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The Environmental Impacts of War and Conflict

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Question

What are the main environmental impacts associated with acts of war and/or conflict?

Contents

1. Summary

This helpdesk report is a rapid literature review on the main environmental impacts of war and conflict, drawing primarily on academic, and peer reviewed literature and only some policy and practitioner sources, as per the request. Where current situations are discussed, such as the ongoing Ukraine war, a few blogs are referred to.

The main direct impacts on the environment of war and/or conflict are: the visible damage or devastation of natural landscapes and habitats, agricultural land and crops, and plant and animal species; deforestation; desertification; biodiversity loss; contamination of water sources; damage to irrigation systems; infrastructure damage and collapse resulting in toxic debris; conflict rubble; and, where nuclear, chemical or biological facilities are targeted or their maintenance compromised, toxic chemical leakage and radioactive pollution in the soil, air and water. Biodiversity is further impacted by soil erosion caused by military movements and damage from bombing, deforestation, water scarcity and contamination, desertification and invasive species overcoming fragile ecosystems left damaged or unprotected.

Public utilities are often targeted deliberately resulting in untreated water supply, waste management deficiencies and toxic build up from damaged machinery and structures. Unexploded munitions and landmines, some of which can remain hazardous even half a century later, can directly degrade the land rendering farming impossible and injuring wildlife, quite apart from human casualties. Toxic waste and burn pits left behind by invading forces leave a legacy of poisonous waste in countries with limited means to treat the waste. There is no consensus on whether ammunition used in conflicts in the Gulf and the Balkans has left deposits of depleted uranium (DU) that are polluting the environment and leading to adverse health outcomes.

Indirect (unintended or incidental) impacts of war include: the environmental cost (energy and natural resources) of military preparations, installations and operations, and weapons testing; toxic waste generation at military bases and weapons production sites; damage to terrain, air quality and marine life through military convoys, aircraft and vessel movements during military exercises. Civilian population exodus and refugee camps outside conflict areas that negatively impact land, habitats and natural resources creating further pollution and waste are “indirect aspects” and beyond the scope of this report. Conflict–sustaining activities are also not covered here, such as poaching, mining, logging, artisanal oil refining, manufacturing home-made weapons, either by combatants to fund their war effort or by civilians to replace lost livelihoods. These environmental consequences are indirect although foreseeable and consequential results of the economic strife caused by war/conflict on food security, resource allocation and environmental governance. In theory, the indirect repercussions of war/conflict on the environment could be so broad, deep and far reaching that the full impact may not even be possible to assess in the short term.

There are a few instances of beneficial impacts when war or conflict has provided biodiverse hot spots a measure of respite from human contact and economic exploitation. Temporary suspension of logging, mining and hunting in the dense forests of Africa may allow endangered species and forestation to recover for a while. Similarly, when areas are vacated due to conflict or become demilitarised zones, like between North and South Korea, nature can flourish unmolested, for a while at least.

The report focuses on the period after World War II (WW2), where the environmental consequences of modern warfare have been the subject of study, research and, in some cases, environmental impact assessments. Faced with the direct, immediate and often catastrophic humanitarian, economic and political fallout of violent conflict, damages to the natural environment, that usually fully manifest in the medium to long term, are either overlooked or underestimated by policymakers, politicians and the public. Hence, until recently, there has been little scientific interest and modest funding for detailed environmental impact assessments or long-term studies. As a result, conflict literature has a significant gap on the environmental outcomes of conflicts, as opposed to the causes of conflict where the literature is plentiful. By prioritising academic literature, this rapid review misses the contributions of non-governmental organisations on these subjects.

Within the literature focussed on the environmental impacts of conflict, common case studies include: the North Atlantic Treaty Organisation (NATO) bombing of Kosovo (1999), and the conflict in the Donbas region of Ukraine (2014). Interestingly there is comparatively less literature on the conflicts in Afghanistan (2001-2021), the Iraq-Iran War (1980-1988), the Gulf Wars (1991 and 2003), the Yemeni civil war (2014 – present) and the ongoing war in Syria (since 2011) despite their relatively greater severity, intensity and duration.

Russia's invasion of Ukraine (February 2022) is a potentially more volatile environmental situation, in comparison to the conflicts in the relatively less populated desert terrains of Iraq and Syria, as Ukraine is the seventh most industrialised nation on earth with the most nuclear reactors in Europe only second to France. Ukraine has thousands of industrial sites, including biological research facilities and chemical plants, as well being a strategic pathway for Europe's energy supply (Avis, 2022, forthcoming). These potentially toxic sites are located near densely populated cities unlike the oil fields of Iraq and Syria, thus any direct or incidental damage to such sites or the energy infrastructure could be catastrophic for the region's human population as well as the natural environment.

In modern warfare, the first widely acknowledged scientific study and documented case of environmental damage during conflict was the (direct and deliberate) use of Agent Orange and other toxic chemicals by US forces, from 1961-1971, during the Vietnam War in a policy known as herbicide. The Vietnam War has been relatively well documented for the sheer horror and magnitude of the devastation to natural habitats and because it was the first war where television and global media brought vivid images and accounts into people's homes, making the war a matter of political and public conscience This helped stir academic and scientific interest and facilitated evidence collection and documentation of environmental damages.

Similarly, the 1991 invasion of Kuwait, where oil fields were deliberately set on fire and burned for many months was televised thus alerting international public and political attention. Kuwait being a middle-income, oil rich country had the resources and willingness to fund the Green Cross International (GCI) multi-disciplinary study on the impacts of the 1991 Gulf War. Apart from the two examples cited above, despite an estimated 200 violent conflicts taking place in the second half of the twentieth century, there is not a single case study in that period which assesses the environmental impacts of any conflict/war comprehensively (Biswas, 2000).

2. Impact on Natural Habitat, Land, Air and Water

Land, Habitats & Biodiversity (Flora, Fauna, Animals)

Direct conflict, nuclear weapons, military training, and military produced contaminants have an "overwhelmingly negative" effect on ecosystem structure and function through "dramatic habitat alteration, environmental pollution, and disturbance" which leads to population declines and biodiversity losses (Lawrence, et al, 2015). There are, however, some cases where military activity has led to population increases or recovery, e.g. when exclusion zones have limited human influence on terrestrial and aquatic systems (Lawrence, et al, 2015). These changes can be temporary, or more permanent, as Lawrence, et. al (2015) highlight, there are cases where "even in the face of massive alterations to ecosystem structure, recovery was possible".

Soil Erosion: Land is inevitably affected by war/conflict due to soil erosion and terrain degradation by combat manoeuvres, construction of bases or fortifications, explosions and combustion of munitions which disturb the topsoil. Significant soil erosion occurs when craters are formed by bombs and missile strikes which also can result in contamination as well as soil conditions being contaminated by oil fires, as in the 1991 Kuwait oil fires (Biswas, 2000, p.304). Depending on the terrain this can eventually lead to gradual desertification of the land as contaminated land cannot be put to residential or agricultural use until it has been treated.

Damage is also caused by the use of military vehicles for combat, training and transport, which can reduce total plant and woody vegetation cover, cause terrain compaction, increase soil erosion rates, change soil structure and chemistry (e.g by lowering the carbon to nitrogen ratios) (Laurence, et al., 2015). Vehicles can also be used as bulldozers to clear paths and sight lines (Laurence, et al., 2015). Military vehicles tend to carry armour and weaponry, making them extremely heavy, with some weighing upwards of 60 metric tons (Laurence, et al., 2015). The potential for damage is context specific – e.g it is exacerbated in already fragile environments (such as the US' Mojave desert), and is affected by the season (such as during wet seasons when track ruts can be enlarged and vegetation removal can be higher) (Laurence, et al., 2015).

The extent of soil erosion is difficult to accurately measure but once the natural topography is altered by military activity the resulting fragile soil becomes vulnerable to further serious erosion. In arid and semi-arid areas, unchecked soil erosion can be followed by gradual desiccation and loss of vegetation. The vicious negative spiral of environmental decline is often compounded by overgrazing and use of remaining sparse vegetation for fuelwood, as seen in areas of Afghanistan where grasslands now have impaired biological productivity as the quality of grasslands has deteriorated after conflict damage to the soil (Saba, 2001, p.283). The compromised grassland ecosystem precipitated changes in wildlife movements and populations often with irreversible consequences for biodiversity (Saba, 2001, p.283).

Habitats: Military battles can cause significant damage to ecosystem structures with weapons leaving large craters, shrapnel, and contamination (Lawrence, et al, 2015). There are examples where air-to-ground military aircraft assault have decimated "entire forest ecosystems leaving behind stumps and craters, alongside contaminated and destabilized soils" (Lawrence et., al., 2015). For example, entire habitats including swamps were decimated by chemical warfare or "herbicide" use during the Vietnam war where US forces used over 72 million litres of various chemicals, most notably Agent Orange, within a 10-year period from 1961 to 1971 (UNEP,

1984). Some sites were targeted repeatedly leaving lasting consequences as entire habitats, especially the swampy marshes, were destroyed resulting in crop destruction, declining animal and plant species, and fish stocks (Biswas, 2000, p.307). In many conflict zones, combatants drain wetlands or marshes as a part of military strategy.

In smaller conflicts, rival groups often fund their war effort through illegal mining and logging causing the exploitation and destruction of rainforests as in Myanmar (McNeely, 2003).

A study on the impact of war on Syria's forests in the coastal areas found "a significant decrease in the total forest area (31,116.0 ha, 24.3%) accompanied by a considerable decrease in density, as the area of dense forests decreased by 11,778.0 ha (9.2%) between 2010 and 2020" (Mohamed, M. 2021, p.1). Frequent forest fires caused by bombardment conflict as well as a lack of environmental governance with the attendant increase in exploitation during the chaos of war all contributed to this decline in forest cover (Mohamed, 2021, pp.18-19).

Ecosystems: In Ukraine's Donbas region, an assessment by UN Environment's Science-Policy Platform on Environment and Security, found: "Conflict has affected, damaged, or destroyed ecosystems within an area of at least 530,000 hectares, including 18 nature reserves covering an area of 80,000 hectares" (UNEP, 2018). In 2014, the fighting also incapacitated forest protection services so that 12,500 forest fires were left burning resulting in near irreversible destruction of 479 hectares of forests, as well as inflicting direct mechanical and chemical damage on trees and vegetation, sometimes weakening or killing entire plantations (UNEP, 2018).

Loss of Species and Invasive Species: Conflict pollution and damage can not only wipe out rare or endangered plant, bird, insect or animal species but also replace them with invasive species or pests, which significantly alter the sanitary and epidemiological conditions of the area. In Eastern Ukraine species such as the curly pelican, whose nesting habitat in the Meotida National Park was impacted by conflict pollution, and Europe's largest colony of black-headed tarrocks have disappeared from the National Park and been replaced by colonising invasive species such as the Asian lady beetle. Incoming species such as jackals and sunfish are now resident in this habitat thus changing the area's biodiversity, land and agriculture in a significant way (OSCE, 2017, p.63). During WW2, military planes that landed to refuel in Pacific Ocean island systems introduced large numbers of invasive species which subsequently led to the exclusion, predation, and extinction of endemic species (Lawrence et., al., 2015).

Each mode of warfare and form of weapon can destroy natural habitats and wildlife in different ways and with variable severity, thus analysis should consider the differential impacts of different methods (e.g aerial assault, naval attack, terrestrial conflict and nuclear attack) and weapons (e.g. high explosive fragmentation, incendiary weapons, enhanced blast munitions, and defoliants) (Lawrence et., al., 2015). Aerial assault impacts on habitats through destruction caused by bombs and noise pollution, e.g. air-to-ground military aircraft assaults have increased the mortality of Asian elephants and snow leopards (Lawrence et., al., 2015). Lawrence et. al., (2015) explains how noise pollution from military aircraft is of serious concern as animals are more sensitive to noise than humans. Depending on the acoustic duration, intensity, and the biology of the specific species, impacts for airplane-related sound pollution can include:

- Primary effects: eardrum rupture; changes in hearing abilities (temporary or permanent); and auditory signal masking (e.g. loss of ability to identify noises from prey, predators, or mates).

- Secondary effects: impediments in reproduction, foraging behaviour, and use of habitat in areas where aircraft noise is prevalent
- Tertiary impacts: population declines; species extinction; and habitat degradation

In regard to naval attacks, naval blasts and sonar operations can interfere with aquatic species, e.g. by causing ear haemorrhaging and beach stranding of dolphins and whales, while conventional naval ordinance can create underwater blasts that injure invertebrates, fish, reptiles, birds, and marine mammals (Lawrence et., al., 2015). There are some examples where sunken naval craft have provided new habitats for aquatic life, where habitats were previously limited (Lawrence et., al., 2015). However, notably, there are concerns about the long-term contamination of these sunken naval crafts (Lawrence et., al., 2015).

Terrestrial conflict can lead to military vehicles incidentally hitting and killing animals. While landmines can affect wildlife mortality even decades after being deployed, especially large mammals (Lawrence, et al, 2015). Landmines have increased the risk of extinction for certain animals such as leopards in Afghanistan, and elephants in Africa. Conversely, in some places, they have created nature sanctuaries by making the land unusable – such as the demilitarised zone of the Korean Peninsula where there are now many cranes (Lawrence, et al, 2015).

Cultivation and Crops: The famed wild pistachios (*Pistacia vera*) of Afghanistan, which used to be exported in abundance, have been reduced to a fraction after years of war. According to FAO Statistics 2000, the pistachio crop in Afghanistan declined from 3800 tons grown over 4700 hectares of harvested area to only 1600 tons produced from the shrunken 2700 hectares harvest area, in the period from 1978, before the Soviet invasion, to 1999 at the end of the civil war. The pistachio trees not only provided a valuable export but played a vital role in the ecosystem of the north and north western Hindu Kush, supporting biodiversity of plants and wildlife in otherwise rugged terrain highly dependent on vegetation for environmental equilibrium (Saba, 2001, p.281).

Water Sources and Irrigation

Irrigation Systems: Afghanistan is a land locked country which was self-sufficient in agriculture in 1974, prior to the wars and conflict which have lasted till 2021. Until the mid-twentieth century the country depended on an ancient but efficient system of underground irrigation systems on which 80% of the population relied on for farming. The irrigation system was severely damaged during the wars first by Soviet bombing and US troops combat manoeuvres such as where swathes of agricultural land and irrigation channels were destroyed by US convoys. The system was also neglected and suffers from lack of repair. This has led to a loss of viable farming land and biodiversity as well as resulting in the loss of livelihoods and food security (Hussona, 2019).

Toxic Water Supply: Both ground water and surface water are impacted in warfare, especially where biological, chemical or nuclear missiles are used creating long term hazards in the water supply (Biswas, 2000, p.304). In Afghanistan, Iraq and Syria: “The water supply in the war zones has been contaminated by oil from military vehicles and depleted uranium from ammunitions. Along with the degradation of the natural resources in these countries and a radical destruction of forest cover, the animal and bird populations have also been adversely affected” (Watson Institute, 2019).

Although not independently verified, this media report from March 2022, illustrates the compound nature of environmental damages during conflict where deliberate destruction to infrastructure may

have resulted in polluting the water supply: “Ukrainian forces have reportedly been destroying bridges to prevent Russian troop movements, with the potential for debris and contaminants to disrupt river habitats. Likely more serious are emissions of pollutants to rivers following fires at industrial or commercial sites, and the efforts to fight them” (CEOBS, 2022).

The Donets River was the most polluted river in Ukraine even prior to the conflict but since the 2014 hostilities, this vital 650-miles long water source has been further contaminated, endangering the health of millions of people who depend on it. Due to the conflict, farming practices were also suspended allowing weeds, invasive species and rodent mice to thrive and reproduce unchecked, thus compounding the long-term environmental impact by also disturbing the biodiversity balance (Butko, 2018).

Air Quality

Dust Pollution: Military convoy movements and heavy machinery kick up dust in desert environments like Iraq, Kuwait and Syria polluting the air with toxins which impact human health and wildlife alike. Combustion from the large quantities of ammunition and weapons used in conflict also pollutes the air and atmosphere. (Watson Institute, 2019)

Oil Fires: When energy sources are targeted, as in Kuwait (1991), where nearly 600 oil wells were reportedly set on fire during the 1991 Gulf War, then thick black smoke impacted air and atmospheric pollution. The oil spills impacted marine life in the area (Linden, 2004).

In 2014-2015, the US bombed oil infrastructure, as part of “Operation Tidal Wave II” a strategy to deprive ISIS of oil revenue. The US also targeted tanker trucks, oil refinery and storage sites in Iraq and Syria (Crawford, 2019, p.22). When ISIS retreated in 2017, it was reported that it too set oil wells and pipelines on fire in Northern Iraq, which burned for up to several months, causing widespread plumes of dark smoke and pollution blocking sunlight and clogging the air with noxious fumes. (Crawford, 2019, p.21). The impact of this on birds’ migratory routes, wildlife and the desert ecosystem is still unknown as no assessments are available on this aspect.

Greenhouse Gases: Military vehicles also consume an extremely high level of petroleum-based fuels producing hundreds of thousands of tons of carbon monoxide, nitrogen oxides, hydrocarbons, and sulphur dioxide in addition to carbon dioxide. Between 2001 and 2017, it is estimated that the U.S. military emitted more than 400 million metric tons of greenhouse gases from war-related fuel consumption, including the major war zones of Afghanistan, Iraq and Syria. The largest portion of Pentagon fuel consumption is for military jets. (Crawford, 2019, p.2).

3. Impact on Infrastructure, Industry and Public Services

Damage to Infrastructure & Public Services

The damage or destruction of infrastructure such as roads, bridges and communications networks result in significant environmental consequences.

Conflict Debris: The accumulated rubble and debris are often toxic and require specialist machinery and disposal which is unavailable to stressed communities in the midst or aftermath of

conflict. After the 2003 US invasion and subsequent war with ISIL, Mosul Iraq, was left with 11 million tonnes of conflict debris (UNEP, 2017, p15).

Industrial Plants: Damage to power supply causes flooding in mines and a breakdown of waste management systems in industrial units. The effluent flowing out degrades the surrounding areas with overflowing chemical and toxic water as witnessed in Iraq, Syria and in the current conflict in Ukraine.

Infrastructure Damage: Infrastructure damage invariably leads to a decline or absence of key public services such as safe provision of utilities, clean water supply, efficient waste management and emergency mechanisms. In both Iraq and Syria, belligerents weaponised public water management and power supply infrastructure by seizing control of them or damaging them, thus denying access to clean water to the population to advance their military goals and/or to extort money to fund their war activity (Rosner, 2016, p8). In Mosul, Iraq, ISIL deliberately fired into power transformers not just damaging power supply to the city but also creating toxic PCB contamination from the attendant leak of transformer oil as well as seizing control of dams and barrages to use water flow as a weapon by either depriving or flooding Syrian government-controlled areas (UNEP, 2017, p21).

Water Treatment: Electricity systems targeted by military attacks to render the enemy's defences inoperable also cause water treatment plants to malfunction. This has immediate ramifications not just on public health but toxic water leaches chemicals and toxins into the soil and atmosphere causing environmental degradation. The US war against Iraq used this policy of targeting power supply to thwart Iraq's defence, thus overcoming the Iraqi military within 43 days. Unfortunately, years later Iraq's power and water infrastructure remain damaged and largely incapacitated (Rosner, 2016, p9).

Waste Disposal: Similarly, a collapse of solid waste collection and treatment/disposal services means accumulated waste amidst densely populated areas causing rodent and insect infestation (as well as allowing invasive species to take over and destroy fragile biodiverse hot spots.) In eastern Ukraine, OSCE's desk and field research report notes that "The conflict has challenged solid household waste management services, especially in communities along the contact line. The lack of adequate disposal services of traditional household wastes is exacerbated by the uncollected wreckage of military equipment, buildings, structures, and infrastructural elements, whose disposal requires additional capacity, and is logistically impossible without a prior demining of the territory and clearing of unexploded munitions." (OSCE, 2017, p55)

Environmental Governance Breakdown: More broadly, conflict acts to undermine progress on environmental issues by straining national resources and political and public attention, this ranges from "cancelled projects, to accelerated degradation and to neglect", finds Weir (2021) in a paper on Yemen. The Al Heswa site is part of Yemen's Aden coastal wetlands, and is one of the most important sites for migratory birds in the Arabian Peninsula (Weir, 2021). While it has not been a location for direct conflict, the conflict has undermined conservation of the area as: financial and political support from the government has ended; visitor revenues have dropped; and as dumping of waste materials near to the region has increased (Weir, 2021).

During conflict, personnel staffing environmental protection and governance institutions may be unable or unwilling to continue their tasks, allowing breaches of environmental laws and

regulations to flourish - e.g. in Mosul, Iraq, ISIL shut down the Niniveh Environment Directorate, confiscated assets and equipment and set the offices on fire (UNEP, 2017, p19).

Toxic Remnants of War: Unexploded Munitions, Landmines and Depleted Uranium (DU)

The United Nations Special Rapporteur on human rights and toxics, has stressed that toxic remnants of war (TRW) contaminate soil, water and habitats posing a real threat to public safety and health. Even decades after conflicts end, TRW pose a threat of physical injury, psychological trauma and economic loss to civilians (UNHRC, 2016).

DU: The use of DU in military weapons is a widely discussed and controversial issue in the literature, without consensus. The vast majority of the literature focusses on the health impacts of DU, rather than the environmental impacts. The main point of contention is that many articles find that DU used during conflict has polluted the environment and led to adverse health outcomes for military personnel and local populations, while many other articles either disprove, or cannot establish, such a link.

The US military first used DU weapons in Iraq during the Gulf War in the 1990s, and DU has subsequently been used in other conflicts in the Middle East and the Balkans. Besic et. al (2017) state that “approximately 320 tons of DU ammunition have been used in the first Gulf War, while around three tons were discharged on Bosnia & Herzegovina (B&H) in the period between 1994 and 1995, one ton in Serbia and Montenegro, and 11 tons in Kosovo in 1999. The second Gulf war resulted in around 430 tons of DU released in Iraq in 2003”. As most DU ammunition penetrates the ground, the theory is that it can potentially lead to airborne and groundwater contamination (Besic et. al., 2017).

A systematic review by Surdyk, et al. (2021) on the health impacts of DU in Iraq highlights the politicisation of research, which has been “mired in debate and controversy”. Their review finds that while “most studies (n=30, 83%) reported a positive association between uranium exposure and adverse health outcomes… we found that the reviewed body of evidence suffers from a high risk of bias” (Surdyk, et al., 2021). A meta-analysis by Besic, et., al. (2017) on DU levels in the Balkan region found that “it is not possible to make a valid correlation between the health effects and depleted uranium-contaminated areas”, and that “while the possibility of depleted uranium toxicity in post-conflict regions appears to exist, there currently exists no definitive proof of such effects, due to insufficient studies of potentially afflicted populations, in addition to the lack of a common epidemiological approach in the reviewed literature” (Besic, et., al. (2017). The International Atomic Energy Agency (IAEA, 2009) concludes that - based on a number of evaluations by national and international organisations, including their own assessments with UNEP and the World Health Organisation (WHO) – “the existence of depleted uranium residues dispersed in the environment does not pose a radiological hazard to the population of the affected regions”.

In terms of the environmental impacts, in locations where DU munitions have been used, “DU penetrators, penetrator fragments and jackets/casings can be found lying on the surface or buried at varying depth. When DU penetrators hit a target’s surface target or the ground, only a small percentage of the penetrator’s mass will transform to DU dust. Air, soil, water and vegetation can potentially be contaminated and affected by DU residues”, explains UNEP (n.d). UNEP has carried out post-conflict environmental assessments focussed on DU in Kosovo,

Serbia and Montenegro, and Bosnia and Herzegovina. The Kosovo study team “could not find significant contamination of the ground surface or the soil except at localised points of concentrated contamination”, close to where the munitions penetrated the ground, and “the level of DU detected decreased rapidly from contamination points” and is “too low to cause any radiological and chemical problems at present or in the future” (UNEP, 2001, p.25).

Landmines: Unexploded land mines degrade farmland and pastures, maim and kill humans but also injure and kill livestock and wildlife. In Afghanistan landmines impacted 12% of all households in 1994 with an average casualty rate of 50 people per week from 1995 to 2001 (Saba, 2001, p284). In Mosul, Iraq it is estimated it will take 3-4 years at a cost exceeding USD 60 million to clear landmines, toxic debris and TRW (UNEP, 2017, p17).

Toxic Waste: Military bases are a source of environmentally hazardous waste – mostly when they are active, but also after they have been closed, if they have not undergone environmental remediation (Atherton, 2021). Atherton (2021) explains that tons of environmentally hazardous waste has been left behind at US bases in Afghanistan. following the US’ rapid withdrawal in August 2021. This includes substances that increase the risk of cancer and other diseases, and waste which can seep into the ground, leach into nearby water sources, and contaminate the air with toxic smoke particles if burned (Atherton, 2021).

Military waste at these bases can include metals, paint, plastics which can produce “toxic smoke contaminated with particulate matter, lead, mercury, dioxins, and irritant gases” outlines a 2014 report by the Special Inspector General for Afghanistan Reconstruction (SIGAR). Afghanistan has neither the means nor the access to pay for costly environmental remediation so future environmental prospects seem bleak, as US law prevents the Department of Defence from funding any clean-up efforts in countries with hostile governments, even if there was enforceable international legislation which required them to do so.

4. Risks and Opportunities in Ongoing Conflicts

In this age of burgeoning environmental consciousness, the ongoing Syrian and Ukrainian wars provide opportunities to formalise documentation of environmental damages and conduct robust, longer term, scientific studies of the environmental footprint of war, addressing current research gaps especially in relation to the degradation of ecosystems, habitats and biodiversity loss.

Ukraine (2022 - ongoing) and the region of Donbas (2014 - ongoing)

In 2014 the Donbas region of the Ukraine witnessed the start of conflict between pro-Russian elements and by 2017 heavy weapons use was so prevalent that Ukraine was spotlighted by the UNEP as being on the verge of an “ecological catastrophe” (UNEP, 2018). The vast amounts of ammunition used in the conflict created water, air and soil pollution in an ecosystem already under stress from industrial pollution before the hostilities even began. Ukraine’s proliferation of heavy industrialisation meant hundreds of sites were especially vulnerable to conflict damage due to the presence of chemical, metallurgical and mining operations as well as atomic energy plants and nuclear waste dumps (Mathiese, 2022).

Even rural land in the Donbas region is controlled by agricultural enterprises which was impacting vulnerable species: 50 mammal species, 38 species of fish, over 10 species of

reptiles, and about 300 birds inhabiting the area were at risk. Due to the conflict these pressures exacerbated threatening to cause potentially irreversible damage to local ecosystems" (UNEP, 2018).

The extent of the damage already witnessed in the Donbas region and the likelihood of similar, if not graver, environmental repercussions of the developing war in Ukraine, underscore the recent resolutions adopted by the United Nations Environmental Assembly, one of which was submitted by Ukraine on armed conflict and the environment (2016) and a resolution was submitted by Iraq on mitigation of conflict pollution (2017). There is growing recognition, which is likely to be strengthened by the Ukraine war, that apart from the inevitable humanitarian and economic fallout, it is the environmental dimensions of war or violent conflict that are potent, long lasting and often irreversible for the planet.

5. References

Atherton, K. D. (2021) U.S Forces are leaving a toxic environmental legacy in Afghanistan. *Scientific American* https://www.scientificamerican.com/article/u-s-forces-are-leaving-a-toxic-environmental-legacy-in-afghanistan/

Austin, J. E. & Bruch, C. E. (2010) The Environmental Consequences of War: Legal, Economic, and Scientific Perspectives. Cambridge University Press.

Avis, W. (2022, forthcoming) Ukraine crisis and climate and environment commitments. K4D Helpdesk Report No.1122. Institute of Development Studies.

Besic, L., Muhovic, I., Asic, A., & Kurtovic-Kozaric, A. (2017). Meta-analysis of depleted uranium levels in the Balkan region. *Journal of environmental radioactivity* 172, 207-217. https://pubmed.ncbi.nlm.nih.gov/28395154/

Biswas, A. K. (2000). Scientific assessment of the long-term environmental consequences of war. The Environmental Consequences of War: Legal, Economic, and Scientific Perspectives. pp.303-315. https://thirdworldcentre.org/wp-content/uploads/2020/07/RPP-Jan-3-00-Scientific-Assessment-of-the-Long-Term-Environmental-Consequences-of-War.pdf

Butko, A. (2018) Ukraine's Donbas bears the brunt of toxic armed conflict. *UNEP* https://www.unep.org/news-and-stories/story/ukraines-donbas-bears-brunt-toxic-armed-conflict

Conflict and Environment Observatory (CEOBS) (2018) Country Brief Iraq. CEOBS https://ceobs.org/country-brief-iraq/

Weir, D. (2022) Environmental trends in the Ukraine conflict 10 days in. *CEOBS* https://ceobs.org/environmental-trends-in-the-ukraine-conflict-10-days-in/

Weir, D. (2021) Report: Protected area conservation in Yemen's conflict. CEOBS https://ceobs.org/protected-area-conservation-in-yemens-conflict/

Crawford, N. C. (2019) Pentagon fuel use, climate change and the costs of war. Watson Institute https://watson.brown.edu/costsofwar/files/cow/imce/papers/Pentagon%20Fuel%20Use%2C%20Climate%20Change%20and%20the%20Costs%20of%20War%20Revised%20November%202019%20Crawford.pdf

Fathi, R. A., Matti, L. Y., Al-Salih, H. S., & Godbold, D. (2013). Environmental pollution by depleted uranium in Iraq with special reference to Mosul and possible effects on cancer and birth defect rates. Medicine, conflict and survival, 29(1), 7-25. https://www.tandfonline.com/doi/full/10.1080/13623699.2013.765173?casa_token=UcgyBn5Dfl8AAAAA%3AIeLY62RhxWyfL5U5c7tEPGChmlN3FOMdrgPRmC8YNUVwFgd5fQfrgc-i62uiFA1QihZKeKiCfv8

Hussona, J. (2019) The reverberating effects of explosive violence on agriculture in Afghanistan. *Action on Armed Violence (AOAV)* https://aoav.org.uk/2019/the-reverberating-effects-of-explosive-violence-on-agriculture-in-afghanistan

International Atomic Energy Agency (IAEA) (2009) Assessing Effects of Depleted Uranium: The IAEA Role. IAEA https://www.iaea.org/sites/default/files/iaearole.pdf

Lawrence, M. J., Stemberger, H. L., Zolderdo, A. J., Struthers, D. P., & Cooke, S. J. (2015). The effects of modern war and military activities on biodiversity and the environment. Environmental Reviews, 23(4), 443-460. https://cdnsciencepub.com/doi/10.1139/er-2015-0039

Linden, O., Jerneloev, A., & Egerup, J. (2004) The Environmental Impacts of the Gulf War 1991. International Institute for Applied Systems Analysis (IIASA) http://pure.iiasa.ac.at/7427/

Mathiesen, K., Guillot, L. & Zimmerman, A. (2022). Ukraine's nuclear nightmare is only part of the war's environmental horrors. *Politico*. https://www.politico.eu/article/ukraine-war-russia-nuclear-power-plant-map-zaporizhzhia-nightmare-environment/

McNeely, J. A. (2003) Conserving forest biodiversity in times of violent conflict. *Oryx* Vol 37 Issue 2. https://doi.org/10.1017/S0030605303000334

Mohamed, M. A. (2021) An Assessment of Forest Cover Change and Its Driving Forces in the Syrian Coastal Region during a Period of Conflict, 2010 to 2020. *Land 2021* 10(2) 191; https://doi.org/10.3390/land10020191

OSCE (2017) Environmental assessment and recovery priorities for Eastern Ukraine. OSCE https://www.osce.org/files/f/documents/4/3/362566_0.pdf

Rosner, K. (2016) Water and electric power in Iraq and Syria: Conflict and fragility implications for the future. Robert Strauss Centre https://www.strausscenter.org/wp-content/uploads/Water-and-Electric-Power-in-Iraq-and-Syria-2016.pdf

Saba, D. S. (2001) Afghanistan: Environmental degradation in a fragile ecological setting. *International Journal of Sustainable Development and World Ecology* Vol 8 pp 279-289. https://www.tandfonline.com/doi/abs/10.1080/13504500109470086

Surdyk, S., Itani, M., Al-Lobaidy, M., Kahale, L. A., Farha, A., Dewachi, O., Akl, E. A. & Habib, R. R. (2021) Weaponised uranium and adverse health outcomes in Iraq: a systematic review. *BMJ global health* 6(2), e004166. https://pubmed.ncbi.nlm.nih.gov/33619039/

UNEP (2017) Technical Note – Environmental Issues in Areas Retaken from ISIL: Mosul, Iraq. Rapid Scoping Mission. UNEP https://reliefweb.int/report/iraq/technical-note-environmental-issues-areas-retaken-isil-mosul-iraq-rapid-scoping-mission

UNEP (n.d.) Depleted uranium. [Webpage] UNEP https://www.unep.org/explore-topics/disasters-conflicts/what-we-do/preparedness-and-response/post-crisis-environmental-0

UNEP (2001) Depleted Uranium in Kosovo. Post-Conflict Environmental Assessment. UNEP http://postconflict.unep.ch/publications/uranium.pdf

UNHRC (2016) Report of the Special Rapporteur on the implications for human rights of the environmentally sound management and disposal of hazardous substances and wastes. UNHRC https://ap.ohchr.org/documents/dpage_e.aspx?si=A/HRC/33/41

Watson Institute (2019) Costs of War: Environmental Costs. [Webpage] Watson Institute https://watson.brown.edu/costsofwar/costs/social/environment

Weir, D. (2017) Conflict Pollution and the Toxic Remnants of War. A Global Problem that receives too little attention. UNEP https://www.unep.org/resources/perspective-series/issue-no-24-conflict-pollution-and-toxic-remnants-war-global-problem

Westing, A. H. (1984) Herbicides in War: the long-term ecological and human consequences. Taylor & Francis https://digitallibrary.un.org/record/101319?ln=en

Westing, A., H. (2013). Pioneer on the environmental impact of war. Springer https://doi.org/10.1007/978-3-642-31322-6

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