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IMPACT OF MILITARY OPERATIONS ON THE NATURE RESERVE FUND OF UKRAINE

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Abstract. The war in Ukraine has caused extensive destruction to the Nature Reserve Fund (NRF), resulting in land degradation, water pollution, biodiversity loss, and disruption of ecosystem functions. Over 1.2 million hectares of protected areas (≈30 % of the NRF) have been impacted. The estimated environmental damage exceeds 2 trillion UAH (~55 billion USD), with restoration costs projected at 1.5–2 billion USD.Key consequences include the loss of 70–80 % of steppe ecosystems, soil contamination with heavy metals (5–10 times above safe levels), 30–50 % reductions in rare fungi and plant populations, and a 25–40 % decline in key bird species. Water pollution has critically degraded rivers such as the Siverskyi Donets and Dniester, and the Black Sea, causing mass die-offs of aquatic organisms. The study also highlights the role of wildfires in NRF degradation, with satellite data revealing increased thermal anomalies and large-scale fires, particularly in the Askania-Nova Biosphere Reserve. Vegetation recovery remains incomplete due to severe ecosystem disturbance. An integrated methodology—combining descriptive analysis, GIS, ecological monitoring, and remote sensing—was employed to assess environmental damage. The findings underline the urgent need for comprehensive recovery measures, including demining, soil remediation, water restoration, and biodiversity conservation. International cooperation (EU, UNEP, World Bank, WWF) and reparations are key mechanisms to support Ukraine's post-war ecological recovery.

Keywords: Nature Reserve Fund (NRF), war impact, wildfires, soil pollution, biodiversity loss, ecosystem restoration.

1. Introduction

The Nature Reserve Fund (NRF) of Ukraine is a national asset and an integral part of the global natural and cultural heritage. In this study, the NRF refers to the state-managed network of protected areas in Ukraine established under national conservation legislation. It includes nature reserves, biosphere reserves, national nature parks, and other officially designated protected territories. These areas encompass ecosystems and landscapes vital for the preservation of Ukraine's rare biodiversity and natural heritage, while also supporting sustainable environmental development and maintaining ecological balance. As such, the NRF constitutes a core component of the national ecological network (On the Nature Reserve Fund, 2018).

War is among the most destructive drivers of environmental catastrophes, often resulting in long-term ecological consequences. During the ongoing conflict in Ukraine, protected areas have suffered extensive damage (Hartmane et al., 2024). Since the onset of armed aggression by the russian federation in 2014, numerous nature reserves, national parks, and other protected sites have been impacted by military activity, pollution, and disrupted natural processes.

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According to the Ministry of Environmental Protection and Natural Resources of Ukraine, approximately 30 % of protected areas have been affected, encompassing over 900 individual sites (Pereira et al., 2022; Udovenko et al., 2023). This poses a major threat to biodiversity and ecological stability, as these areas are critical for conserving rare species of flora and fauna and delivering key ecosystem services, including water purification, carbon sequestration, and climate regulation (Mammadov et al., 2024).

The impact of war on Ukraine's NRF includes the destruction of ecosystems, water and soil contamination (Biyashev et al., 2024; Shebanina et al., 2024), and exposure to hazardous chemicals, ammunition, and landmines that hinder natural restoration (Drobitko & Alakbarov, 2023; Subiros et al., 2024). Critical ecological disruptions include interrupted animal migration routes, declining populations of rare species, and shifts in plant communities caused by environmental contamination (Rawtani et al., 2022; Tsaryk & Kuzyk, 2022; Kvach et al., 2025). The military conflict has also significantly degraded aquatic ecosystems, with rivers and lakes polluted by oil, heavy metals, and chemical residues from military equipment and munitions (Slessarev et al., 2024), while simultaneously undermining ecological tourism and conservation efforts (Kucher et al., 2023).

Of particular concern is the intensification of wildfires across protected areas, caused by combat activity, shelling, airstrikes, and the inability to respond due to landmines or occupation. These pyrogenic impacts have destroyed habitats and disrupted vegetation cycles, severely limiting ecosystem resilience and recovery (Filho et al., 2024; Gatti et al., 2025).

One of the most pressing challenges is assessing the environmental damage to protected areas, given the long-term consequences for biodiversity and ecosystem functionality (Zwarich & Pylipets, 2024). It is critical to identify contamination levels and develop damage assessment methodologies that support effective postwar ecosystem restoration and conservation planning (Gatti et al., 2025). Restoration strategies must adopt an integrated approach that combines ecological, social, and economic dimensions while leveraging international conservation mechanisms for biodiversity and ecosystem service recovery (Skliar & Skliar, 2024).

Ukraine's protected areas play a vital ecological role not only at the national level but also as part of global natural systems. Their destruction or degradation carries broader implications for biodiversity and ecological security in Europe and globally. Therefore, it is essential to implement both national recovery initiatives and internationally aligned conservation strategies focused on sustainable ecosystem development (Verzillo, 2025). The protection of Ukraine's NRF during wartime requires the development and implementation of new natural resource management approaches to safeguard the country's environmental heritage for the future.

The *objective* of this study is to provide a comprehensive analysis of the destructive impact of warfare on land, water resources, and biodiversity within Ukraine's NRF, assess pyrogenic dynamics and environmental damage, and outline restoration pathways for protected areas with international support.

2. Materials and Methods

2.1. Area of Study

Fig. 1 illustrates the impact of the war on Ukraine's NRF, highlighting the affected forests, steppes, and other protected areas.

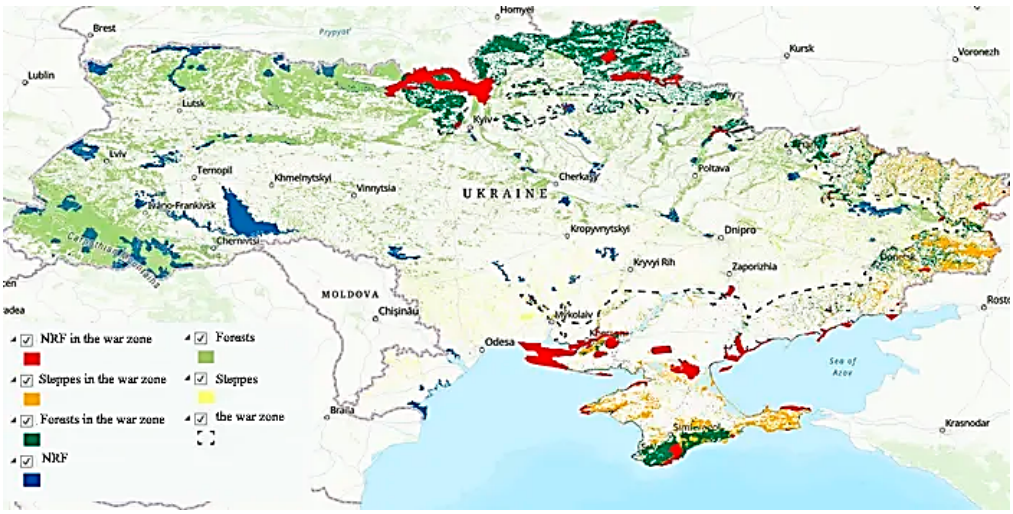

Fig. 1. Damage to natural and protected areas of Ukraine due to the military invasion of the russian federation (Ministry of Environmental Protection and Natural Resources of Ukraine, 2023)

The most damaged regions include the eastern, southern, and northern parts of Ukraine, where military operations have led to significant environmental degradation. The war zone overlaps with critical natural reserves, particularly in Donetsk, Luhansk, Kherson, Zaporizhzhia, and Crimea, posing a severe threat to biodiversity and ecosystem stability.

2.2. Methods

An integrated methodological approach was applied, combining descriptive analysis, spatial (GIS) analytics, ecological monitoring, and remote sensing techniques to assess the environmental consequences of warfare on NRF territories.

Area and number of NRF located in hazardous zones and temporarily occupied territories (Rybalova et al., 2023)

Type of NRF	Total Area of NRF, ha	Number of NRF	NRF in Hazardous Zones		NRF in Occupied Territories	
			Area, ha	Number	Area, ha	Number
Nature Reserve	92578	9	14197	5	51775	6
Biosphere Reserve	369527	3	334217	3	-	-
National Nature Park	406855	17	270098	15	14005	3
Regional Landscape Park	224359	16	125972	15	84	1
Nature Sanctuary	524241	797	328537	739	112599	61
Protected Tract	22832	103	18625	101	553	2
Natural Monument	9319	392	7045	350	2263	42
Botanical Garden	1135	4	55	2	1080	2
Dendrological Park	406	6	404	6	-	-
Zoological Park	49	3	45	3	-	-
Park-Monument of Landscape Art	1890	76	1232	62	387	14
Total	1653191	1426	1100427	1301	182746	131

1. Remote Sensing and GIS Analysis. Satellite monitoring data were used to evaluate the pyrogenic dynamics of protected areas. Thermal anomalies were identified using NASA FIRMS data, based on MODIS and VIIRS sensors with spatial resolutions of 375–1000 meters. To determine the extent of burned areas, multispectral Sentinel-2 imagery with 10-meter resolution was utilized. Damage visualization was performed using the Short-Wave Infrared Reflectance (SWIR) index. Post-fire vegetation recovery was analyzed using the Normalized Difference Vegetation Index (NDVI), calculated from red and near-infrared reflectance bands.

2. Spatial Analysis of Ecosystem Degradation. Pre-war and post-war conditions of natural territories were compared using Sentinel-2 imagery in the QGIS environment. Indicators assessed included forest cover loss, wetland degradation, habitat fragmentation, landscape structure changes, and the identification of the most severely affected areas.

3. Descriptive and Archival Analysis. Archival environmental data regarding NRF conditions before and after the full-scale invasion were systematized. Sources included official reports from the Ministry of Environmental Protection of Ukraine, the State Environmental Inspectorate, scientific publications, and open-source data (media, satellite services).

4. Ecological Monitoring. Field and remote-sensing observations were conducted to assess biodiversity changes and the condition of soils and water. Baseline ecological indicators were established to characterize the impact of warfare on rare and endangered species, soil fertility, and hydrological stability.

This integrated approach enables an in-depth investigation of the scale of ecological destruction, the spatial dynamics of fire-related processes, and the ecosystem restoration potential within Ukraine's protected areas.

3. Results and Discussion

3.1. Adverse Impact of War on the Land Resources of Ukraine's NRF

Military operations in Ukraine have led to significant degradation of land resources within NRF, manifesting in mechanical soil destruction, contamination

with toxic substances, and the loss of natural vegetation cover (Smirnova et al., 2024). According to the Ministry of Environmental Protection and Natural Resources of Ukraine, approximately 1.2 million hectares of protected land have been affected by military actions, accounting for more than 30 % of the total NRF area. The most heavily damaged regions include Kharkiv, Donetsk, Luhansk, Kherson, and Zaporizhzhia oblasts, where hostilities have been most intense (Dudnieva, 2024).

In total, 17 national parks, 9 nature reserves, and 3 biosphere reserves have come under the influence of active hostilities or occupation. Among them are UNESCO-recognized sites such as the Black Sea Biosphere Reserve, located in Kherson and Mykolaiv oblasts, and the Askania-Nova Biosphere Reserve. Up to 14 % of the Chornobyl Radiation and Ecological Biosphere Reserve was affected by fire caused by military activities, and up to 94 % of the territory was under occupation, leading to severe soil degradation (Filho et al., 2024). One of the most severe consequences of the war has been the destruction of steppe ecosystems in southern and eastern Ukraine. In Meotyda National Nature Park (Donetsk Oblast), over 80 % of the territory was devastated by artillery shelling and military equipment. Explosions and fires destroyed vast areas of rare flora, including Ukrainian feather grass (*Stipa ucrainica* P. Smirn., 1951) and Schrenk's tulip (*Tulipa schrenkii* Regel, 1873) (Kvach et al., 2025). The destruction of steppe soils has also led to the disappearance of habitats for species such as the spotted ground squirrel (*Spermophilus suslicus* (Güldenstädt, 1770) and the Caspian whipsnake (*Dolichophis caspius* (Gmelin, 1789), both listed in the Red Book of Ukraine.

Mechanical soil disruption has caused widespread erosion, which has significantly accelerated due to military operations. According to ecological assessments, in regions like the Luhansk Nature Reserve, water erosion has increased 3–4 times, resulting in the loss of topsoil and impeding natural soil regeneration (Kucher et al., 2023). Heavy machinery traversing protected areas has compacted the soil, negatively affecting its structure and aeration. As a result, vegetation recovery has been considerably slowed or rendered impossible without human intervention.

Another ecological concern is chemical contamination of soils due to munitions explosions, military equipment residues, and fuel spills. In Zaporizhzhia National Nature Park, levels of heavy metals such as lead, cadmium, and mercury have been found to exceed pre-war levels by 5–10 times (Gatti et al., 2025). Toxic contamination leads to mutations and the death of microorganisms that play a key role in maintaining soil fertility. This directly impacts plant health and poses a threat to wildlife that comes into contact with contaminated soil and water (Slessarev et al., 2024).

In addition to chemical contamination, landmines have become a serious environmental threat across protected territories. According to the State Environmental Inspectorate of Ukraine, approximately 30 % of natural areas in conflict zones are contaminated with explosive ordnance, making them inaccessible and unfit for natural regeneration. For example, in the Chornobyl Biosphere Reserve, around 2.000 mines and munitions have been identified, endangering species such as the Przewalski's horse (*Equus przewalskii* (Poliakov, 1881)) and the white-tailed eagle (*Haliaeetus albicilla* (Linnaeus, 1758) (Halyna et al., 2024). In the Yelanets Steppe Nature Reserve, located in Mykolaiv Oblast, large areas have been mined, preventing conservation measures and biodiversity monitoring efforts.

3.2. Analysis of Pyrogenic Dynamics within Ukraine's Nature Reserve Fund

The full-scale invasion of Ukraine by the russian federation has significantly intensified wildfire impact on the country's NRF. Areas that previously experienced minimal anthropogenic disturbance have become zones of active conflict, which has severely limited the implementation of fire prevention measures. Since early 2022, the number of thermal anomalies across Ukraine has dramatically increased, particularly within national parks and biosphere reserves.

Satellite data from FIRMS (MODIS and VIIRS) confirmed numerous instances of thermal anomalies indicative of wildfire activity. Compared to the pre-war period (January–February 2022), a marked increase in thermal hotspots was observed in March–April 2022, especially in areas of ongoing combat. This trend persisted into 2023–2025, albeit with some reduction in intensity in later years (Fig. 2).

a *b* *c*

Fig. 2. Thermal anomalies in Ukraine for the periods:
a – 24.01–24.02.2022; *b* – 24.02–24.03.2022; *c* – 01–30.04.2025

The Askania-Nova Biosphere Reserve exemplifies the large-scale pyrogenic impact. In 2023 alone, at least seven major wildfires were recorded within the reserve, destroying over 5.300 hectares of steppe ecosystems. Sentinel-2 satellite imagery using the SWIR spectral index clearly delineated burn zones and enabled detection of changes in phytocenotic structures (Fig. 3).

a *b*

c *d*

Fig. 3. Pyrogenic events in the Askania-Nova Reserve during:
a – 30.07.2022; *b* – 29.08.2022; *c* – 27.03.2023; *d* – 24.08.2023; *e* – 08.09.2023; *f* – 28.09.2023

e *f*

Fig. 3. (Continuation). Pyrogenic events in the Askania-Nova Reserve during:
a − 30.07.2022; *b* − 29.08.2022; *c* − 27.03.2023; *d* − 24.08.2023; *e* − 08.09.2023; *f* − 28.09.2023

The post-fire ecosystem recovery in Askania-Nova was evaluated using the Normalized Difference Vegetation Index (NDVI). NDVI dynamics indicated gradual, yet incomplete, vegetation regeneration in 2024 following peak fire events in August–September 2023. Vegetation indicators in summer 2024 remained below pre-war levels, highlighting the lasting impact of wildfires (Fig. 4).

Fig. 4. NDVI trends in the area
of highest pyrogenic impact within Askania-Nova Reserve

Overall, pyrogenic dynamics within Ukraine's NRF during wartime are marked by high spatial variability and closely correlate with front-line proximity and combat intensity. The most affected reserves are located in occupied zones or near active hostilities. These findings are critical for assessing the loss of Ukraine's natural heritage and for designing strategies for ecological rehabilitation of impacted areas.

3.3. Pollution of Water Resources in Ukraine's Nature Reserve Fund During the War

The war in Ukraine has caused extensive pollution of water resources, significantly affecting ecosystems within NRF. Explosions, shelling, the destruction of hydraulic structures, and the leakage of fuels and toxic substances have led to severe deterioration in the quality of water in rivers, lakes, reservoirs, and estuaries. According to the Ministry of Environmental Protection and Natural Resources of Ukraine, approximately 20 % of aquatic ecosystems in protected areas have undergone critical changes due to military actions.

One of the most heavily affected water bodies is the Kakhovka Reservoir, which lost more than 70 % of its water volume after the dam was destroyed. This led to the mass death of riverine flora and fauna, a decline in groundwater levels, and the degradation of coastal ecosystems (Kvach et al., 2025). As a result, large areas, including the "Velykyi Luh" and "Nyzhnodniprovskyi" National Nature Parks, lost their wetlands, which had served as vital habitats for numerous bird, amphibian, and fish species. Notably, populations of sterlet (*Acipenser ruthenus* Linnaeus, 1758), wood frog (*Rana sylvatica* LeConte, 1825), and squacco heron (*Ardeola ralloides* (Scopoli, 1769) suffered significant declines, as these species are highly dependent on such ecosystems (Gatti et al., 2025).

Beyond the physical loss of water bodies, the Siverskyi Donets River−an essential source of freshwater for eastern Ukraine−was heavily polluted. Military activity caused the release of heavy metals

(lead, cadmium, mercury) and petroleum products into the river, increasing pollutant concentrations 5–7 times above pre-war levels (Kucher et al., 2023). Similar outcomes were observed in the Dniester Estuary, where polluted runoff entered the waters following infrastructure destruction in the south. These contaminations led to mass deaths of mollusks, crustaceans, and fish, such as the Black Sea sprat (*Clupeonella cultriventris* (Nordmann, 1840) and zander (*Sander lucioperca* (Linnaeus, 1758) (Slessarev et al., 2024).

The Black Sea ecosystem has also been severely impacted by the war, as large amounts of fuel, explosives, and toxic waste from sunken military equipment have entered its waters. Water analyses conducted near the coasts of Odesa and Mykolaiv oblasts revealed elevated concentrations of polycyclic aromatic hydrocarbons and heavy metals (Halyna & Seredyuk, 2024). These contaminants pose serious risks to marine biodiversity, including populations of the long-snouted seahorse (*Hippocampus guttulatus* Cuvier, 1829), common dolphin (*Delphinus delphis* Linnaeus, 1758), and the turbot (*Scophthalmus maeoticus* (Pallas, 1814), which are highly sensitive to pollution.

Another critical issue is the pollution of groundwater due to infrastructure destruction and the leakage of hazardous chemicals. According to the State Environmental Inspectorate of Ukraine, 60 % of groundwater samples collected in conflict zones exceeded safe levels for ammonium, nitrates, and heavy metals. The situation is particularly critical in Zaporizhzhia and Kharkiv oblasts, where industrial waste has entered river systems. In the "Homilshanski Lisy" National Nature Park, located along the Siverskyi Donets River, there has been a sharp decline in fish and aquatic invertebrate populations, indicating severe chemical contamination (Dudnieva, 2024).

3.4. Damage to Biodiversity in Ukraine's Nature Reserve Fund During the War

The war in Ukraine has caused catastrophic losses in biodiversity, manifesting in the destruction of natural habitats, mass mortality of rare and endangered species, disruption of animal migration routes, and contamination of ecosystems with toxic substances. Ecosystem destruction and soil contamination have led to significant changes in the mycobiota of protected areas. In forests affected by combat, the number of fungi, which play a cr ucial role in sustaining soil ecosystems, has drastically declined. In particular, in the Homilshanski Lisy and Rivne Nature Reserves, populations of the dotted bolete (*Boletus luridiformis* (Rostk.) Sacc., 1888) and the rare pine bolete (*Boletus pinophilus* Pilát & Dermek, 1973) have decreased. These fungi are essential components of mycorrhizal relationships in coniferous forests (Kvach et al., 2025). Due to heavy metal contamination from military equipment, toxins accumulate in fungal fruiting bodies, posing health risks to wildlife and humans consuming wild mushrooms.

Explosions, fires, the movement of military vehicles, and soil contamination have caused the disappearance of numerous rare plant species. In the Black Sea Biosphere Reserve, large-scale fires resulted in the loss of over 60 % of steppe vegetation, critically impacting populations of Dnipro feather grass (*Stipa borysthenica* Klokov ex Prokudin, 1980) and Buhian pink (*Dianthus hypanicus* Andrz., 1821) (Kucher et al., 2023). These plants are endemic to the Black Sea region, and their natural recovery may take decades.

Another critically affected species is the Dnipro ragwort (*Senecio borysthenicus* (Andrz.) Andrz. ex Czerep., 1995), which grows in floodplain meadows and on sandy dunes of the Nyzhnodniprovskyi National Nature Park. Military operations in these areas have destroyed approximately 50 % of this species' populations, significantly increasing the risk of its extinction in Ukraine (Slessarev et al., 2024).

The war has led to a massive decline in bird populations, particularly those inhabiting steppes, wetlands, and forests. Rare species such as the booted eagle (*Hieraaetus pennatus* (Gmelin, 1788) and the griffon vulture (*Gyps fulvus* (Hablizl, 1783) have been severely affected by the destruction of reserves in the Meotyda and Karadag regions. Shelling and fires in these areas have resulted in the disappearance of up to 40 % of breeding populations (Gatti et al., 2025).

The population of the black stork (*Ciconia nigra* (Linnaeus, 1758), which nests in forest ecosystems of central and western Ukraine, has also suffered greatly. Frequent explosions and deforestation for military needs have complicated nesting conditions, leading to a 25 % reduction in population size compared to pre-war levels (Dudnieva, 2024).

War-induced damage to aquatic ecosystems has also threatened species such as the common tern (*Sterna hirundo* Linnaeus, 1758) and squacco heron (*Ardeola ralloides* (Scopoli, 1769), which depend on the wetlands of the Dniester Estuary and the Kakhovka Reservoir. Due to contamination from heavy metals and petroleum products, about 35 % of nesting colonies of these species have been lost, putting their regional survival at risk (Halyna et al., 2024).

Recent work by Filho et al. (2024) confirms that over 30 % of avian nesting habitats in the Chornobyl Biosphere Reserve have been affected by wildfires and military occupation, threatening endangered species such as the white-tailed eagle (*Haliaeetus albicilla* (Linnaeus, 1758) and the red-footed falcon (*Falco vespertinus* Linnaeus, 1766).

3.5. Assessment Challenges and Environmental Damage to Ukraine's NRF

The full-scale war has caused enormous environmental losses in Ukraine, particularly in its NRF. According to the Ministry of Environmental Protection and Natural Resources of Ukraine, total environmental damages from military operations already exceed 2 trillion UAH (about 55 billion USD), a substantial share of which stems from degraded ecosystems within protected areas. Restoration of forests and steppe ecosystems alone is estimated to require at least 1.5 billion USD, while mitigating water pollution may cost an additional 500 million USD (Kvach et al., 2025).

One of the main challenges in assessing damage is the lack of access to all affected areas due to ongoing hostilities and extensive landmines. Preliminary estimates suggest that approximately 30 % of NRF territory in eastern and southern Ukraine is inaccessible for ecological monitoring (Dudnieva, 2024). Another challenge lies in methodology−standard damage assessment methods require long-term monitoring, including soil, water, and air analysis, as well as tracking changes in plant and animal populations (Halyna et al., 2024).

3.6. Financing Mechanisms for the Restoration of Protected Areas

Securing funding for the restoration of Ukraine's ecosystems will be a key post-war priority. Potential mechanisms for financing include:

Government Funds and International Financial Aid. Ukraine should establish a national "Protected Areas Restoration Fund", co-financed by international donors and governed transparently. Current national recovery programs are already being designed with support from the EU and the U.S. For instance, the EU's Green Recovery Program may offer up to €500 million in grants for the restoration of protected areas. The World Bank has also expressed readiness to support the rehabilitation of ecologically sensitive zones and fund post-war environmental recovery initiatives (Slessarev et al., 2024).

Reparation Mechanisms. Ukraine has legal grounds to seek compensation from the russian federation for ecological damage through international courts, including the International Court of Justice and the European Court of Human Rights. One potential source of funding could be frozen Russian assets, which may be redirected toward ecological rehabilitation of protected areas (Kucher et al., 2023).

Support from International Environmental Organizations. The World Wide Fund for Nature (WWF) is actively involved in conservation efforts in Ukraine and can assist in funding restoration of degraded ecosystems. The United Nations Environment Programme (UNEP) has special funds designated for war-related environmental damage and can become a strategic partner in demining reserves and rehabilitating soils (Gatti et al., 2025).

3.7. The Role of International Organizations in NRF Recovery

International organizations are vital not only for financial aid, but also for providing scientific monitoring and effective recovery strategies. Among the key partners for Ukraine are:

Green Climate Fund (GCF) – capable of financing long-term projects for protected area restoration and climate adaptation.

Global Environment Facility (GEF) – supports programs on biodiversity, forest conservation, and remediation of contaminated sites.

European Environment Agency (EEA) – provides technical assistance in developing environmental policy and standards suitable for Ukraine.

World Resources Institute (WRI) – specializes in ecological mapping and ecosystem service assessment.

Some researchers (Filho et al., 2024) propose the development of a "Marshall Plan for Environmental Recovery", which would consolidate international support and deliver a coordinated approach for cleaning and restoring Ukraine's protected areas.

4. Conclusions

The war that has been ongoing in Ukraine since 2014 has triggered an unprecedented ecological crisis, profoundly affecting the country's Nature Reserve Fund. Over 1.2 million hectares of protected areas have been damaged, which constitutes more than 30 % of all protected areas, including biosphere reserves, national nature parks, and regional landscape parks. The most

heavily impacted areas are in eastern and southern Ukraine, notably the Black Sea Biosphere Reserve, Meotyda, Askania-Nova, and the Luhansk and Rivne Nature Reserves.

A combination of descriptive analysis, geoinformation modeling (based on Sentinel-2 satellite imagery in QGIS), remote sensing, and ecological monitoring enabled the assessment of spatial dynamics of ecosystem destruction. Notable consequences include forest cover reduction, soil degradation, water pollution, and loss of up to 50 % of populations of certain plant, fungal, and animal species. The destruction or disappearance of habitats for species such as *Stipa borysthenica*, *Ciconia nigra*, and *Boletus pinophilus* poses a direct threat to regional biodiversity.

A particularly critical issue is the intensification of pyrogenic processes, which have affected large areas of protected territories. Satellite imagery revealed more than 5.000 hectares of burned ecosystems in the Askania-Nova Biosphere Reserve alone, indicating a p rofound transformation of natural landscapes.

Despite the severe damage, accurate assessment remains difficult due to several factors: limited access to occupied areas, landmines, the destruction of monitoring infrastructure, and a lack of pre-war baseline data for parts of the NRF. Total environmental damage is currently estimated at over 2 trillion UAH (≈55 billion USD), with restoration costs projected at 1.5–2 billion USD.

The recovery of Ukraine's NRF requires a systematic and long-term approach. Priority actions should include demining, soil remediation, reintroduction of rare species, restoration of wetlands, and the reconstruction of environmental monitoring infrastructure. Funding can be secured through: reparations; targeted funds from international partners (UNEP, GEF, WWF, Green Climate Fund, EU Green Recovery); Ukraine's national environmental fund; and public-private partnerships (PPP).

Ukraine has a unique opportunity not only to restore its damaged ecosystems but also to integrate modern European practices in the management of protected areas, contributing to the conservation of Europe's landscape and biotic diversity as a whole.

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