CLIMATE DAMAGE CAUSED BY RUSSIA'S WAR IN UKRAINE

24 February 2022 – 23 February 2025

Preliminary assessment by the Initiative on GHG Accounting of War

24 February 2025

Introduction

This paper summarises research calculating the carbon emissions created since Russia's full scale invasion of Ukraine began three years ago today. It is based on detailed analysis and modelling that pinpoints only those emissions attributable to the war and its impacts in Ukraine and Russia. The underlying methodologies remain largely unchanged since the previous iteration in June 2024[1], a report that offers the reader a more detailed explanation of the calculations given in this assessment.

The underlying datasets have been updated for this edition from a wide range of authoritative sources, although not all data sources were complete up to 23 February 2025. A full assessment will be released in spring 2025 containing verified data up to 23 February 2025 and may contain additional emissions sources which were currently not addressed.

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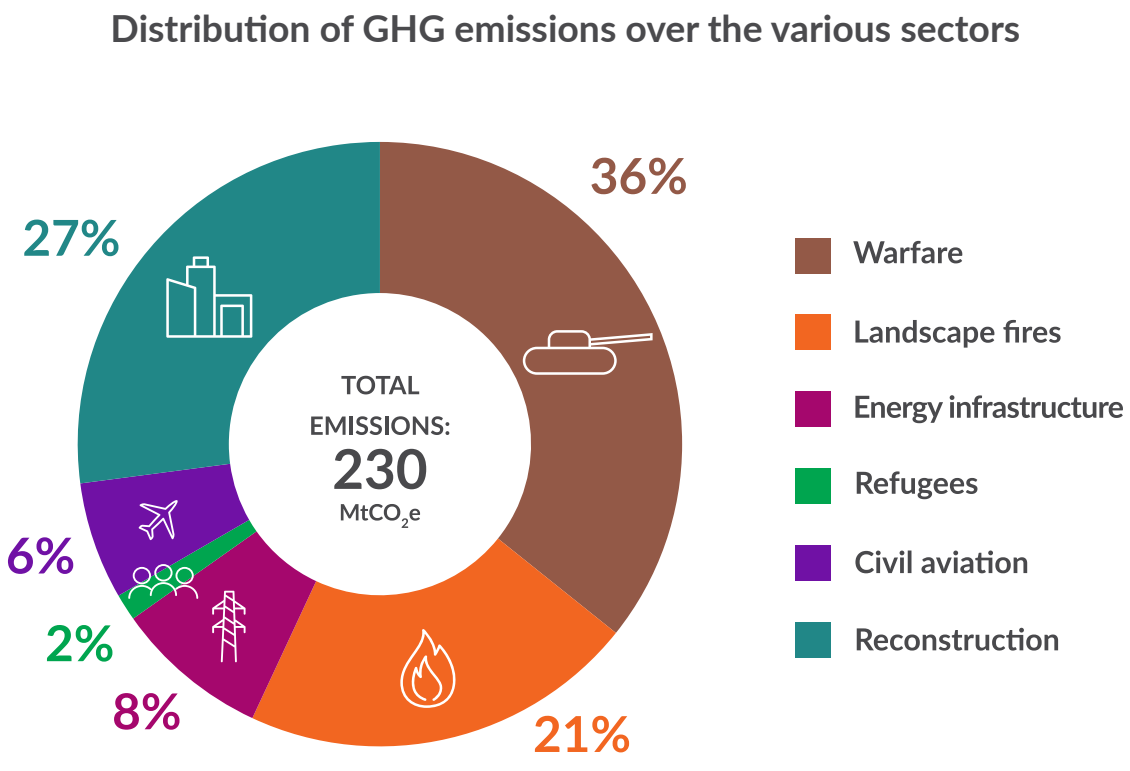
1. Climate Damage caused by Russia's war in Ukraine, 24 February 2022 – 23 February 2024. https://en.ecoaction.org.ua/climate-damage-by-russia-24-months.html

2024: static frontlines, escalating emissions

Greenhouse gas emissions caused by warfare, buildings reconstruction, landscape fires, damage to energy infrastructure, refugee and civil aviation displacement increased by 30% or **55 million tonnes of CO_2 equivalent during the third year of the war to bring the total to 230 $MtCO_2e$ since the full-scale invasion began on 24 February 2022**. The emissions are the equivalent of the annual emissions of Austria, Hungary, Czech Republic and Slovakia combined or the annual emissions of 120 million fossil fuel automobiles. While all sectors contributed to the increase of emissions in the third year of the war, landscape fires driven by conflict saw a notable jump due to unusually dry conditions, probably driven by global warming. Warfare emissions (e.g. tanks using fuel, fortification construction etc) grew steadily in during the third year of the war to become the single largest emissions category mainly due to the continued use of large quantities of fossil fuel and ammunition. The other major category, emissions from reconstruction of damaged buildings and infrastructure, grew at a slower pace as most of the damage occurred during the first weeks and months following the full-scale invasion.

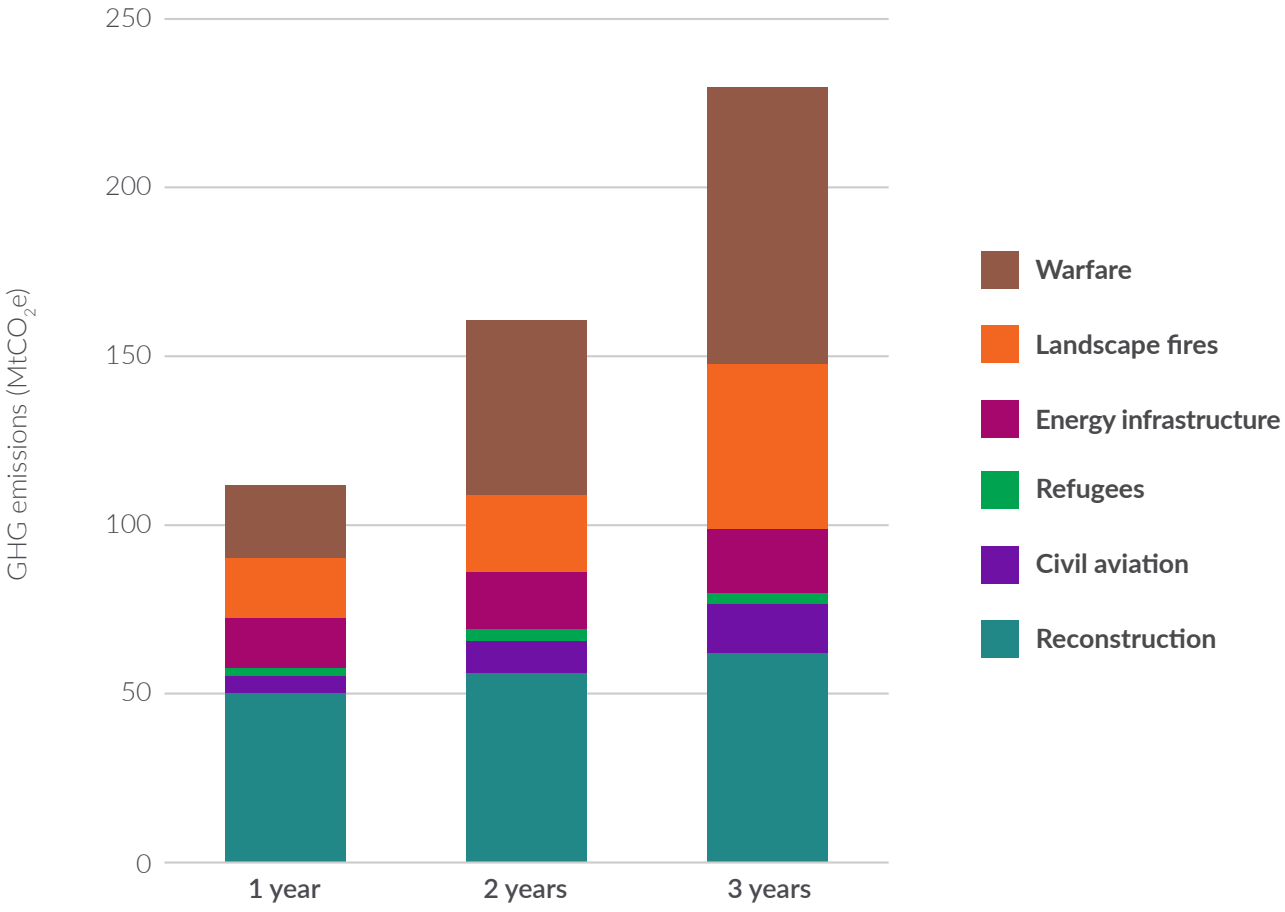
The Russian Federation should be held liable for these emissions and resulting climate-related damage. Applying a social cost of carbon of 185 US Dollars / tCO_2e, this amounts to over 42 billion USD.



Graph 1: Distribution of GHG emissions

SECTOR	EMISSIONS 36 MONTHS ($MtCO_2e$)	PERCENTAGE, %
Warfare	82.1	36
Landscape fires	48.7	21
Energy infrastructure	19.0	8
Refugees	3.3	2
Civil aviation	14.4	6
Reconstruction	62.2	27
TOTAL	**229.7**	**100**

Table 1. Total emissions after three years of war



Graph 2: Evolvement of war emissions over three years

Conflict and climate change combined to hit forests hard in 2024

Forest fires caused by the war escalated dramatically in 2024, more than doubling the burned areas from an annual average of 38.3 thousand hectares in the previous two years to 92.1 thousand hectares in 2024 in Ukraine. Emissions from all landscape fires, including forests, increased with 25.8 $MtCO_2e$ in 2024, which is a 113% growth compared to 22.9 $MtCO_2e$ 2022 and 2023 combined, resulting in a new total of 48.7 $MtCO_2e$. As shown in the image below, the majority of fires occurred at or near the front lines or at border areas. By comparing the frequency of *all* frontline landscape fires with landscape fires away from the war zone (under similar conditions like land cover type and fire weather index) only fires as a result of hostilities were included in the figures above. Climatological analysis showed that the summer of 2024 was much drier than average for Ukraine, likely caused by climate change. These dry conditions created the ideal conditions for fires caused by the ongoing hostilities to start as small fires and then expand into larger blazes. As it is dangerous for firefighters to operate in the war zone, these fires rage on in an uncontrolled manner, growing larger in size and intensity, and leading to carbon emissions and destroying vegetation and other natural carbon sinks. The year 2024 stands out as a worrying example of how climate change and armed conflict mutually reinforce each other, leading to increased global warming (cycle of destruction).

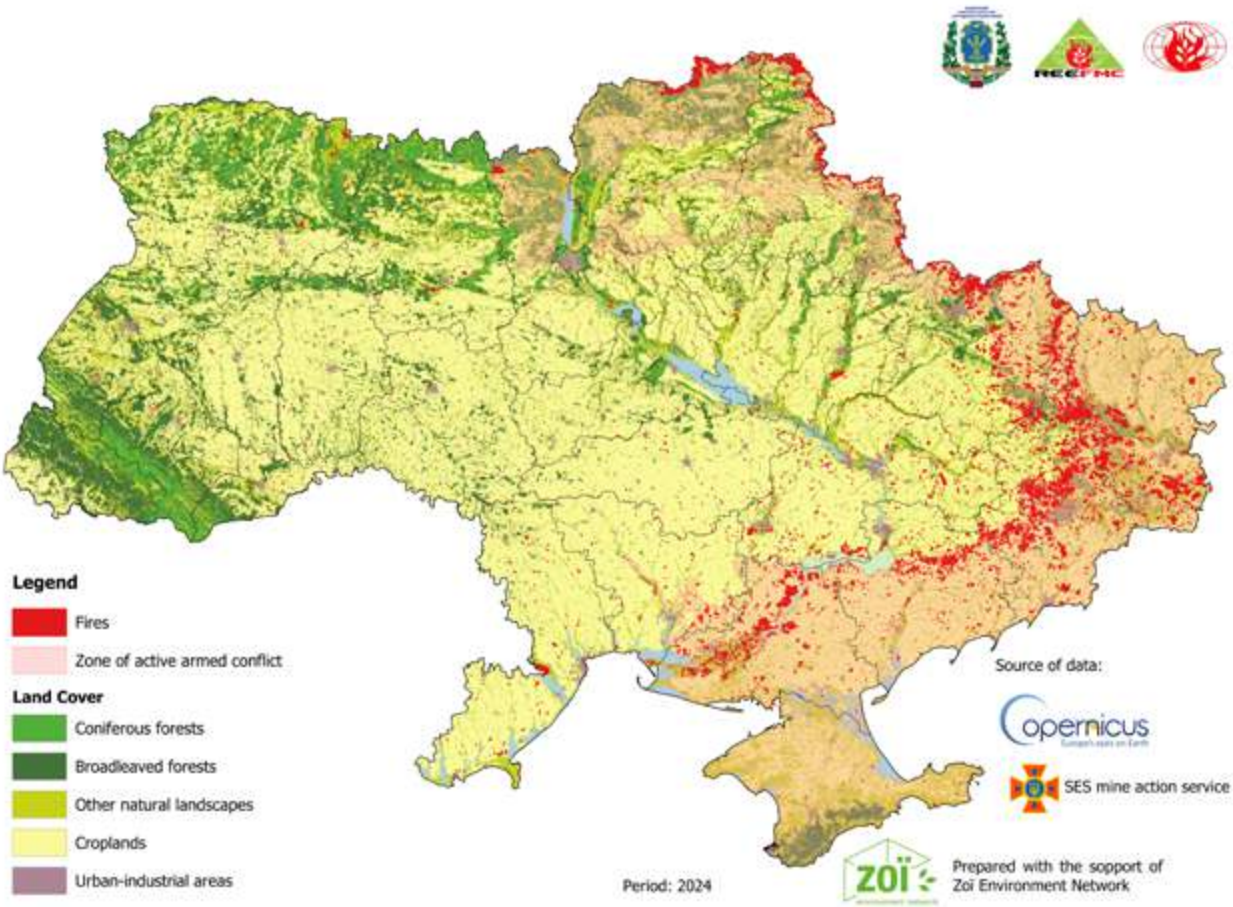
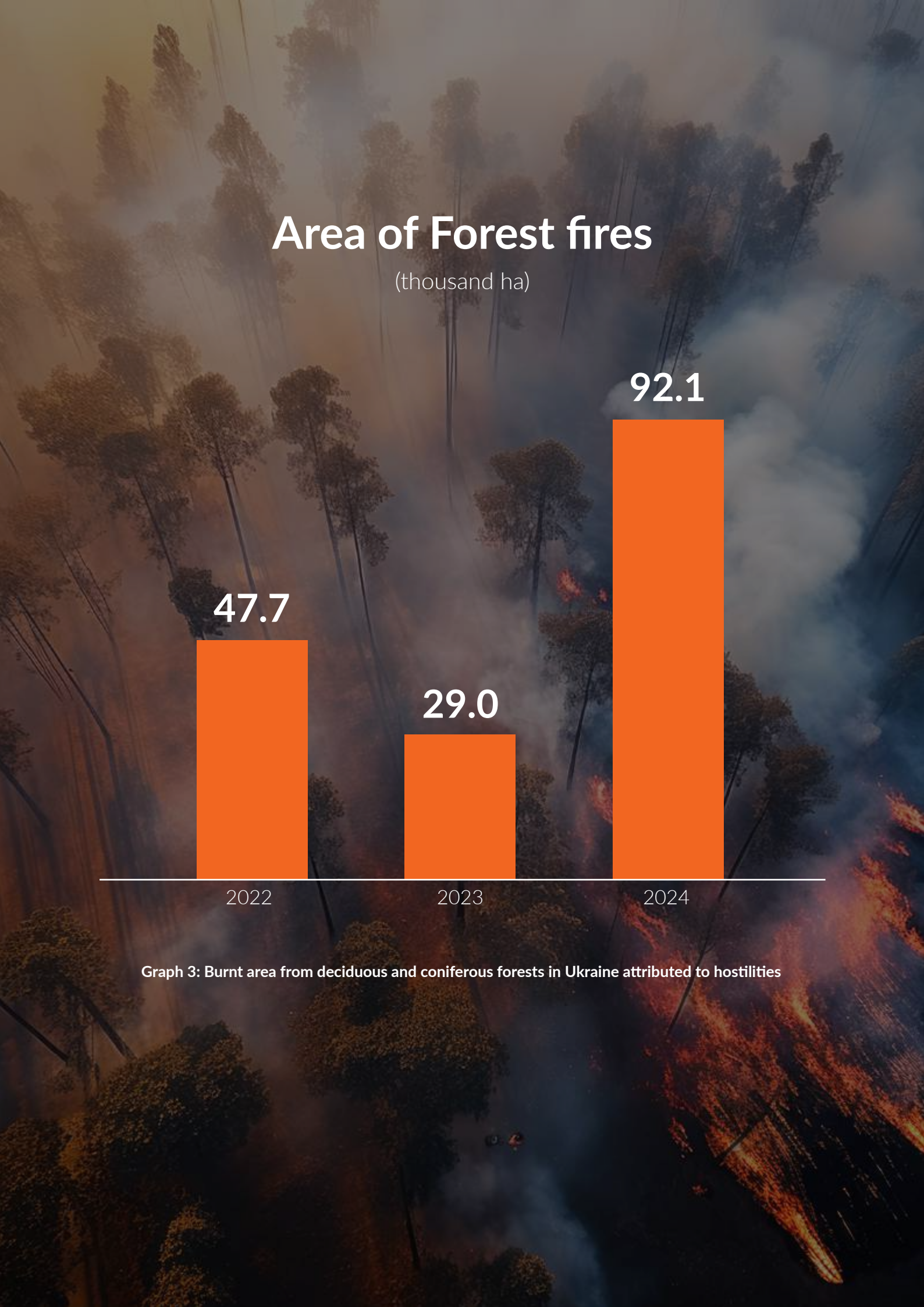


Figure 1: Landscape fires during 2024[2].

2. Zibtsev S., Myroniuk V., Soshenskyi O., Regional Eastern European Fire Monitoring Centre, https://nubip.edu.ua/en/node/9087/2



Graph 3: Burnt area from deciduous and coniferous forests in Ukraine attributed to hostilities

Increased use of drones did not reduce emissions from ammunition use

As hostilities continue unabated, warfare has become the largest source of carbon emissions after three years. Warfare emissions started with 21.9 $MtCO_2e$ in the first 12 months, increased by 29.7 $MtCO_2e$ in the second 12 months and by a further 30.5 $MtCO_2e$ in the third 12 months, adding up to 82.1 $MtCO_2e$ after three years of war. Fossil fuel used by tanks and fighter jets, large guzzlers of diesel and kerosine, make up the brunt of warfare emissions. But the use of ammunition for artillery was a large contributor in the third year of the war as well. The usage of drones has become more prominent in the third 12 months, but it did not replace the usage of carbon-intensive artillery shells.

SOURCE OF EMISSIONS	$MtCO_2e$
Fuel consumption	74
Manufacturing and use of ammunition and explosives	5
Manufacturing of military equipment	2.5
Building of fortifications	0.6
TOTAL	**82.1**

Table 2: Total emissions from warfare

More destruction of energy infrastructure

The destruction of energy infrastructure created another 2.8 million tonnes CO_2e (+16%) in the past 12 months, bringing the total to 19.0 $MtCO_2e$ since 2022. Intensified attacks on oil depots and oil refineries caused a surge of these emissions in the past 12 months (2.1 million tCO_2e) compared to the first two years (1.1 million tCO_2e). Russia continued attacking power stations and the electricity grid to deprive Ukrainian society of electricity, in particular during the winter months. These continued attacks not only caused the release of CO_2, but also the extremely potent greenhouse gas SF_6, which is 24,000 times stronger as a greenhouse gas than CO_2. A recent article in Nature[3] slightly reduced previous estimations of the amount of methane, another potent greenhouse gas, that escaped from the Nord Stream pipelines.

SOURCE OF EMISSIONS	$MtCO_2e$
Sabotage of Nord Stream 1 & 2 pipeline	14.0
Gas flaring at the Black Sea platforms	0.5
Damage to domestic natural gas infrastructure	0.3
Attacks on oil depots and refineries	3.1
SF_6 emission from electric equipment	1.1
TOTAL	**19.0**

Table 3: Total emissions from damaged and destroyed energy infrastructure

3. Methane emissions from the Nord Stream subsea pipeline leaks, Nature, January 2025. https://www.nature.com/articles/s41586-024-08396-8

Reconstruction of housing, public buildings and infrastructure will be a daunting task

The destruction of civil infrastructure created another 6.2 million tonnes CO_2e (+11%) in the last 12 months, bringing the total to 62.2 $MtCO_2e$ since 2022. Although most damage was caused during the first weeks of the conflict, front line urban centres are still being severely damaged. Russian forces slowly but steadily occupied more territory in eastern Ukraine, leaving a trail of destruction. As Russia tries to weaken the Ukrainian economy, the category Industry & Utilities saw the biggest increase in damage in the last 12 months. Rebuilding what was destroyed will require massive volumes of construction materials of which carbon-intensive concrete and steel will cause over 80% of the future reconstruction emissions.

SOURCE OF EMISSIONS	$MtCO_2e$
Buildings	24.5
Transport & Infrastructure	15.7
Industry & Utilities	22.0
TOTAL	**62.2**

Table 4: Total emissions from the future reconstruction

Refugees

Movements of refugees from or back to Ukraine have been very small in 2024, and therefore no additional emissions were added to the total in this preliminary assessment.

Civil aviation

The methodology to calculate additional emissions from civil aviation due to airspace closures has been fully updated. This new and unique analysis is based on real-time flight data of 350000+ annual flights flying over Russia, Ukraine or Belarus before the invasion and the diverted and longer routes these flights are forced to take due to airspace closures. Additional emissions are 4.8 million tCO_2e bringing the total to 14.4 million tCO_2e after three years of war. A complete description of the data sources, impacted flight connections, the new diverted flying routes and resulting emissions will be provided in the full emissions report, to be released in spring 2025, or as a separate report specifically focussing on the impact of the war on civil aviation.