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@ ✉ Correspondence author
Irland, Lloyd C.
lcirland@gmail.com
174 Lord Road, Wayne, ME 04284, USA

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Russian Invasion: Rapid Assessment of Impact on Ukraine's Forests

L. C. Irland[1], L. Iavorivska[2], S. Zibtsev[3], V. Myroniuk[4], B. Roth[5], A. Bilous[6]

The War has had serious effects on Ukraine's forests, in the form of direct damage and fires caused by various munitions. Important damage, though, includes extensive minefields, dud ordnance, and booby traps which are causing forests to be closed to all activities. A study using remotely sensed data reveals that in 2022, more than 70,000 ha of the forests suffered severe destruction and damage due to shelling, fires, and illegal logging by occupying forces.

Substantial efforts and innovative strategies are needed to address reforestation and restoration in the face of future climate change. In much of the steppe region and adjacent areas, forests and shelterbelts have been under stress already. The loss of shelterbelts in these regions can compromise future harvests due to rising droughts, sandstorms, soil erosion, and other environmental challenges Important damage, though, is not visible in drone images: extensive minefields, dud ordnance, and booby traps are causing forests to be closed to all activities. Simply completing damage assessments and developing plans for addressing these issues will be an enormous task, involving all agencies, private groups, and local governments concerned with forests, and with international support.

Difficult decisions on priorities will be required. Planning is underway on an international basis for programs of demining, bolstering fire management systems, and initiating restoration programs. An overstressed forest fire control system will need to be redesigned to handle future challenges. Shelterbelts will in many instances recover naturally on their own as it will be too hazardous for active restoration measures until demining is done, a task that will take decades. Full restoration of normal, safe activity in the rural areas and forests will only be achieved generations in the future. This paper presents a rapid assessment of the immediate issues and important longterm concerns.

Key words: *damage assessments; forest fires; forest release; landscape restoration; shelterbelts.*

[1] *Irland, Lloyd C.* – PhD, Founder and president, The Irland Group, 174 Lord Road, Wayne, ME 04284, USA. Phone: 0011-1-207-685-9613, lcirland@gmail.com ORCID: https://orcid.org/0000-0003-0637-2609

[2] *Lidiia Iavorivska* – PhD, PostDoc Position, College of Earth & Mineral Sciences, Pennsylvania State University, 319B EES Building University Park, PA 16802, USA. Phone (cell): 814-321-1419. E-mail: lui100@psu.edu ORCID: https://orcid.org/0000-0002-6224-6271

[3] *Sergiy Zibtsev* – Full Member of the Forestry Academy of Sciences of Ukraine, Professor, Doctor of Agricultural Sciences, National University of Life and Environmental Sciences (NUBiP) of Ukraine, 15 Geroiv Oborony st., Kyiv, Ukraine, 03041. Tel.: +38(044)527-85-23. E-mail: sergiy.zibtsev@nubip.edu.ua ORCID: https://orcid.org/0000-0003-0684-9024

[4] *Viktor Myroniuk* – Full Member of the Forestry Academy of Sciences of Ukraine, Doctor of Agricultural Sciences, Professor of the Department of Forest Mensuration and Forest Management at National University of Life and Environmental Sciences of Ukraine, 15 Geroiv Oborony st., Kyiv, Ukraine, 03041. Tel.: + 38(044)527-85-23. E-mail: victor.myroniuk@nubip.edu.ua ORCID: https://orcid.org/0000-0002-5961-300X

[5] *Roth Brian* – Ph.D, Executive Director, Forest Release and Independent consultant. E-mail: Rothb19699@gmail.com ORCID: https://orcid.org/0000-0002-0510-1500

[6] *Andrii Bilous* – Full Member of the Forestry Academy of Sciences of Ukraine, Professor, Doctor of Agricultural Sciences, Head of the Department of Forest Mensuration and Forest Management at National University of Life and Environmental Sciences of Ukraine, 15 Geroiv Oborony st., Kyiv, Ukraine, 03041. He currently (Dec. 2023) serves on the front lines with the Army. Tel.: + 38(044)527-85-23. E-mail: bilous@nubip.edu.ua ORCID: https://orcid.org/0000-0002-7589-4307

Introduction. European history is pockmarked with shell holes. On a church wall in Lviv, Ukraine, tourists are shown a cannonball removed from the masonry after a 17th-century siege by the Turks. World War One anniversaries in 2018 spawned assessments of the lingering effects of major battles; farmers continued to pull dud artillery rounds out of fields where they rose to the surface with the frost (Hemmings, 2019; Taylor, 2018). Even in 1944, 26 years later, US soldiers moving through the killing fields at Verdun passed shell holes that had not yet revegetated (Ataman, 2018; Irland, 2004). Entrenchments from World War Two, left as memorials, can be seen in Kyiv today.

War has returned to what historian Timothy Snyder memorably termed The Bloodlands (Plokhy, 2023; Kimmage, 2023). The unfolding tragedy of the Russian invasion is creating impacts on forests, woodlands, and rural landscapes of unprecedented geographic extent – likely long into the future. Never the actual targets, the forests have suffered massive collateral damage. When the guns fall silent, those responsible for the forests, and those who live near them and depend on them, will face immense losses, long-term costs, and risks. Ukrainian Prosecutor General, Andriy Kostin, estimates that "approximately 30% of Ukraine's territory – 174,000 sq. km – is contaminated with explosive objects, and over 2.4 million ha of forests are damaged". Press attention to the issue has been extensive (e.g., RFE/RL, 2022, 2023; Economist, 2023; Reese, 2023; Giles, 2023; WWF-Ukraine, 2022) and refereed studies in English-language publications are appearing (Prins, 2022; Myroniuk, et al., 2023; Shumilo, 2023). The reactions of the international community have led to boycotts on Russian lumber exports, with significant effects (Irland, 2023).

Methods and Materials. This article reports a brief Rapid Assessment. This methodology is based on opportunistic means of gaining a good sense of situations and issues by a combination of methods (see, e.g., Beebe, 2014). Assessment of press reports, review of existing scientific and grey literature, and analysis of existing data are common methods. These are supplemented by interviews with individuals with close acquaintance with the subject. Interviewees for this Assessment included Ukrainian soldiers serving at the front, US experts on munitions effects, an American soldier with demining and unexploded ordinance experience, and a retired American NCO with experience in armored warfare. In addition, the principal author has experience in combat in the field artillery.

Areas Affected by Military Operations. It is easily forgotten that the war actually began in 2014. While most of the visible damage is from present-day combat, many areas have been vulnerable to sporadic rocket and other attacks for many years. The incursions of Winter 2022 were quickly repulsed, leaving damage at lower levels than the intense combat in the eastern counteroffensive of Summer 2023. Areas directly within range of artillery range up to 40 km or more on either side of the margins of occupied areas.

A depopulated zone, spanning 10 kilometers in width (about 10,000 km^2 area) and situated within range of Russian artillery, exists along Ukraine's northern border with Belarus and Russia. Relentless shelling persists from across the border, resulting in forest fires (the region primarily consists of highly flammable pine forests), the destruction of homes, and pollution due to ammunition, including unexploded ordnance. Consequently, residents are fleeing the northern Ukrainian territories in the Chernihiv and Sumy regions and seeking refuge elsewhere. In the future, the frequency and intensity of forest fires in this zone may rise since foresters are unable to safely gain access to these wooded areas. Similar conditions exist at present in the East.

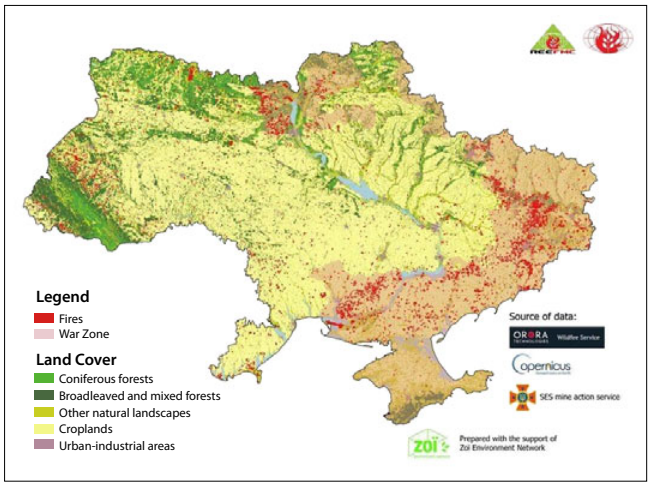

Fig. 1. Ukraine fires Jan 2023 to Oct 31, 2023.
Source: Myroniuk, pers. Comm.

Chornobyl Exclusion Zone. The Chornobyl Exclusion Zone (CEZ) stretches more than 100 km near the state border of Belarus and Ukraine. It was occupied by invading Russian troops within one to two days, who established control of the decommissioned Chornobyl Nuclear Power Plant. Occupying troops were not informed about personal protective measures against radiation exposure, and many cases of radiation impact were reported (Radynski, 2023). Before February 2022, a major forest fire had occurred: in April 2020 of more than 70,000 ha. In March 2022 another fire of 25,000 ha damaged Scotch pine forests' health, productivity, and biodiversity. Measurements show that these fires release radiation hazards. Massive contamination by unexploded ordnance (UXO), booby traps, and land mines were left behind by the retreating invaders near roads, along fighting positions, and other strategic points.

For the moment, UXO and landmines are major obstacles to managing forest health and forest fires. The Global Fire Monitoring Center in Freiburg, Germany, under the leadership of Professor Johann Georg Goldammer, developed a system of safe prescribed burning of contaminated terrains that soon may be tested in Ukraine in CEZ (Goldammer, et al., 2016). If successful, the government of Ukraine will seek opportunities to more widely apply it. Elsewhere, the forests suffer serious effects, some easily visible and others not obvious to the naked eye but far more widespread and long-lasting.

Visible Effects. *Increases in Fires.* During the warmer seasons, large areas of eastern and southern Ukraine are prone to fire. In the immediate area of infantry contact, tracer ammunition and short-range infantry-carried missiles will start fires. Ignitions can be caused by artillery fire, rockets, tank rounds, phosphorus shells, flares, burning vehicles, and other munitions (Zibtsev, et al., 2023). At training bases in the US, live-fire exercises with infantry weapons and tank weapons are halted during high-fire danger periods.

Ukraine has an extensive system that detects fire occurrences by satellite. In January 2022, only 1,900 ha burned nationwide; in March, the area burned reached 307,000 ha during a time when fire activity is usually nominal. Using remotely sensed data, intensity of combat was compared with fire incidence in a series of "buffer" areas at greater distances from the front lines. Total areas burned reached more than 1.1 million ha by end October 2023, a land area roughly half that of Kyiv Oblast (Tab.). While a great deal of this was agricultural and other natural land, the impact on forests has been large. The warfare has led to fire numbers and area burned far beyond the capacity of fire services to manage (Fig. 2A, 2B).

Table. **Landscape areas burned, 2022 to October 31, 2023. Hectares**

Year	Unknown	Forest		Other Natural	Agricultural	Settlement	Total
		Coniferous	Broadleaved				
2022	1,620	31,479	26,924	272,424	419,980	6,191	758,618
2023	1,025	14,895	11,720	128,373	236,448	1,919	394,380
Total	2,645	46,374	38,644	400,797	656,428	8,110	1,152,998

Source: V. Myroniuk, pers. comm. December 2023.

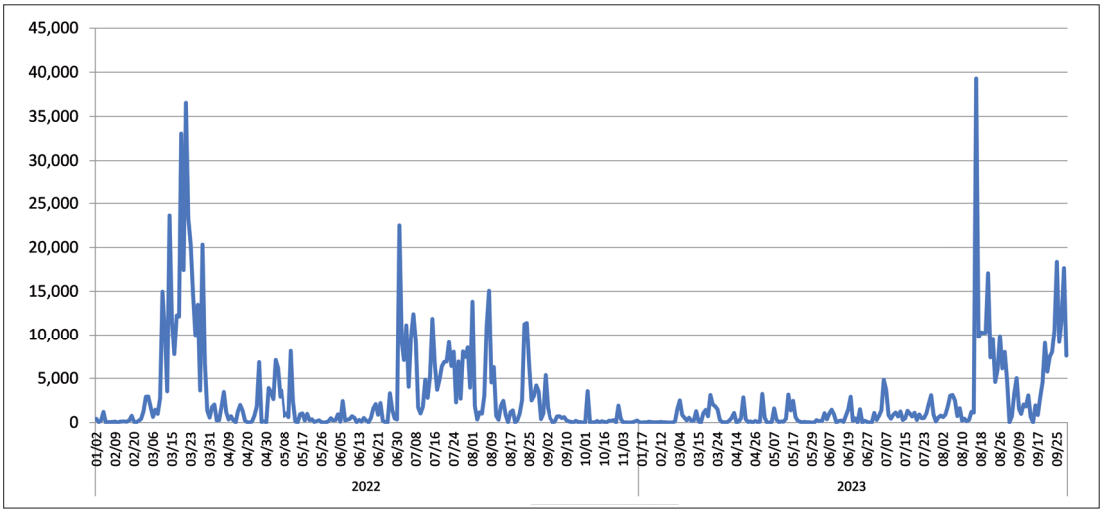

Fig. 2A. Daily area burned, January 1, 2022 to October 31, 2023

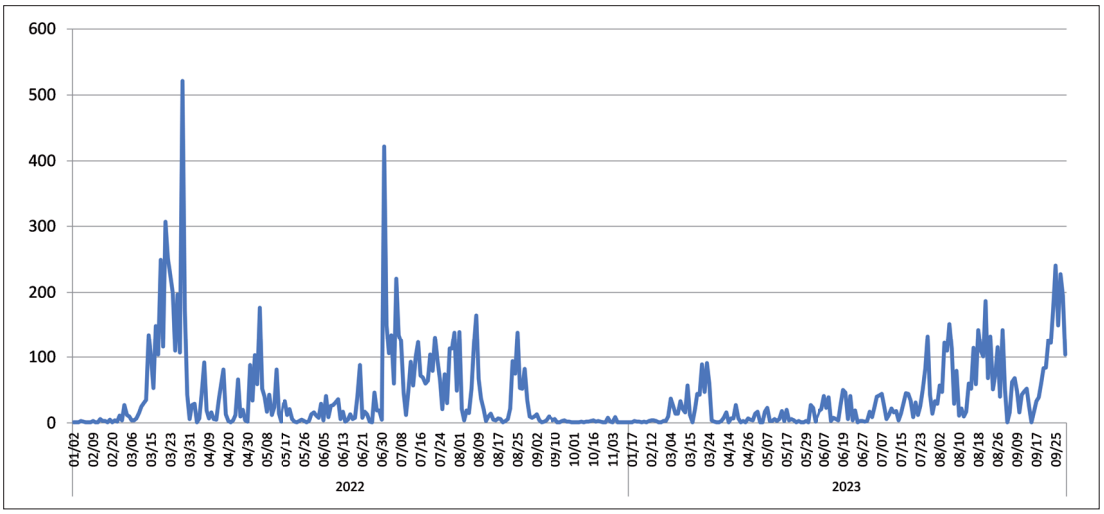

Fig. 2B. Number of fires, January 1, 2022 to October 31, 2023

More than 45% of fires by the number and 42.9% by burnt area occurred in the 5 km buffer, where the combat was most intense. In the buffer of 25 km, 62.1% of all fires by number and 66% by area were recorded (Fig. 3).

To compare combustibility and fire density during the fire season 2022 with the fire norm before the war, an analysis was also conducted for 2013, which is the best corresponding year with similar Fire Weather Index values and the absence of shelling. Combustibility in the same buffers was greater by 2.65 to 3.85 times compared with the 2013 fire season ($F_f = 7.9$ $p=0.01$); fire density was higher by 1.77 to 2.44 times in 2022. This difference was also statistically significant ($F_f=4.31$ $p= 0.05$) (unpublished research by S. Zibtsev and co-workers). Many of the fires are surface fires in the litter and ground cover; Numerous photos show scorching that in some stands will cause growth loss and insect infestations in the future (Fig. 4). Insects are already an emerging issue in some areas (e.g. Zhezhkun and Parohnyach, 2020; Goldammer, 1979, 2013).

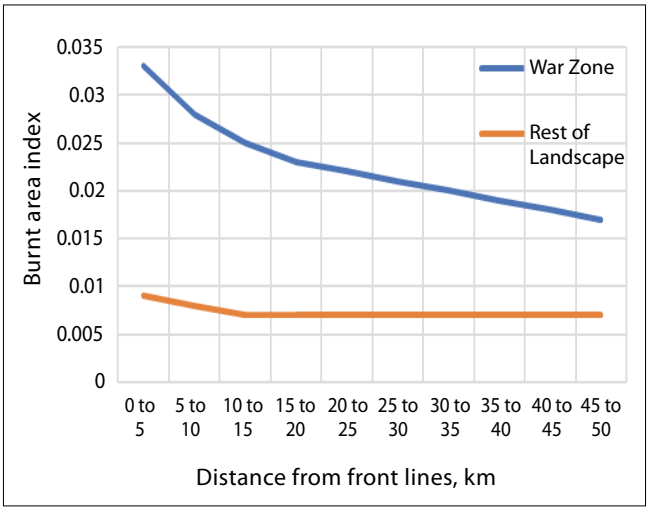

Fig. 3. Area burned per 1,000 ha, by zone from front lines or rest of landscape (Zibtsev, unpublished)

In territory that was liberated in the spring of 2022 (Sumy and Chernihiv regions), the duration and intensity were lower with significantly fewer fires. At the time of this writing in December 2023, prolonged action in the counteroffensive is producing locally extreme, high levels of artillery combat and resulting damage. Forest district offices on the eastern fronts of the Kharkiv Region were looted during occupation from February 2021 to October 2022. In addition to firefighting equipment, forest inventory equipment was also stolen. There is a need for metric GPS and inventory (calipers, clinometers, tape measures, etc.) and also, ATVs for mobile firefighting equipment.

A study using remotely sensed data reveals that in 2022, more than 70,000 ha of the forests suffered severe destruction and damage due to shelling, fires, and illegal logging by occupying forces (Dr. Andrii Bilous, personal communication). Of particular concern is the extensive harm inflicted on plantations that play a crucial role in soil erosion prevention, as well as the substantial loss of shelterbelts. Urban trees also fell victim to the ravages of battle.

Also visible in the abundant drone imagery is the routine disruption and rutting of muddy rural and forest roads, minor bridges, and ditches by repeated passage of heavy armored vehicles, self-propelled guns, and massive demining machinery. This widespread damage will be costly to repair to restore their use to ordinary civilian vehicles and mitigate ongoing erosion and sedimentation into waterways (Popkin, 2023).

Fig. 4. Ground fire with scorching on bole. In one or more years, this may not be visible from aerial imagery or drone surveys. Photo Andriy Bilous

Entrenchments – Positional Warfare. By midsummer 2023, hundreds of miles of territory had been bisected by trench lines. There are as many as three of them on the invader's side and at least one on the Ukrainian side (Fig. 5). Where offensive operations attempt to penetrate the lines, artillery fire is concentrated in massive amounts, further churning up the landscape and leaving behind dud projectiles. The fortifications themselves cause damage; repairing such areas will be costly.

Invisible Threats. In contrast to the visible effects detectable from above or by roadside "windshield cruises", far wider areas are damaged by invisible effects. These are mines, shrapnel, duds, and booby traps.

Minefields. In front of the trenches are wide bands of minefields, totaling millions (HRW, 2023; Sampson and Granados, 2023). Modern engineering has provided fiendish devices for placing them: there are tracked vehicles that lay mines as if they were simply drainage pipes. Artillery shells exist that will lay antipersonnel mines, bury them for concealment, never touched by human hands. A mobile rocket launcher is

capable of firing 50 mines in one volley with a range of up to 12 km (Fig. 6). During offensives, demining is conducted only on lanes needed to move troops and vehicles to the points of contact. Thus, a defense line that has been breached has not been cleared of hazards over its entire length.

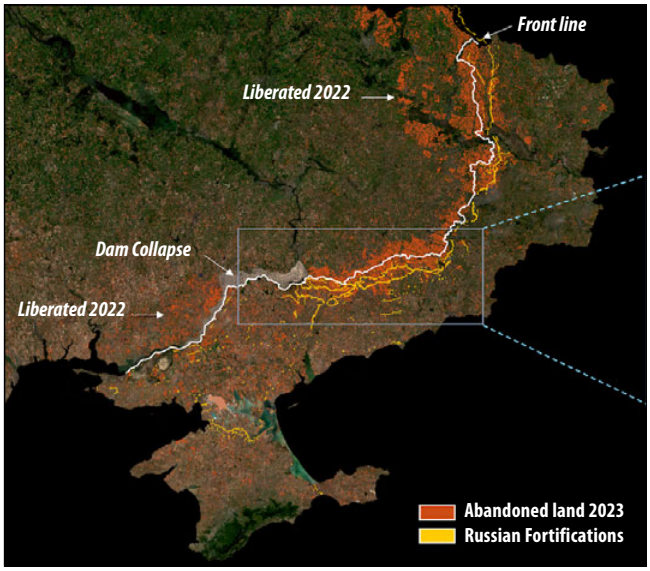

Fig. 5. Eastern Ukraine, entrenchment systems along hundreds of km of front. Source: NASA

Fig. 6. Expended projectile from rocket mine launcher

Antipersonnel mines pose a significant threat to both humans and wildlife. For instance, foxes, known for their curiosity and habit of digging the ground when intrigued by unusual scents, frequently fall victim. The invisible effect of mining activity can cause vast areas of forests to be declared off-limits to any activity until safe. The search and certification process will take many years, as accurate maps of minefields often do not exist.

Shrapnel. Shrapnel remains in trees from small-arms bullets, artillery bombardment, and tank clashes (Fig. 7). This is invisible to aerial imagery, though often locatable on the ground by damage to foliage and branches. In areas of heavy artillery usage, trees peppered with shrapnel are likely in most of a stand. Most fuses will detonate on contact with branches. This is even more so in the case of deliberate airbursts above the canopy.

Fig. 7. Shrapnel collected from battlefield

Unexploded Ordnance. Amidst the military jargon in the press, a new and ominous term enters our lexicon: UXO or unexploded ordnance. This is military speak for duds (Fig. 8). The dud rate of fuses on Soviet-era ammunition is said to be high. While most of that has been expended by this writing, the UXO problem is daily becoming more severe. The duds are unintended mines. In some areas, retreating invaders have left behind booby traps.

Fig. 8. UXO: mortar round half buried in forest floor. Photo Andriy Bilous

Artillery: "The Final Argument of Kings". The muzzle of a 19th-century Prussian field gun at the US Army Artillery Museum at Fort Sill, Oklahoma bears this motto in Latin. Experts describe this as an artillery war. Ammunition expenditures have been immense – surely millions of rounds, most of explosive-power higher than seen in past wars. Drone and satellite images (Fig. 9) illustrate vast fields of shell craters attesting to this.

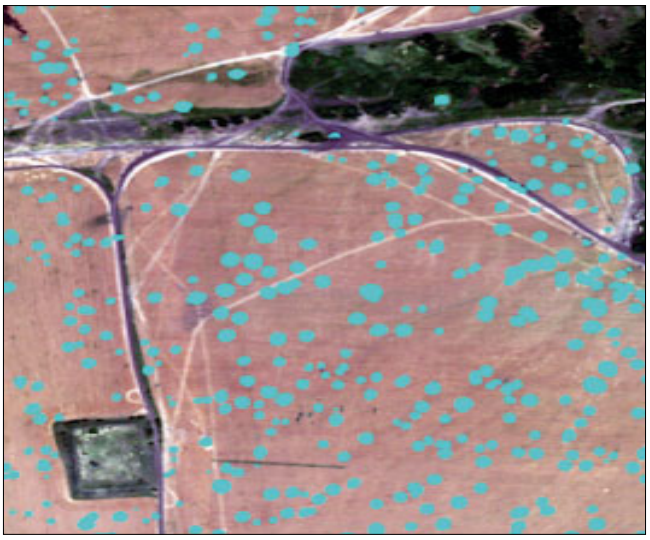

Fig. 9. Shell craters detected by satellite. NASA

The principal artillery of most modern armies is now the 155 mm howitzer. Howitzers are no longer basically "area fire" weapons. Improved metallurgy, highly accurate and prompt location data for both guns and targets and electronic fire direction have improved accuracy and responsiveness. Guided shells exist but are costly. They are used against point targets such as tanks, missile launchers, and supply dumps. Projectiles weigh 90 to 100 pounds and have a casualty radius of up to 100 meters (Catovic and Kljuno, 2021; UN, 2014). The standard high-explosive shell splits into many fragments on detonation, injuring personnel, and damaging vehicles and any nearby trees. Fuzes may be detonated by branches of the trees. Size and depth of shell craters vary by soil type, moisture content, and many other factors (Fig. 10). Research indicates that 155 mm rounds produce craters about 1.7 meters in diameter (Kennedy, 1982). This is very similar to results reported for early 1940's Soviet 152mm rounds (Korhonen, 1999-2006) who suggests a typical radius of 3 meters and depth of half that. These old estimates do not account for differences in spoils or modern propellants and casing designs.

Both sides now use cluster bombs, formally known in the US as innovative conventional munitions, or ICM (a euphemism if there ever was one). Even small-caliber artillery can deliver these, as can rockets. These are shells that open up above the ground and shower it with numerous small bomblets. Some of these fail to detonate and remain as hazards for some time.

Experienced, well dug-in and well-led troops can withstand severe bombardment. This means that positional warfare leads to high ammunition expenditures in concentrated areas. Long ranges of current artillery mean that a swath up to 40 km on each side of the line of contact can be affected.

Fig. 10. Closeup of shell crater

Shelterbelts and windbreaks are used as cover. Attacks on vehicles and entrenched positions in and near forests fill the trees with shrapnel, endanger them with fires, and leave behind numerous craters. Artillery positions are now readily detected. In maneuver operations, a unit must "shoot and scoot" to avoid counterbattery fires. Typically, in positional warfare, artillery operates from a safe distance to minimize risks, often at its maximum effective range. It relies on semi-permanent or permanent enclosed positions known as a "firebase" because finding a new suitable position is challenging. Frequent, long-distance movements of artillery can make it more vulnerable to detection by enemy drones.

Ironically, extraordinary improvements in accuracy, especially with revolutionary guided 155 mm guided projectiles, rockets, and infantry portable antitank rockets, have not led to lower ammunition expenditures. Automatic, speedy reloading systems encourage high rates of fire, to the point of accelerating tube wear and loss of accuracy. The intensity and desperation of combat have led to lavish ammunition usage and unprecedented collateral damage for every unit of actual military effect.

Discussion: Needs and Responses. A major need is to strengthen measures for organizing incident commands for individual fires (Zibtsev, et al., 2023). While the Ukrainian State Emergency Services has an incident command system, the state enterprise, Forests of Ukraine, charged with fire protection on over 7.2 million ha, does not. The existing fire protection system is designed for early detection and rapid response; it is not designed for the challenges now being faced with large campaign fires. The Ukrainian Fire Service is working to arrange for training in the US and Canada on management systems used for this purpose. Huge amounts of specialized safety gear are needed for forest managers, loggers, and demining personnel.

Modern armies have developed impressive, massive mine-clearing vehicles, but these are designed for clearing narrow lanes in open areas. They are useless in woods and windbreaks, where detecting and clearing mines and UXO must be conducted by World War I methods that are labor intensive, exacting, exhausting, and dangerous. Recruiting, training, equipping, and managing demining workers will be a huge administrative task.

A group of North American forest professionals concerned with developments in Ukraine has formed a non-profit, non-governmental organization called Forest Release (forestrelease.org) to assist with efforts to make Ukraine's forests safe, productive, and sustainable. The term "forest release" refers to terminology from the International Mine Action Standards defining when an area is declared clear of landmines and UXO so that forests can be safely entered for management, operations, and recreation.

Forest Release is based in Maine and is led by Brian Milakovsky and Dr. Brian Roth. Its mission is to improve the livelihoods and well-being of forest users and managers in former conflict zones. The group provides humanitarian support for the donation and distribution of forest firefighter safety gear, funding for Ukrainian UXO education, and non-technical survey teams. Ultimately, the group aims to support local landmine and UXO disposal teams. Furthermore, it is crucial to adapt the timber processing industry in Ukraine to include the detection of metal fragments within the wood.

To increase effectiveness of donation use an Ukrainian counterpart of Forest Release is being established. It will be called "Ukrainian Forest Safety Center" (UFSC) and has status of public non profit organisation. Its main efforts will be concentrated on training of forestry personnel of different agencies (military forestry, communal forestry, state forestry) to use the National Intergrated Landscape Fire Strategy approach (https://nubip.edu.ua/en/node/9087/11), prevention, preparedness, use of special equipment (military helmets, military life vests and standard fire management gear like protective uniforms for firefighters, radio stations, water pumps, hoses, drip torches and hand tools) during fire suppression in forests contaminated by unexploded ordnance and mines. UFSC will be closely cooperating with the Regional Eastern Europe Fire Monitoing Center (REEFMC) and US counteparts in donation collection and transfer, training, and developing a national system of incident management based on the US Incident Command System. (UFSC can be reached through Volodimyr Braiko at vbb0703@ukr.net).

Substantial efforts and innovative strategies are needed to address reforestation in southern and eastern Ukraine in the aftermath of the war and in the face of climate change. The loss of shelterbelts in these regions can result in future harvest failures due to rising droughts, sandstorms, soil erosion, and other environmental challenges (Listopadsky, 2015) (Fig. 11).

Issues for these belts have long been discussed as well (Kovalenko, et al., 2021). The challenges are several: the extensive mining and UXO hazards will have to be cleared in the shelterbelts themselves before work can begin. Badly cratered fields will have to be regraded and smoothed over after demining. To enable all this, rural roads and farm lanes will first have to be demined and certified safe. Finally, these shelterbelts in many instances date back to the 1930s, when climate and farming methods were different. New varieties of plant material and cultural methods for restoration will be needed to ensure future climate resilience (e.g. Mize, et al., 2008; Rempel, et al., 2017; Schoeneberger, et al., 2017). Needs of modern agricultural methods may call for rearrangement of their layouts on the land. Setting priorities will be challenging. Already programs are in development to mobilize support for these and other restoration and mitigation issues (e.g., Forest Europe, 2023).

Fig. 11. Farm landscape with shelterbelts and wetlands. Google Earth

We expect that future assessments and research will likely lead to revisions in some of our present judgments – possibly most of them – and surely will elaborate needed local details and operational practices.

Honoring the Fallen. A sensitive issue arises after fierce battles, as numerous soldiers from both sides perished and were either buried in shelterbelts or left above ground. Moving forward, there is a need to locate and commemorate all of these fallen soldiers, and many forests will serve as memorials in their honor.

Peace Will Bring a New and Different War. One day the tanks will be back in their vehicle parks, weapons locked in the armories, and the reservists "back on the block", as soldiers say. Thereafter, generations will inherit an ongoing war against the dangers and costs of clearing mines and UXO, smoothing over shell holes and filling in abandoned trench lines, and restoring farms, fields, and forests (Fig. 12) to safe and normal uses. Care for the forests and shelterbelts will necessarily take a lower priority after meeting basic human needs, restoring active agriculture, and rebuilding housing, cities, and infrastructure. Combat will be followed by a prolonged, costly, and dangerous cold war against the long-term invisible threats described here, as well as restoration actions. Young soldiers now serving will be old men before these tasks are completed.

Fig. 12. Fires in Rubizhne area, June 2022. Planet.com by permission

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Російське вторгнення: швидка оцінка впливу на ліси України

Л. С. Ірланд[1], Л. А. Яворівська[2], С. В. Зібцев[3], В. В. Миронюк[4], Б. Рот[5], А. М. Білоус[6]

Надано швидку оцінку важливих нагальних і довгострокових проблем. Війна зумовила серйозні наслідки для лісів України у вигляді прямої шкоди та пожеж, спричинених різними боєприпасами. Однак значна шкода включає також великі мінні

поля, непридатні боєприпаси та міни-пастки, через які ліси закриті для будь-якої діяльності. В Україні фунціонує система супутникового виявлення пожеж, однак вона не готова до нинішніх викликів. У січні 2022 р. по всій країні горіло лише 1900 га; у березні ж площа горіння досягла 307 тис. га. Інтенсивність бойових дій порівнювалася нами з інтенсивністю вогню у низці зон на більшій відстані від лінії фронту. Це порівняння показало високу кількість пожеж поблизу фронту порівняно з районами, розташованими далі. Понад 45% пожеж за кількістю та 42,9% за площею вигоряння виникло в радіусі 5 км, де бойові дії були найбільш інтенсивними. У радіусі 25 км зафіксовано 62,1% усіх пожеж за кількістю та 66% за площею. Загальна площа спалених територій на кінець жовтня 2023 р. сягнула понад 1,1 млн га, що приблизно вдвічі менше площі Київської області. Хоча велика частина цієї території була зайнята сільськогосподарськими та вкритими природною рослинністю землями, вплив пожеж на ліси був значним. Надзвичайно великі пожежі виникли внаслідок короткочасних спалахів інтенсивних боїв; у багатьох випадках впродовж 2022-2023 рр. щоденна площа вигорання перевищувала 10 000 га по всій країні.

Дослідження з використанням даних дистанційного зондування показує, що у 2022 р. понад 70 000 га лісів зазнали серйозних руйнувань і пошкоджень через обстріли, пожежі та незаконну вирубку окупантами. Потрібні значні зусилля та інноваційні стратегії для лісовідновлення та відновлення ландшафту перед загрозою майбутніх змін клімату. У більшій частині степового регіону та прилеглих територій ліси і захисні смуги вже зазнали стресу. Втрата захисних смуг у цих регіонах може поставити під загрозу майбутні врожаї через зростаючі посухи, піщані бурі, ерозію ґрунту та інші екологічні проблеми. Значні небезпеки замінування і нездетонованих боєприпасів необхідно буде усунути перед початком робіт. Після розмінування поля, вкриті кратерами, доведеться відновлювати та зачищати. Для цього необхідно розмінувати та перевірити безпечність сільських доріг і смуг. Сучасні армії використовують масові машини для розмінування, але вони призначені для очищення вузьких смуг на відкритих територіях. Вони непридатні для лісів і захаращених повшкодженими деревами ділянок, де роботи повинні проводитися методами Першої світової війни, які є трудомісткими, вимогливими, виснажливими та небезпечними. Найняття, навчання, оснащення та управління працівниками з розмінування буде величезним адміністративним завданням, яке триватиме багато років.

Нагальною потребою є організація аварійних команд для окремих пожеж. Державна служба України з надзвичайних ситуацій має таку систему, а держпідприємство «Ліси України», яке займається пожежною охороною понад 7,2 млн га територій, її не має. Існуюча система призначена для раннього виявлення та швидкого реагування; вона не придатна для викликів великих пожеж, з якими зараз стикаються лісові господарства. З цією метою українська пожежна служба організовує навчання в США та Канаді. Крім того, величезна кількість спеціалізованого захисного спорядження потрібна фіхівцям лісового господарства, лісорубам і персоналу з розмінування. Звичайне завершення оцінювання збитків і розробка планів вирішення цих проблем буде величезним завданням із залученням усіх установ, приватних груп і органів місцевого самоврядування, які займаються лісами, а також міжнародної підтримки. Потрібні будуть складні рішення щодо пріоритетів. На міжнародній основі планується розмінування, посилення систем пожежогасіння та ініціювання програм відновлення. У багатьох випадках захисні смуги відновлюватимуться природним шляхом самі по собі, оскільки це буде надто небезпечно для активних заходів з відновлення, поки не буде виконано розмінування, яке займе десятиліття. Повне відновлення нормальної, безпечної діяльності в сільській місцевості та лісах буде досягнуте лише майбутніми поколіннями.

Ключові слова: оцінювання збитків; лісові пожежі; розмінування лісів; відновлення ландшафту; лісосмуги.

[1] *Ірланд Ллойд* – засновник і президент «The Irland Group», доктор філософії, 174 Lord Road, Wayne, ME 04284 США. Тел. 0011-1-207-685-9613. E-mail: lcirland@gmail.com ORCID: https://orcid.org/0000-0003-0637-2609

[2] *Яворівська Лідія Андріївна* – науковий співробітник, доктор філософії, Коледж наук про землю та мінерали, Університет штату Пенсільванія, 319B EES Building University Park, PA 16802, США. Телефон (моб.): 814-321-1419. E-mail: lui100@psu.edu ORCID: https://orcid.org/0000-0002-6224-6271

[3] *Зібцев Сергій Вікторович* – академік Лісівничої академії наук України, професор кафедри лісівництва, доктор сільськогосподарських наук. Національний університет біоресурсів і природокористування України, вул. Героїв Оборони, 15, м. Київ, 03041, Україна. Тел.: + 38(044)527-85-23. E-mail: sergiy.zibtsev@nubip.edu.ua ORCID: https://orcid.org/0000-0003-0684-9024

[4] *Миронюк Віктор Валентинович* – академік Лісівничої академії наук України, професор кафедри таксації лісу та лісового менеджменту, доктор сільськогосподарських наук. Національний університет біоресурсів і природокористування України, вул. Героїв Оборони, 15, м. Київ, 03041, Україна. Тел.: +38-044-527-85-23. E-mail: victor.myroniuk@nubip.edu.ua ORCID: https://orcid.org/0000-0002-5961-300X

[5] *Бріан Рот* – виконавчий директор «Forest Release» та незалежний консультант, доктор філософії. E-mail: Rothb19699@gmail.com ORCID: https://orcid.org/0000-0002-0510-1500

[6] *Білоус Андрій Михайлович* – академік Лісівничої академії наук України, завідувач кафедри таксації лісу та лісового менеджменту, професор, доктор сільськогосподарських наук. Національний університет біоресурсів і природокористування України, вул. Героїв Оборони, 15, м. Київ, 03041, Україна. Тел.: +38(044)527-85-23. E-mail: bilous@nubip.edu.ua ORCID: https://orcid.org/0000-0002-7589-4307