particularly in the Eastern regions where the majority of battles have occurred - reveals the profound devastation, with entire neighbourhoods and settlements reduced to ruins. Significant damage is reported in education ($10.1 billion) and healthcare ($2.9 billion), with widespread destruction across various regions, posing significant challenges for Ukraine's economy and humanitarian efforts.

The attacks on refineries, chemical plants, energy facilities, industrial depots, and pipelines are severely impacting the Ukrainian environment, posing a significant risk to human health. These issues extend beyond Ukraine, affecting not only the environment and health of its citizens but also posing transboundary risks to nearby countries. In inhabited regions, explosive weapons can cause environmental hazards, such as hazardous material-containing rubble. Sewage may leak out of control as a result of damage to the water system. Inadequate waste management leads to solid trash being burned outdoors and hazardous landfills (Nikolaieva, Zwijnenburg, 2022).

The direct cost of the Russian assault on Ukraine's infrastructure, as of September 1, 2023, was $151.2 billion; since June 2023, the amount has increased by $700 million. At $55.9 billion, the housing industry is the most severely impacted, followed by infrastructure ($36.6 billion) and

industry ($11.4 billion). The Dutch NGO PAX verified 63 military strikes against Ukrainian energy facilities between February and November 2022, with Russian troops carrying out the biggest attack in October. This resulted in severe blackouts and a humanitarian disaster, depriving millions of people of basic services and damaging 40% of Ukraine's electrical infrastructure (ib*idem*).

When assessing the overall costs of the conflict, it's essential to consider not only the economic and environmental implications of the already destroyed infrastructure but also the costs associated with dismantling initiatives that were either already in place or under development at the onset of the war. While Ukraine's pre-war system was not among the most sustainable, and the country was not highly proactive in combating climate change, some progress had been made, such as the expansion of protected areas and the adoption of renewable energy sources. However, the war has significantly disrupted these initiatives. The focus has understandably shifted to defending the country against invaders, essentially halting the progress made in these policy areas. Moreover, the conflict has had broader consequences, setting back global efforts in the fight against climate change.

Nevertheless, there is an ongoing plan for extensive reconstruction, and the noteworthy aspect is that the primary goal of the plan is to transform the country into a greener and more sustainable place. The Post-war Recovery and Development Plan, aligned with green economy and low-emission principles, focuses on five key areas identified by the "Environmental Safety" Working Group: reforming environmental administration, climate policy, effective waste management, sustainable resource use, and conservation of ecosystems and biodiversity in protected areas.

The national Council for Reconstruction, led by the President, has a working group on urban planning. The European Commission's 'RebuildUkraine' framework focuses on swift housing solutions, emphasizing inclusivity for sustainable recovery, including trauma, environmental considerations, and full inclusivity.

Radiological and nuclear concerns. – Ukrainian energy is mainly produced nationally by the state-owned company Energoatom. The largest part of the energy produced within the country comes from nuclear power plants. Energoatom operates four nuclear power plants with 15 reactors in total:

Rivne, South Ukraine, Khmelnytskyy, and Zaporizhzhya - largest nuclear power plant in Europe. Aside from operational NPPs, Ukraine is home to the decommissioned Chernobyl nuclear power station, research reactors, spent fuel storage, historic nuclear explosion sites, uranium facilities, and a variety of industrial, medical, and research institutions that use radioactive materials.

The international community quickly recognized the alarming situation for environmental and public health safety in Ukraine following the outbreak of war in 2022, given the significant presence of nuclear power plants (NPPs) in the region. With the memory of the Chernobyl disaster less than 40 years ago, substantial efforts were undertaken to ensure the safety of both the plants and the surrounding territory. The ongoing conflict has raised serious concerns about Ukraine's nuclear facilities, including the potential for infrastructure damage, unsafe conditions, and the risk of nuclear materials falling into the wrong hands. This situation may disrupt routine maintenance, jeopardize safety protocols, and impede the proper management of radioactive waste.

The overall instability in the area has heightened fears of accidental or intentional targeting of nuclear facilities, posing severe risks to both the environment and public safety. The potential for nuclear radiation leakage from the occupied Zaporizhzhia Nuclear Power Plant poses a real threat to the entire region. Russia's unwillingness to exclude the use of nuclear weapons adds an extraordinarily irresponsible dimension to the dangers, increasing the risk of a regional disaster (High-Level Working Group on the Environmental Consequences of the War in Ukraine, 2023). The threat emerged early in the conflict when Ukrainian officials reported that "Russian forces have seized control of the Chernobyl power plant in northern Ukraine, the site of the world's worst nuclear disaster, and are holding staff hostage" (Tuysuz, Qiblawi, 2022). Consequently, the international community closely monitors the situation to mitigate these potential threats and ensure the secure operation of Ukraine's nuclear facilities during the conflict.

Since then, the International Atomic Energy Agency (IAEA) has worked closely with the Ukrainian government to prevent major accidents in the country's nuclear plants. Notably, Europe's largest power plant, Zaporizhzhya, has placed five reactors in cold shutdown and one in hot shutdown for specific safety functions, including the processing of liquid

radioactive waste. The organization has started the process of stationing teams at the Chornobyl site and Zaporizhzhya nuclear power facilities in Ukraine on a permanent basis. The purpose of this extension is to lessen the possibility of a serious nuclear catastrophe occurring while the war is still going on.

Results. – The Russo-Ukrainian war has inflicted profound environmental devastation across multiple dimensions, with widespread and long-lasting consequences. The conflict has led to severe deforestation, the contamination of vital soil and water resources, and a significant decline in air quality. These environmental disruptions have critically endangered ecosystems, forcing wildlife to relocate, altering migratory patterns, and pushing numerous species toward extinction. Biodiversity has suffered immensely, with key habitats destroyed or severely compromised, particularly in regions heavily impacted by military activities. Iconic species like the Eurasian Brown Bear, Eurasian Lynx, and European Bison, as well as over 750 plant and mushroom species, have seen their survival and conservation efforts jeopardized.

Moreover, the war's environmental toll extends beyond immediate destruction. The damage to crucial infrastructure, including nuclear facilities, has raised significant safety concerns, with the risk of radioactive contamination threatening not only Ukraine but also neighbouring regions. The conflict has also resulted in extensive air pollution, driven by the movement of military vehicles, explosions, and fires, which have significantly deteriorated air quality and contributed to the release of toxic elements into the environment.

Additionally, the war has disrupted ongoing environmental initiatives and conservation efforts, halting progress on sustainable development and climate action. The destruction of infrastructure, including water and waste management systems, has further exacerbated environmental challenges, leading to long-term consequences for public health and safety. As Ukraine contemplates post-war recovery, the environmental costs of reconstruction - both immediate and long-term - pose significant challenges, underscoring the need for comprehensive, sustainable approaches to rebuilding that prioritize ecological restoration and climate resilience.

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Cinque Impatti Ambientali di Ampia Portata del Conflitto Attuale in Ucraina. – Nel 2013, il presidente ucraino Viktor Yanukovych tentò di rafforzare i legami con la Russia, provocando proteste che sfociarono nel conflitto nell'Ucraina orientale e nell'annessione della Crimea da parte della Russia. Nel febbraio 2022, la Russia ha avviato un'invasione su larga scala, scatenando una guerra totale. Questo documento si propone di valutare i cinque effetti più devastanti che il conflitto tra Russia e Ucraina ha sull'ambiente, con particolare attenzione alle conseguenze su ecosistemi e biodiversità, risorse idriche, qualità dell'aria, infrastrutture, e ai rischi radiologici e nucleari. La ricerca utilizza un approccio misto, basato principalmente su analisi qualitative e comparative, con l'integrazione occasionale di analisi geospaziali. I primi risultati indicano un grave degrado ambientale, legato all'inquinamento causato dalle attività militari e ai danni alle infrastrutture. In conclusione, si sottolinea l'urgenza di affrontare le conseguenze ambientali del conflitto per promuovere la sostenibilità nelle aree colpite.

Keywords. – Impatto ambientale, Conflitto Russia-Ucraina, Degrado ecosistemico

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