ASERS

Journal of Environmental Management and Tourism

Quarterly
Volume XIV
Issue 5(69)
Fall 2023
ISSN 2068 – 7729
Journal DOI
https://doi.org/10.14505/jemt

ASERS Publishing

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ASERS Publishing
http://www.aserspublishing.eu
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Journal of Environmental Management and Tourism

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Authors are encouraged to submit high quality, original works that discuss the latest developments in environmental management research and application with the certain scope to share experiences and research findings and to stimulate more ideas and useful insights regarding current best-practices and future directions in Environmental Management.

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Deadline for submission:	21st October 2023
Expected publication date:	December 2023
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Volume XIV, Issue 5(69), Fall 2023

DOI: https://doi.org/10.14505/jemt.v14.5(69).23

Impact of War on the Natural Preserve Fund: Challenges for the Development of Ecological Tourism and Environmental Protection

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Article info: Received 22 May 2023; Received in revised form 17 June 2023; Accepted for publication 19 July 2023; Published 1 September 2023.

Abstract: The global deterioration of the quality of the natural environment causes an increase in the importance of ecological tourism, primarily at the sites of the nature reserve fund. This paper is one of the first attempts to fill the existing gaps in the question of the impact of war on protected natural areas. The article determines the development trends, current state, and problems of the objects of the nature reserve fund in Ukraine in the conditions of unjustified full-scale russian military aggression and makes an approximate calculation of the damages caused as a result of hostilities. It was established that during 2012–2020, the number of objects of the nature reserve fund in Ukraine increased by 605 units or by 7.5 %; the area of these objects increased by 562,460.6 hectares or by 14.3 %. Due to russian military aggression, danger threatens 900 protected areas, which is 1.2 million hectares or about 30 % of the area of all protected areas of Ukraine. The damage calculation was carried out on the example of the Feldman EcoPark regional landscape park in the Dergachy district of the Kharkiv region. It was established that the approximate estimate of damages from the loss of ecosystem services of this landscape park as of 20.05.2022 was 16,979.5 thousand USD, including in terms of ecosystem services: (i) recreation and ecotourism – 13,846.2 thousand USD; (ii) air purification from solid fine particles and harmful gases – 272.1 thousand USD; (iii) biodiversity habitat – 2,861.3 thousand USD. In addition, the amount of damage caused to the regional landscape park due to the loss of animals, calculated based on special fees for calculating the amount of damage to the nature reserve fund, amounts to 63,350 USD. The determined damage estimates are preliminary and need to be clarified after the end of the war.

Keywords: ecosystem services; ecological damage; ecological tourism; nature reserve fund; Ukraine.

JEL Classification: O13; Q50; Q57; R11.

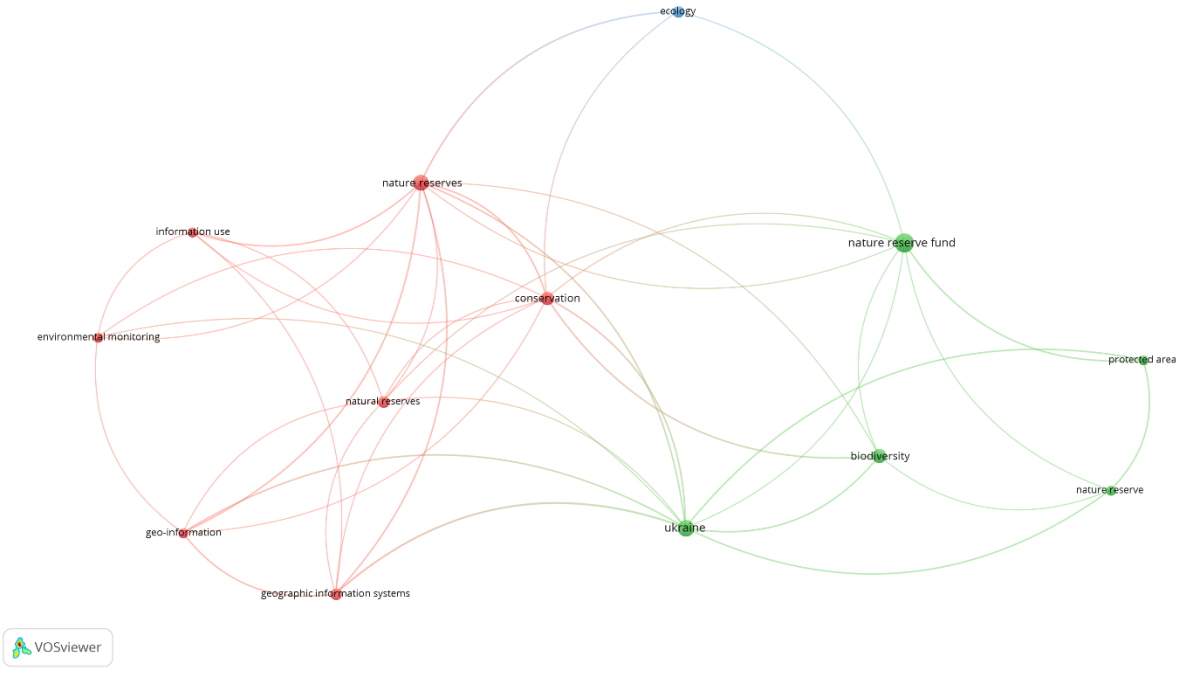
Introduction

The global deterioration of the natural environment is causing the growing importance of ecological tourism. The objects of the nature reserve fund (NRF) are the core for the development of ecological tourism. The development of ecological tourism has a particularly high potential in regions with a high share of natural heritage (Melnyk and Chyr 2019). Ecological tourism is designed to form the ecological consciousness of society, to convey to people the urgency and importance of issues of environmental protection.

The results of a search in the Scopus database with the search query “nature reserve fund” in the search field “TITLE-ABS-KEY” allowed to find 38 indexed documents. At the same time, a combined search for the phrases “nature reserve fund” and “ecological tourism” made it possible to find only two works devoted to the issues of the natural reserve fund of the Transcarpathian region as a core of the development of ecological tourism (Melnyk and Chyr 2019) and the rural “green” tourism as a driver of local economy development (Yakymchuk *et al.* 2021). The paper by Melnyk and Chyr analyzed the dynamics of nature protecting in the Transcarpathian region, the potential of the nature reserve fund of the region for the development of ecological tourism; in particular, for comparison, the authors analyzed the part and ratio of functional zones in the national natural parks of Europe and Ukraine (Melnyk and Chyr 2019). In the article by Yakymchuk *et al.* the prerequisites for the improvement of the nature reserve fund as a basis for the development of ecological tourism have been formed, the use of ethno-festivals as an innovative form of tourism activation within regional landscape parks and other categories of the nature reserve fund has been substantiated (Yakymchuk *et al.* 2021).

The bibliometric analysis of the metadata of the specified 38 documents allowed us to identify three clusters of keywords that reflect the main directions of research on the objects of the nature reserve fund in the world (Figure 1).

Figure 1. Network visualization of the connection between nature reserve fund and other related categories

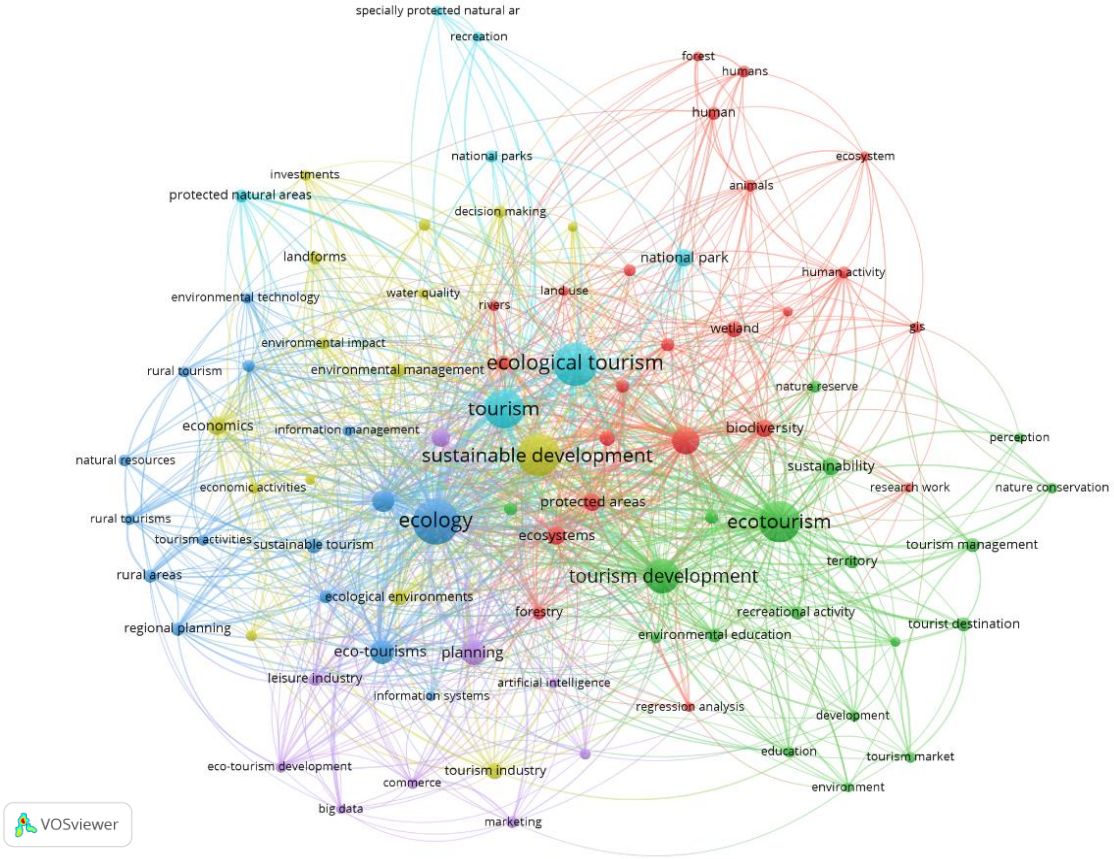


Source: developed by the authors based on the Scopus database using the program VOSviewer.

On the other hand, the results of a search in the Scopus database with the search query “ecological tourism” in the search field “TITLE-ABS-KEY” allowed us to find 386 indexed documents. The largest number of works were published by Chinese scientists. The distribution of documents by type indicates that the leading positions are occupied by articles (60.8 %) and conference papers (30.1 %). Environmental science (23.2 %), earth and planetary sciences (12.6 %) and social sciences (12.6 %) take the leading positions in the subject area. According to the results of the bibliometric analysis of the metadata of these documents, we identified six clusters of keywords that reflect the main directions of research on the objects of ecological tourism in the world (Figure 2). Each cluster is marked with different colors. For example, the largest is the red cluster, which includes 23 keywords and focuses on environmental protection. The second largest is the green cluster, which includes 19

keywords and focuses directly on the development of ecological tourism. The smallest is the blue cluster, which includes 7 keywords and focuses on tourism in general and ecological tourism in particular.

Figure 2. Network visualization of the connection between ecological tourism and other related categories



Source: developed by the authors based on the Scopus database using the program VOSviewer.

The objects of the nature reserve fund provide the population with ecological services, which, according to the international project "Millennium Ecosystem Assessment", are understood as all the useful benefits that can be obtained from proximity to nature (Millennium Ecosystem Assessment 2005). As part of this project, scientists have developed methods for estimating the cost of clean air, a beautiful landscape, the rustling of leaves, and the singing of birds. In Ukraine, comprehensive studies have been conducted on the assessment of ecosystem services of forests (Soloviy 2016; Soloviy and Burda 2022), wetlands, and swamps (Andreieva *et al.* 2021).

Environmentalists and economists around the world have developed methods for estimating the cost of clean air, a beautiful landscape, the rustle of leaves, and the singing of birds. These natural benefits, which are so familiar to us, are becoming more and more precious and desirable against the background of the rapid movement of life in the capital. According to the studies of scientists (Constanza *et al.* 1997; Sedell *et al.* 2000), the total value of forest ecosystem goods and services is 4.7 trillion USD annually, of which the total cost of boreal forests (temperate zone) is 894 billion USD annually. Depending on the region, the cost of soil stabilization services per hectare of forest varies from 1.94 to 5.5 million USD per ton for cleaning the air from solid fine particles (dust, soot) and harmful gases, each tree costs an average of 4.16 USD annually. For biological diversity, the forest is a habitat, 17.5 thousand USD is worth a hectare of forest, if you count the participation of birds in the fight against insect pests. The value of pollination services is 19.23 thousand USD up to 33.65 thousand USD for a year.

In Ukraine, similar comprehensive studies on the assessment of ecosystem services of forests have been conducted. Thus, the work presents approaches to the assessment of forest ecosystem services, analyzed the ecosystem services provided by the forests of Ukraine and their indicators, and proposed an institutional-and-organizational mechanism for the payment of fees for forest ecosystem services, the use of which will facilitate the identification and integration of previously undervalued services into economic activity, improving the well-being of forest-dependent communities and entering the international markets of ecosystem services (Soloviy

2016). Valuable for our work is the study of modern trends in the development of methodological bases for assessing the value of forest ecosystem services within nature-reserved territories, as a result of which it was established that the economic assessment of ecosystem services is an attempt to assign them quantitative indicators of economic value, including services that are at least partially covered market and those that are not yet valued on the market today. From a methodological point of view, the assessment of ecosystem services should be interdisciplinary, and from a practical point of view, it should consider the experience of assessments in other countries and the best practices of international projects (Soloviy and Burda 2022).

Unfortunately, for Ukraine, similar comprehensive studies on the assessment of ecosystem services of the objects of the nature reserve fund have hardly been conducted. However, there are some developments in this direction as well. Thus, the study identified the values of Holosiivsky forest ecosystems and found out the reasons for their degradation as a result of the impact on the forest ecosystems of a large city and the imperfect organization of the territory of the national nature park (NNP) "Holosiivskyi" in the city of Kyiv (Shyshchenko *et al.* 2019). An economic evaluation of the ecosystem services of NNP "Holosiivskyi", the area of which is 10,988.14 hectares, was also carried out. Each of the three million residents of Kyiv, even if they are not in the national park, receives from it obvious benefits of their own, which pass unnoticed by the residents, because there is no need to pay for such services. Calculations show that every resident of Kyiv should pay about 70 UAH to the state treasury every day for the work that wild nature does instead of complex technologies (Soloviy 2016; Soloviy and Burda 2022).

EPL ecologists have calculated the cost of some ecosystem services of the NNP "Holosiivskyi" according to the methods used in other countries of the world, especially for the residents of Kyiv. Unfortunately, not all services can be estimated, at least roughly in monetary terms. In particular, it can be calculated that the national park provides the following ecosystem services for one year (at a minimum estimate) (Soloviy 2016; Soloviy and Burda 2022):

- air purification – 480 million UAH;
- soil stabilization – 60 million UAH;
- fight against insect pests – 5,775 million UAH;
- pollination of plants – 6,346.9 million UAH;
- recreation – 240 million UAH;
- cooling the city in summer, forming a microclimate – 3,816 million UAH;
- wood (including firewood) – 40 million UAH.

The total cost of ecosystem services of the NNP "Holosiivskyi" is at least 76.7 billion UAH every year. Every year, every citizen of Kyiv receives 25,500 UAH from the national service park free of charge. From this calculation, it is clear that the most valuable resource among those provided by the forest is not wood at all. Therefore, by preserving natural territories in a wild state, we get much more than by taking resources from them (Soloviy 2016; Soloviy and Burda 2022).

Another article presents calculations of the cost of direct use and the potential economic value of the ecosystem services of the Askania steppe, the main part of which is part of the Askania-Nova biosphere reserve. According to the classification established within the project "Evaluation of Ecosystems on the Threshold of the Millennium", four types of ecosystem services are distinguished: (1) providing; (2) supporting; (3) adjustment rooms; (4) cultural (Lukavenko and Derevska 2017).

Preservation of the objects of the nature reserve fund is particularly important in the context of achieving the goals of sustainable development, in particular in the fight against land degradation. It was established that during the period from 2000 to 2018, the consumption of "clean" land in Ukraine occurred at a rate of 48.8 km^2 or 0.01 % per year in cities and 266 km^2 or 0.04 % per year in villages and towns. Despite the decrease in the total number of the population, including urban residents, there was an intra-regional migration increase of 2.1 %, caused both by the search for work and the resettlement of the population from the temporarily occupied territories of the Donetsk and Luhansk regions of the Autonomous Republic of Crimea, which led to an unjustified increase in the area of built-up land in settlements of individual regions (Budziak *et al.* 2021). Ukrainian scientists are also investigating the issue of directions for ensuring the sustainability of rural tourism (Okolovych 2022), challenges and guidelines for strengthening of environmental security of territories in war conditions (Irtyshcheva *et al.* 2022), the strategic directions for restoration of environmental security in the post-war period (Zamula and Shavurska 2023) and economic recovery of post-war Ukraine (Lemishko *et al.* 2022).

However, research on assessing the impact of war on nature reserves is in its infancy, which served as one of the key motivations for this work.

1. Materials and Methods

The research was carried out in two stages. In the first stage, the development trends, current state, and problems of the objects of the nature reserve fund in Ukraine under the conditions of russian military aggression were determined. In the second stage, an approximate calculation of damages caused as a result of hostilities was carried out (on the example of Feldman EcoPark).

In 2013, a regional landscape park "ECO PARK" was created in the Dergachy district of the Kharkiv region by the decision of the Kharkiv regional council. The landscape park with an area of 140.5 hectares includes 37 hectares, seized from the permanent land user – the Danyliv State Experimental Forestry Research Institute of Forestry and Agromelioration named after Vysotskyi, 78 hectares of the Danyliv forest farm, 3 hectares of the "Lisova Polyana" recreation complex, 3.15 hectares of the "Halychyna" recreation camp, 18.5 hectares of the reserve lands of the Dergachy district administration, the "Feldman EcoPark" zoo (Website of Feldman EcoPark 2022; Klimov *et al.* 2005).

This park has been in the line of fire since the first days of the full-scale invasion and is under fire every day. Because of this, the park suffers losses, animals die, and the infrastructure of the park is destroyed. Unfortunately, due to military operations, the authors cannot conduct the necessary research to fully assess the damage, but we decided to try to calculate the damage with the help of information that everyone can find freely available.

We were not able to find a specific method by which the damage caused to the NRF facility was previously assessed. Because of this, the authors chose two methods of determining damages – ecosystem services were calculated and assessment through fees, which were approved by the Resolution of the Cabinet of Ministers of Ukraine (2022).

Most of the park consists of forest plantations, so the number of ecosystem services provided by this area is very large. These include air purification and treatment of respiratory diseases, soil stabilization, pest control, plant pollination, cooling of the city in summer, microclimate formation, wood (including firewood), conducting scientific activities, forming a system of knowledge and values, recreational and conservation activities, tourism, protection of soils from erosion, genetic and decorative resources, biological diversity. We evaluated some of them, determined by the possibilities of obtaining information, namely: loss of ecosystem services related to recreation and ecotourism, air purification, and loss of biological diversity and its habitat.

The information base of the research at the first stage is data on the statistics of the nature reserve fund for 2012–2020, obtained from the statistical collections of "Environment of Ukraine", at the second stage – data collected by the authors from open sources.

2. Results and Discussion

2.1. Development Trends, Current State, and Problems of Nature Reserve Fund Objects in Ukraine in the Conditions of Russian Military Aggression

1.1. Trends in the development of nature reserve fund objects in Ukraine. The determination of the development trends of the nature reserve sphere is based on the statistical analysis of the series of dynamics regarding the number (Table 1) and area (Table 2) of the objects of the nature reserve fund of Ukraine.

Table 1. Indicators of the dynamics of the number of objects of the nature reserve fund of Ukraine

Years	The number of objects of the nature reserve fund, units	Absolute increase, units		Growth rate, %		Growth index, %		Absolute value of 1% increase, units
		basic	chain	basic	chain	basic	chain	
2012	8,028	-	-	100.0	-	-	-	-
2013	8,101	73	73	100.9	100.9	0.9	0.9	80
2014	8,154	126	53	101.6	100.7	1.6	0.7	81
2015	8,184	156	30	101.9	100.4	1.9	0.4	82
2016	8,245	217	61	102.7	100.7	2.7	0.7	82
2017	8,296	268	51	103.3	100.6	3.3	0.6	82
2018	8,396	368	100	104.6	101.2	4.6	1.2	83
2019	8,512	484	116	106.0	101.4	6.0	1.4	80
2020	8,633	605	121	107.5	101.4	7.5	1.4	85

Source: authors' calculations based on data from the State Statistics Service of Ukraine.

After analyzing the data, we can conclude that the number of NRF facilities in Ukraine is increasing every year. Absolute base growth during 2012–2020 ranged from 73 to 605 units and indicates a positive trend towards an increase in the number of NRF objects. The dynamics of chain growth confirm the stability of this positive trend. The most productive year for the formation of the NRF network was 2020 when 120 facilities were put into operation. The least productive year was 2015 when 30 facilities were commissioned. The chain rate of growth over the last three years exceeded 1 %, and the growth rate also significantly accelerated during the analyzed period. So, the data in the Table 1 shows that during 2012–2020, the number of NRF facilities in Ukraine increased by 605 units or by 7.5 %. The absolute value of 1 % growth increased from 80 units in 2012 to 85 units in 2020.

The analysis of the dynamics of the area of objects of the Nature Reserve Fund of Ukraine (Table 2) shows that during 2012–2020 the growth trend was ambiguous since a period of unambiguous growth of the area was recorded – from 2013 to 2016, during which time the area increased by 10.1 % compared to 2012; in 2017, the area of NRF facilities decreased by 7.7 % compared to 2016, but then again a positive trend towards the growth of this area was recorded.

Table 2. Indicators of the dynamics of the area of objects of the nature reserve fund of Ukraine

Years	The number of objects of the nature reserve fund, units	Absolute increase, units.		Growth rate, %		Growth index, %		Absolute value of 1% increase, units
		basic	chain	basic	chain	basic	chain	
2012	3,922,563.2	-	-	100.0	-	-	-	-
2013	3,958,769.0	36,205.8	36,205.8	100.9	100.9	0.9	0.9	39,226
2014	3,992,521.3	69,958.1	33,752.3	101.8	100.9	1.8	0.9	39,588
2015	4,082,780.6	160,217.4	90,259.3	104.1	102.3	4.1	2.3	39,925
2016	4,318,224.1	395,660.9	235,443.5	110.1	105.8	10.1	5.8	40,828
2017	3,985,022.4	62,459.2	-333,201.7	101.6	92.3	1.6	-7.7	43,182
2018	3,991,638.5	69,075.3	6,616.1	101.8	100.2	1.8	0.2	39,850
2019	4,085,862.4	163,299.2	94,223.9	104.2	102.4	4.2	2.4	39,916
2020	4,485,023.8	562,460.6	399,161.4	114.3	109.8	14.3	9.8	40,859

Source: authors' calculations based on data from the State Statistics Service of Ukraine.

So, after analyzing the data, it can be noted that the dynamics of the area of objects of the nature reserve fund of Ukraine are mostly positive. The absolute basic increase in the area of objects of the nature reserve fund fluctuated in a wide range of 36,205.8–562,460.6 ha. The absolute value of 1 % growth increased from 39,226 hectares in 2012 to 40,859 hectares in 2020. The highest chain growth rate of the analyzed area was recorded in 2020 when it was 9.8 %, which correlates with the highest growth rates of the number of objects nature reserve fund in the specified year. Therefore, during 2012–2020, the area of objects of the nature reserve fund of Ukraine increased by 562,460.6 hectares or by 14.3 %.

1.2. The impact of the war on the objects of the nature reserve fund of Ukraine. According to the data of the Ministry of Environmental Protection and Natural Resources of Ukraine (Briefing on the environmental damage caused by Russias war of aggression against Ukraine, 2022), about 20 % of all nature conservation areas of Ukraine have been affected by the war, 0.9 million hectares of protected areas suffer from the war, and 812 objects of the nature reserve fund are in danger (Figure 3).

The nature reserve fund of the highest level of protection (national parks, natural and biosphere reserves, national natural parks) in Ukraine covers 1,236,366 hectares. At the same time, 44 % of them were in the war zone, under the temporary control of the russian invaders, or are inaccessible to Ukraine; 11,600 hectares of protected areas burned in 4 months of the war. Also, due to the military actions in most regions, the processes of creating new territories for the nature reserve fund have stopped (Vasyliuk 2022).

As of August 15, 2022, 900 protected areas are at risk due to military actions, which is 1.2 million hectares or about 30 % of the area of all protected areas in the country. As a result of hostilities, the number of forest fires increased almost threefold, and the area of fires increased 90 times. The territories and objects of the nature reserve fund along the Azov-Black Sea coast and the eastern and northern borders of Ukraine are under

particular threat. As of the specified date, the Kherson region has already lost more than 5,000 hectares of forest, which is a real ecological disaster for the region, where the natural reproduction of forests is almost impossible (Ilyina and Kobzar 2022).

As noted by R. Strelets, the damage to the environment reached almost 1 trillion UAH during half a year of the war. About 20 % of protected areas are affected by war; in the risk zone – 2.9 million hectares of the territories of the Emerald Network and 17 Ramsar sites with an area of more than 600 thousand hectares. The russians occupied 8 Ukrainian nature reserves and 12 national natural parks. Some of them are in critical condition. For example, almost "80 % of the territory of the National Park "Holy Mountains" was destroyed; in May, the Kinburn Spit burned for a whole week due to hostilities, and relict forests burned there; there is currently a humanitarian crisis in the occupied "Ascania Nova" (Strilets 2022).

The main problems for the territories of the nature reserve fund, caused by military actions, include the following: death and scaring of animals; destruction of vegetation and loss of biodiversity; damage to the territory by military equipment and ruptures from explosions; destruction of the upper layer of soils; pollution of ecosystems by-products of explosions due to the burning of objects affected by shelling, as well as due to the destruction of military equipment; fires in forests and other natural ecosystems; disruption of the regular lifestyle of wild animals, depopulation and mass migration of species; cessation of nesting of birds, instead, alien species fly in their place; distribution of abandoned pets in nature; the threat of death of animals due to mining; spread of alien plant species on damaged areas; problems with keeping animals (impossibility to buy feed for animals; scaring of animals kept; impossibility to care for animals; destruction of pens for animals) (Ilyina and Kobzar 2022; Vasyliuk 2022).

Figure 3. Basic data on the impact of the war on the protected territories of Ukraine as of 20.05.2022

Source: data from the Ministry of Environmental Protection and Natural Resources of Ukraine (Briefing on the environmental damage caused by Russias war of aggression against Ukraine, 2022).

2.2. Calculation of Damages Caused as a Result of Hostilities. The Example of Feldman EcoPark

2.1. Estimation of losses from loss of ecosystem services about recreation and ecotourism. According to mass media, in recent years, the park has been visited by about 2.7 million tourists per year. Since the visit was free, to calculate the value of tourist services, we took the price of tickets determined for the Kharkiv Zoo. It was planned that a ticket for visitors to the Kharkiv Zoo would cost 100 UAH for children and 200 UAH for adults (Feldman will build a new ecopark in Odesa for $15 million. Economic truth, 2020; Zoo in Kharkiv: how to get there, how to sign up and schedule, 2022). So, we calculated the average price of a ticket – 150 UAH. That is, on the condition that a ticket would cost 150 UAH for one visitor on average, then the annual cost of the tourist component of ecosystem services provided by the park would be 405 million UAH.

2.2. Assessment of damages from the loss of an ecosystem service related to air purification from solid fine particles (dust, soot) and harmful gases. Unfortunately, we do not have the opportunity to count the number of trees on the site, but a tree from a tree is usually planted at a distance of about 5 meters. Accordingly, there are 20 trees at a distance of 100 m, and 400 on an area of 100x100 m. Further, we assume that the entire territory, except for the zoo and the recreation camp, has forest plantations – this is 163.5 hectares. As for the ecosystem service of cleaning the air from solid fine-dispersed substances (dust, soot) and harmful gases, each tree on average annually provides them for 4.16 USD (Holosiiv National Park – a treasure trove of free benefits Press

release – Ecology Right Human, 2022). Based on these data, we calculated that 65,400 trees are growing on this territory, which provides 272,064 USD worth of ecosystem services. At the current exchange rate, this is equivalent to 7,957,872 UAH.

2.3. Assessment of damage from the loss of an ecosystem service about the habitat of biological diversity. For biological diversity, the forest is a habitat. A hectare of forest costs 17.5 thousand USD, if we consider the participation of birds in the fight against insect pests (Holosiiv National Park – a treasure trove of free benefits Press release – Ecology Right Human, 2022). Thus, the economic loss from the damages of this ecosystem service is 2,861,250 USD. At the current exchange rate, this is equal to 83,691,563 UAH.

As a summary, it can be noted that the estimated number of damages from the loss of ecosystem services of the regional landscape park "Feldman - EcoPark" is 16,979,467 USD (Table 3).

Table 3. Approximate assessment of losses from the loss of ecosystem services on the example of the regional landscape park "Feldman - EcoPark" of Dergachy district, Kharkiv region

Ecosystem service	Damages	
	UAH	USD
Recreation and ecotourism	405,000,000	13,846,153
Air purification from solid fine particles and harmful gases	7,957,872	272,064
Biodiversity habitat	83,691,563	2,861,250
The loss of three ecosystem services	496,649,435	16,979,467

Source: authors' calculations based on available data.

2.4. Damage assessment based on special fees for calculating the amount of damage to the nature reserve fund. It is possible to determine the damage caused by taxes. Fires start every day due to shelling, animals die, and their habitats disappear. Institutions of the Nature Reserve Fund, the State Environmental Inspectorate, and state enterprises in the forest industry record crimes against nature. The damage caused to the territories and their biodiversity is assessed for further compensation to Ukraine for the loss of biodiversity thanks to approved fees for calculating the amount of damage to the nature reserve fund in the following cases (https://mepr.gov.ua/news/39175.html):

- illegal felling or damage to trees and plants with lignified stems;
- destruction or damage of forest crops, natural undergrowth, and self-sowing, seedlings and saplings;
- destruction or damage to lawns and flower gardens;
- illegal collection or destruction of wild herbaceous plants, forest litter, medicinal plants, wild fruits, nuts, berries, and secondary forest materials; illegal extraction or destruction of objects of the animal world, damage or destruction of their dwellings and structures, places of stay and reproduction;
- damage to karst speleological, geological, and hydrological objects;
- traffic, flights, and landings of aircraft;
- arbitrary occupation of land plots;
- destruction or damage to drainage ditches, drainage, and anti-erosion systems, roads, and other objects.

It should be noted that, according to the authors, these taxa are more suitable for peacetime. In the territories where military operations are taking place, it is worth considering in more detail: the factors of disturbance of vegetation cover and soil, factors affecting/affecting animals, physical pollution and transformation of the landscape, and impact on forest plantations.

The main factor in the disturbance of vegetation and soil is shell explosions. Factors affecting/affecting animals – the death of animals, noise, provoking the escape and/or migration of animals. The main impact on forest plantations is fired due to explosions.

At this time, we do not know the exact number of animals that died due to the shelling of the park. However, you can calculate the approximate number by collecting information from the official website, social networks, and media publications. Thus, as of May 20, 2022, it is known about the death (Ryazantseva 2022; Website of Feldman EcoPark 2022; Solodovnik 2022; Primates died during shelling in the Kharkiv Ecopark 2022; The baby was left an orphan: the russians killed a couple of bison in the Kharkiv Ecopark 2022): 2 bison; 4 does; 3 welsh goats; 1 mandrill; 9 red deer (another 20 escaped); 2 orangutans; 1 chimpanzee; 2 kangaroos.

According to the taxes of 2022, one individual deer is worth 45,565 UAH, so the losses amount to

410,085 UAH, and if we consider the escaped deer, then 1,321,385 UAH. According to the taxes of 2022, one doe is worth 30,377 UAH (Resolution of the Cabinet Ministers of Ukraine, 2022), so the losses amount to 121,508 UAH. Thus, the amount of damage caused to the regional landscape park "Feldman - EcoPark" due to the loss of animals, calculated based on special fees for calculating the amount of damage to the nature reserve fund, amounts to 1,852,978 UAH or 63,350 USD. Comparing the results of our research with recently published data, it should be noted that the state environmental protection inspectors of the Kharkiv region recorded the criminal consequences of Russian aggression and calculated at least 1,280,000 UAH in damages caused to the environment due to the death of animals in the park "Feldman - EcoPark". We agree with the opinion that the rescue of animals from the park "Feldman - EcoPark", its preservation and restoration is an event that deserves a special place in the great book of the struggle of the people of Ukraine for life and freedom in this terrible war unleashed by Russia. This is a story that not only shows the indomitable will and dedication of people, but also reveals their humanism and faith in the future (Kharkiv Ecopark will welcome visitors again, 2023).

So, as of May 20, 2022, we were able to calculate losses from the loss of ecosystem services and the loss of animals for 497,502,413 UAH or 17,042,817 USD. This is a huge amount and, unfortunately, not final; there is an assumption that it could be significantly larger.

While discussing and summarizing the obtained results, it should be noted that several assessment methods should be used for a more comprehensive assessment of the damage caused. Research suggests that, in contrast to the traditional method of using a single approach, economic valuation of ecosystem services using multiple methods helps to address several limitations (Vicente *et al.* 2023). One of the obstacles to overcoming information limitations is the lack of access to complete data on the damage caused. Despite all the difficulties and challenges, on June 1, 2023, on International Children's Day, the park "Feldman - EcoPark" opened for visitors the first location "Alpacas Valley", which was demined, restored, and made safe for visitors (Kharkiv Ecopark will welcome visitors again, 2023). Restoration and development of protected areas and objects should become one of the components of the Ukraine Recovery Plan (Shvedun *et al.* 2023). At the same time, at the post-war stage, it is necessary to rethink the practice of ecological tourism in nature conservation areas and bring it to a "sustainable course" (Perera *et al.* 2023). Future planning for the restoration of war-damaged nature reserves and the development of sustainable tourism will require research to develop methodological recommendations and strategic plans.

Conclusions

A bibliometric analysis of publications on the nature reserve fund and ecological tourism based on the Scopus database proved the presence of gaps in the development of ecological tourism in the territories of the nature reserve fund in the conditions of martial law and the loss of ecosystem services due to the war. This article is one of the first attempts to fill the existing gaps. The development trends, current state, and problems of the objects of the nature reserve fund in Ukraine in the conditions of russian military aggression were determined, and an approximate calculation of the damage caused because of hostilities was carried out. After analyzing the data, we noted that the dynamics of the area of objects of the nature reserve fund of Ukraine are mostly positive. The absolute basic increase in the area of objects of the nature reserve fund fluctuated in a wide range of 36,205.8–562,460.6 hectares. The absolute value of 1% growth increased from 39,226 hectares in 2012 to 40,859 hectares in 2020. During 2012–2020, the area of the country's natural reserve fund increased by 562,460.6 hectares or by 14.3 %. Due to military actions, 900 protected areas are at risk, which is 1.2 million hectares or about 30 % of the area of all protected areas of Ukraine. As a result of hostilities, the number of forest fires increased almost threefold, and the area of fires increased 90 times. The territories and objects of the nature reserve fund along the Azov-Black Sea coast and the eastern and northern borders of Ukraine are under particular threat. Since we did not find a specific methodology, according to which the damage caused to the NRF object was previously assessed, therefore we chose two methods of determining the damage – (1) calculated damage from the loss of ecosystem services about (a) recreation and ecotourism, (b) cleaning the air from fine particulate matter and harmful gases, (c) biodiversity habitat, and (2) assessment using taxes, which were approved by the Resolution of the Cabinet of Ministers of Ukraine. As a result of the calculations, it was established that the total amount of damage caused to the regional landscape park "Feldman - EcoPark" due to the loss of ecosystem services and the loss of animals as of 20.05.2022 amounted to 17,042,817 USD. However, this figure is not final, and it will probably be much higher, but it will be possible to determine it after the end of the war. Therefore, a promising direction of research is the development and testing of an internationally recognized methodology for determining the damage caused by military aggression to the objects of the nature reserve fund. The development of a program for the post-war restoration of nature reserve objects as a basis for environmental protection and the

development of ecological tourism should also be included among the promising directions.

Credit Authorship Contribution Statement

Anatolii Kucher: Conceptualization, Investigation, Methodology, Formal analysis, Writing – original draft, Supervision, Writing – review and editing.
Anna Honcharova: Investigation, Formal analysis, Writing – original draft, Data curation, Validation.
Lesia Kucher: Conceptualization, Investigation, Project administration, Software, Writing – original draft, Writing – review and editing, Visualization, Funding acquisition.
Mariia Bieloborodova: Investigation, Writing – original draft, Data curation, Funding acquisition.
Liudmyla Bondarenko: Data curation, Funding acquisition, Investigation, Writing – original draft.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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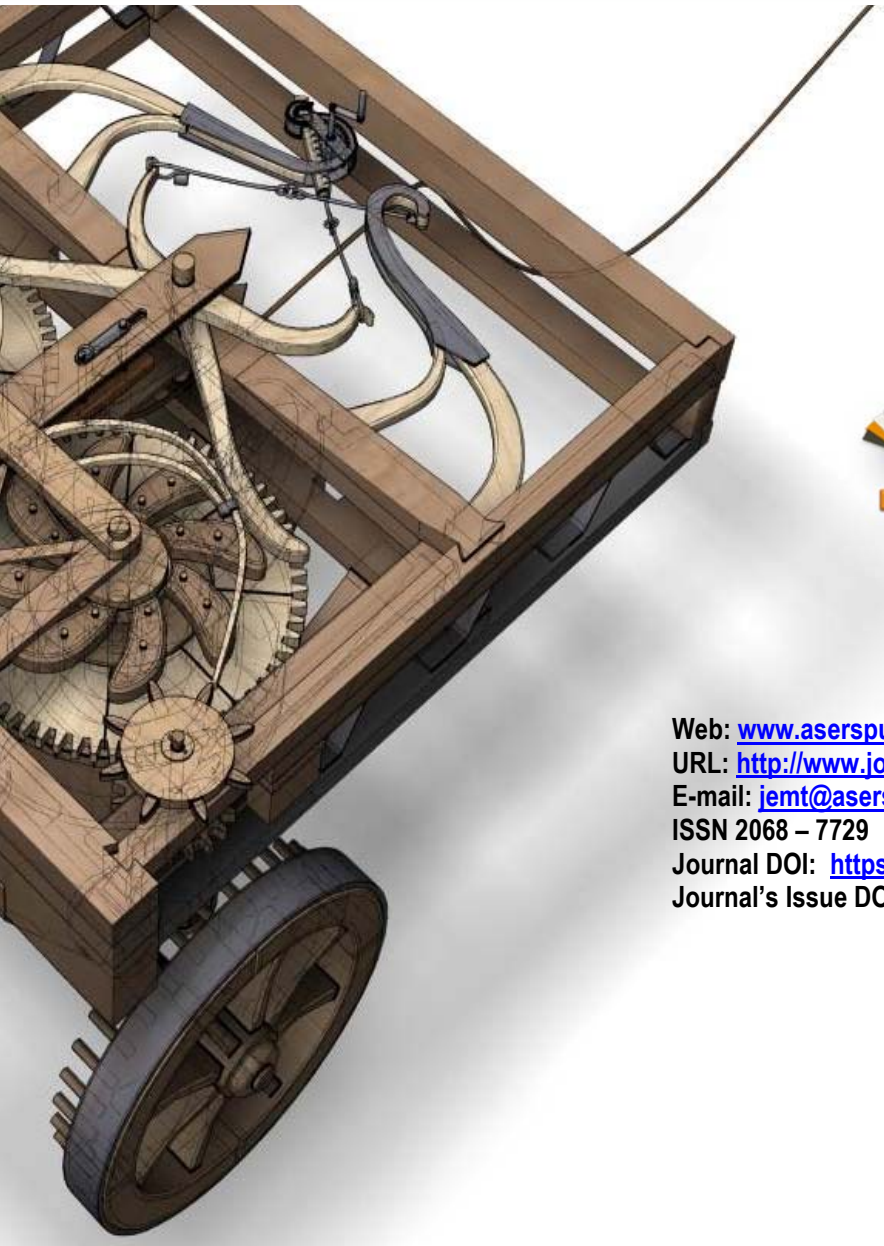

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