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ONE YEAR LATER: UNRAVELING CLIMATE AND ECOLOGICAL SECURITY IN UKRAINE

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On February 24, 2022, the brutal Russian invasion of Ukraine irrevocably altered the geopolitical landscape. The year since has witnessed a devastating humanitarian catastrophe in the country, and also a complex and systemic interplay of climate change, environmental degradation, and conflict. In the wake of the initial invasion, the Center for Climate and Security published a briefer overviewing challenges and concerns regarding climate and ecological security in the midst of the conflict.[1] One year after the invasion, this briefer reassesses the war's implications for the energy transition, as well as global climate, ecological and food security.

THE NEED TO ACCELERATE THE CLEAN ENERGY TRANSITION

The urgency of reducing Europe's dependence on Russian oil and gas sparked innovative approaches to the clean energy transition as the links between renewable energy and security became more concrete in the midst of conflict in Europe. In response, even while prioritizing short-term energy security, many European countries increased their ambition on and investment in renewable energy development. The REPowerEU plan, first

1 Erin Sikorsky, Elsa Barron, and Brigitte Hugh, ed. Francesco Femia and Christine Parthemore, "Climate, Ecological Security and the Ukraine Crisis: Four Issues to Consider," March 12, 2022, The Center for Climate and Security, an institute of the Council on Strategic Risks, https://climateandsecurity.org/wp-content/uploads/2022/03/Climate-Ecological-Securityand-the-Ukraine-Crisis_Four-Issues-to-Consider_BRIEFER-31_2022_11_3.pdf

presented in May 2022, set targets relating to saving energy, producing clean energy, and diversifying energy supplies. Specific targets for 2030 include reducing gas consumption by 30 percent and achieving 69 percent renewable electricity generation.[2][3] While the EU still needs policy and technological development to reach these targets, significant progress has already been made and the International Energy Agency (IEA) increased its 2022-2027 forecast for renewable electricity capacity growth in Europe by thirty percent.[4]

A focus on energy security has also reinvigorated debates around nuclear energy in Europe. The increased risk of energy shortfalls made the phasedown of nuclear power plants in countries like Germany politically challenging[5] and has sent France, which relies on nuclear energy for 67 percent of its total energy use, scrambling to bring over half of its nuclear reactors back online after being closed for maintenance.[6] However, even with operational reactors, reliance on nuclear energy still presents challenges for security as Europe's nuclear energy industry is still, in part, dependent on Russia. In 2021 the Russian company Rosatom provided 20 percent of Europe's uranium supply and France, the largest European producer, imports 15 percent of it's uranium from Russia.[7] Overall, the emphasis on nuclear energy as a solution has remained limited, and concerns about human and environmental safety as well as cost remain additional challenges to nuclear energy development.[8]

Even outside of Europe, the conflict sparked creative proposals and investments to boost energy security and sustainability. A proposal that originated with climate activist Bill McKibben to invoke the Defense Production Act to manufacture heat pumps for the European market and reduce Europe's reliance on Russian gas for heating was adopted by the White House in June.[9][10] The order invoked the co-benefits of increased domestic production, sustainable technology adoption, and energy security. As anticipated, the adoption of

2 "REPowerEU Plan." May 18, 2022, European Commission, https://eur-lex.europa.eu/resource.html?uri=cellar:fc930f14-d7ae-11ec-a95f-01aa75ed71a1.0001.02/DOC_1&format=PDF.

3 "Is the European Union on track to meet its REPowerEU goals?" December 2022, International Energy Agency, https://www.iea.org/reports/is-the-european-union-on-track-to-meet-its-repowereu-goals.

4 "Renewables 2022: Executive Summary." December 2022, International Energy Agency, https://www.iea.org/reports/renewables-2022/executive-summary.

5 Frank Jordans, "EXPLAINER: Why Germany is delaying its nuclear shutdown." October 18, 2022, AP News, https://apnews.com/article/russia-ukraine-technology-germany-nuclear-power-olaf-scholz-7b22d8d55cea98b76925376a94ffdcff.

6 "Minister: All French nuclear reactors to restart by winter." September 2, 2022, AP News, https://apnews.com/article/russia-ukraine-france-bdb5df78ae6b6305289819d11ff15a6a.

7 Patricia Coheh, "Why Russia Has Such a Strong Grip on Europe's Nuclear Power." March 10, 2023, New York Times, https://www.nytimes.com/2023/03/10/business/economy/russia-nuclear-energy-ukraine.html.

8 Joseph Stephansky, "No nuclear power 'renaissance' as Europe wrestles energy crisis." October 6, 2022, Al Jazeera, https://www.aljazeera.com/news/2022/10/6/europe-sees-shift-in-attitudes-no-nuclear-power.

9 Maxine Joselow and Vanessa Montalbano, "Heat pumps can counter Putin and the climate crisis, advocates say." March 10, 2022, The Washington Post, https://www.washingtonpost.com/politics/2022/03/10/heat-pumps-can-counter-putin-climate-crisis-advocates-say/.

10 Adam Aton, "Biden Order Will Boost Heat Pumps and Building Insulation." June 7, 2022, E&E News, https://www.scientificamerican.com/article/biden-order-will-boost-heat-pumps-and-building-insulation/.

heat pumps in Europe has accelerated, with sales in 2022 up from 2021 by 37 percent,[11] making homes and buildings in Europe less carbon intensive and more energy secure.

Researchers, policymakers, and advocates have also designed creative proposals regarding methane leaks and flaring. After the United States and European Commission's Task Force to Reduce Europe's Dependence on Russian Fossil Fuels identified reducing methane leakage as a strategy for "Diversifying LNG [liquefied natural gas] Supplies in Alignment with Climate Objectives," the IEA investigated the potential benefit of methane leak and flare reduction.[12] The IEA found that if all countries exporting natural gas to the European Union were to eliminate non-emergency flaring and reduce methane emissions from oil and gas operations, those measures alone could replace one-third of the natural gas supplied by Russia in 2021.[13]

Russia's invasion of Ukraine and the subsequent energy security crisis have underscored the national and global security benefits of a rapid transition to clean energy, including increased energy security and reduced reliance on malign fossil fuel exporters.[14] Certainly, the transition to clean energy does not come without its own challenges to be managed. Many renewable energy technologies require metals and critical minerals acquired through contentious mining and distributed through precarious supply chains, as well as more interconnected energy grids that bring potential cyber vulnerabilities. Yet, as demonstrated this year, the climate and security bonuses of diversified and clean energy are non-negotiable given the climate and geopolitical risks of continued reliance on fossil fuels.

UKRAINIAN ECOLOGICAL SECURITY AND CLIMATE CHANGE

The war in Ukraine has also set many of Ukraine's ecosystems ablaze—both figuratively and literally.[15] As of January 2023, Ukraine's environment ministry had tallied up costs[16] of Russia's invasion in terms of environmental damage. About $19 B of damages are attributed directly to Russian operations (not including the cost of increased air pollution, which accounts for 59% of the total). Since most of this figure was attributed to damaged farmland, the true cost when including the degradation of natural ecosystems that produce "public goods," could be considerably higher.

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11 Kate Abnett, "Heat pump sales in Europe jump to record high." February 20, 2023. *Reuters*, https://www.reuters.com/business/energy/heat-pump-sales-europe-jump-record-high-2023-02-20/.

12 "FACT SHEET: United States and European Commission Announce Task Force to Reduce Europe's Dependence on Russian Fossil Fuels." March 25, 2022, The White House, https://www.whitehouse.gov/briefing-room/statements-releases/2022/03/25/fact-sheet-united-states-and-european-commission-announce-task-force-to-reduce-europes-dependence-on-russian-fossil-fuels/

13 "The Energy Security Case for Tackling Gas Flaring and Methane Leaks." June 2022, The International Energy Agency, https://www.iea.org/reports/the-energy-security-case-for-tackling-gas-flaring-and-methane-leaks

14 "National Security Voices for Clean Energy." 2023, The Center for Climate and Security, https://councilonstrategicrisks.org/national-security-voices-for-clean-energy/

15 Yehor Hrynyk, "Russia's invasion is putting the future of Ukraine's forests at risk," August 5, 2022, Atlantic Council, https://www.atlanticcouncil.org/blogs/ukrainealert/russias-invasion-is-putting-the-future-of-ukraines-forests-at-risk/.

16 "Little green mayhem: The war has devastated Ukraine's environment, too," January 12, 2023, *The Economist*, https://www.economist.com/europe/2023/01/12/the-war-has-devastated-ukraines-environment-too#.

For example, Ukraine has claimed that Russia has accidentally killed thousands of dolphins in the Black Sea via naval activities, leading Ukrainian President Zelensky to accuse Russia of ecocide[17] at the UN Biodiversity Conference in Montreal in December 2022. While fighting had already impacted around 3 million hectares of forest—an area roughly the size of Belgium—Ukraine's environment ministry warned that 2.9 million hectares of protected areas may be destroyed as the war continues. Though Russia stands accused of logging some of Ukraine's national parks, Ukraine may reduce forest protections to boost its damaged economy via increased logging, prompting concerns[18] from Ukrainian conservationists. Such a change could increase logging in sensitive protected areas such as the Carpathian Mountains. Protected ecosystems tend to disproportionately conserve biodiversity, provide ecosystem services (e.g. clean drinking water) to society, or have significant cultural importance.

As with the Persian Gulf following the 1991 Gulf War,[19] it is possible that marine sediments in the Black Sea will have been contaminated by oil spilled from coastal facilities and ships[20] damaged during the conflict. However, regular pollution from maritime trade may actually be reduced while transits are suppressed.[21] On land, Russian operations have led to the draining of at least one reservoir—the Kakhovka[22]—an act which may be directed at undermining water availability for agriculture, drinking, and power infrastructure. Ukraine released dams in the spring of 2022 to flood the village of Demydiv and the surrounding area, slowing Russian progress toward Kyiv.[23] In some cases, bodies of water like these have accumulated chemical pollutants[24] from industry and accidents over many decades. These pollutants may be relatively inaccessible in stable bottom sediments, but when the water is drained all at once, contaminated sediments may be released via wind upon drying or flow into other water bodies, undermining air, water, and soil quality in the surrounding environment and thus human health.[25] Further, such releases can kill millions of fish within the drained waterbody, devastate its aquatic ecosystems, and erase ecotone (edge) habitats for birds and other terrestrial animals that relied on the body of water.[26] Such changes may undermine local communities that harvest wildlife for food.

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17 Elizabeth Fitt, "Black Sea dolphin deaths prompt ecocide allegations against Russia," December 16, 2022. Mongabay, https://news.mongabay.com/2022/12/black-sea-dolphin-deaths-prompt-ecocide-allegations-against-russia/.

18 Hrynyk, "Russia's invasion is putting the future of Ukraine's forests at risk."

19 Readman, J. W., S. W. Fowler, J-P. Villeneuve, C. Cattini, B. Oregioni, and L. D. Mee. "Oil and combustion-product contamination of the Gulf marine environment following the war." *Nature* 358, no. 6388 (1992): 662-665. https://www.nature.com/articles/358662a0.

20 Carole Landry, "The sinking of the Moskva," April 14, 2022, *The New York Times*, https://www.nytimes.com/2022/04/14/briefing/russia-ukraine-war-flagship-mariupol.html.

21 Readman et al., "Oil and combustion-product contamination of the Gulf marine environment…"

22 Geoff Brumfiel, Connie Hanzhang Jin, Jacob Fenton, Meredith Rizzo, and Julian Hayda, "Russia is draining a massive Ukrainian reservoir, endangering a nuclear plant," February 10, 2023, NPR, https://www.npr.org/2023/02/10/1155761686/russia-is-draining-a-massive-ukrainian-reservoir-endangering-a-nuclear-plant.

23 Andrew E. Kramer, "They flooded their own village and kept the Russians at bay," April 27, 2022, *The New York Times*, https://www.nytimes.com/2022/04/27/world/europe/ukraine-russia-war-flood-infrastructure.html.

24 Christopher Flavelle, "As the Great Salt Lake dries up, Utah faces an 'environmental nuclear bomb,'" June 7, 2022, *The New York Times*, https://www.nytimes.com/2022/06/07/climate/salt-lake-city-climate-disaster.html.

25 "Radiological conditions in the Dnieper River basin," 2006, International Atomic Energy Agency, https://www-pub.iaea.org/MTCD/publications/PDF/Pub1230_web.pdf.

26 "Little green mayhem," *The Economist*.

Extensive shelling and heavy-vehicle maneuvers in agricultural fields and forests are likely to have impacted soil quality through mixing,[27] compaction, and chemical pollution. Research on the soil effects of shelling during WWI found evidence of localized contamination by heavy metals such as lead.[28] This kind of soil pollution can result in bioaccumulation of harmful chemicals in agricultural and other food products.[29] Given Ukraine's importance to global food production, such impacts could undermine international food security.[30]

Soil compaction is a well-known source of soil degradation in agricultural[31] and forest[32] settings, reducing water-holding capacity and aeration, and making it more difficult for plant roots to penetrate soils and access nutrients. Thus, the war in Ukraine may reduce the functioning of the country's soil ecosystems, the provisioning of agricultural and forestry products to society, and the health of natural ecosystems—such as forests and grasslands—growing in those soils. Ukraine sought to illustrate these critical issues in its COP27 pavilion, which featured a full wall display of unique Ukrainian soils at risk from war.[33]

A concern that runs through all these impacts to Ukraine's ecosystems is whether they will be able to recover. As with the country as a whole, the answer is far from certain. Heavily perturbed or degraded ecosystems sometimes fall into alternative stable states, where the ecological dynamics of the new ecosystem help to maintain it, preventing a reversion to its original configuration.[34] Some forests may end up stuck as shrub, grass, or scrublands, bodies of water may be left hypoxic (i.e. with low levels of oxygen) and uninhabitable to most fish, or carbon may be lost from an ecosystem that is not then regained. Thus, the functions and services that Ukraine's people derived from their ecosystems before the war, may not all recover when the fighting has ended, leaving the country less ecologically secure.

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27 Hupy, Joseph P., and Randall J. Schaetzl. "Introducing "bombturbation," a singular type of soil disturbance and mixing." *Soil science* 171, no. 11 (2006): 823-836. https://journals.lww.com/soilsci/Abstract/2006/11000/INTRODUCING__BOMBTURBATION,__A_SINGULAR_TYPE_OF.1.aspx.

28 Meerschman, Eef, Liesbet Cockx, Mohammad Monirul Islam, Fun Meeuws, and Marc Van Meirvenne. "Geostatistical assessment of the impact of World War I on the spatial occurrence of soil heavy metals." *Ambio* 40 (2011): 417-424. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3357735/.

29 Rai, Prabhat Kumar, Sang Soo Lee, Ming Zhang, Yiu Fai Tsang, and Ki-Hyun Kim. "Heavy metals in food crops: Health risks, fate, mechanisms, and management." *Environment international* 125 (2019): 365-385. https://www.sciencedirect.com/science/article/pii/S0160412018327971.

30 "The impacts and policy implications of Russia's aggression against Ukraine on agricultural markets," August 5, 2022, The Organisation for Economic Co-operation and Development, https://www.oecd.org/ukraine-hub/policy-responses/the-impacts-and-policy-implications-of-russia-s-aggression-against-ukraine-on-agricultural-markets-0030a4cd/.

31 Sjoerd Willem Duiker, "Effects of soil compaction," March 8, 2005, PennState Extension, https://extension.psu.edu/effects-of-soil-compaction.

32 Greacen, Emmett L., and R. Sands. "Compaction of forest soils. A review." *Australian Journal of Soil Research* 18, no. 2 (1980): 163-189. https://www.fs.usda.gov/rmrs/documents-and-media/compaction-forest-soils-review.

33 Alejandro De La Garza, "Ukraine isn't just at COP27 to talk about climate," November 15, 2022, Time, https://time.com/6234092/ukraine-cop27-russia-war/.

34 Suding, Katharine N., Katherine L. Gross, and Gregory R. Houseman. "Alternative states and positive feedbacks in restoration ecology." *Trends in ecology & evolution* 19, no. 1 (2004): 46-53. https://www.sciencedirect.com/science/article/abs/pii/S0169534703003197.

Finally, Russia's invasion has sparked notable greenhouse gas emissions, contributing to climate security risks beyond Ukraine's borders. In addition to fossil-fuel dependent military weapons, equipment, installations, and transportation, Russia's invasion has prompted emissions from refugee movements, sabotage of gas pipelines, land disturbance, and the fossil fuel resources required to repair and rebuild destroyed infrastructure.[35] At COP27, the UN climate conference which took place in Egypt at the end of 2022, Ukraine's environment minister reported 33 million tons of greenhouse gasses directly linked to the war–roughly the annual emissions of New Zealand–noting sources such as forest fire and intentionally burned oil reserves.[36] These added emissions are now part of the larger story of how climate change is accelerating a wide range of security threats around the world.

DECREASING GLOBAL FOOD SECURITY

While soil quality is a long-term impact of the war on agriculture, the disruption of Ukraine's role as a key grain producer for Africa and the Middle East has already imperiled global food security in the last year–from disrupted growing seasons to more expensive and dangerous shipping. As the conflict began, CCS noted that food prices were already hitting record highs and predicted, along with other food security experts, that the conflict–after years of COVID-19-related disruption and climate change impacts–would disrupt the global food system.[37]

Throughout the conflict, Ukrainian wheat fields have been one of the many plains of battle. In the summer of 2022, Ukrainians raced against fires to rescue as much of the wheat harvest as possible, and though it remains unconfirmed, some of the fires have been attributed to Russian attacks.[38] Ukrainian farmers have done their best to continue farming in the midst of war, but winter wheat planting in 2022 fell by as much as 40%, with spring planting likely to follow suit.[39] Additionally, estimates suggest 84,200 pieces of agricultural machinery have been damaged, four million tons of grains and oilseeds have been destroyed or stolen, and storage facilities for 9.4 million tons of agricultural products have been damaged.[40]

Beyond planting, Ukrainian exports were stymied by a Russian blockade in the Black Sea, a crucial trade route. For much of the year, Ukraine attempted to export food by train and truck, but these methods are more expensive

35 Scott Moore, "Warfare and Global Warming." December 14, 2022. *New Security Beat*. https://www.newsecuritybeat.org/2022/12/warfare-global-warming/.

36 Georgina Rannard, "COP27: War causing huge release of climate warming gas, claims Ukraine." November 14th, 2022. BBC. https://www.bbc.com/news/science-environment-63625693

37 Sikorsky, Barron, and Hugh, "Climate, Ecological Security and the Ukraine Crisis: Four Issues to Consider," March 12, 2022, https://climateandsecurity.org/wp-content/uploads/2022/03/Climate-Ecological-Securityand-the-Ukraine-Crisis_Four-Issues-to-Consider_BRIEFER-31_2022_11_3.pdf.

38 Tim Lister and Petro Zadorozhnyy, "Ukraine's harvest becomes the new battlefield, as fires blacken its arable heartlands," July 16, 2022, CNN, https://www.cnn.com/2022/07/11/europe/ukraine-harvest-battlefield-intl/index.html.

39 Pavel Polityuk, "Ukraine's 2023 wheat crop seen falling to 15 mln T -agrarian council," September 1, 2022, *Reuters*, https://www.reuters.com/markets/asia/ukraines-2023-wheat-crop-seen-falling-15-mln-t-agrarian-council-2022-09-01/.

40 Caitlin Walsh, "Russia, Ukraine, and Global Food Security: A One-Year Assessment," February 24, 2023, CSIS, https://www.csis.org/analysis/russia-ukraine-and-global-food-security-one-year-assessment.

and less effective. A July deal brokered by the United Nations and Türkiye enabled some Ukrainian wheat to leave by sea, of which, 65% went to developing countries.[41] However, Russian volatility–as demonstrated by its brief withdrawal from the deal in November–leaves cause for concern about the safety of the route and the longevity of the deal, which was extended for only 60 days on March 18.[42, 43] Meanwhile, Russia has sold stolen Ukrainian wheat to countries that cannot or will not quibble about the source of much-needed food.[44]

Partly as a result, in 2022, 1.3 billion people went hungry globally, an increase of 118.7 million from 2021, according to the U.S. Department of Agriculture.[45] Food prices peaked in mid-2022 as a result of decreased supply and increased transport prices. Though they have come down in the intervening months, the International Food Policy Research Institute notes that given climate and conflict around the globe—including drought and heat conditions in many southern hemisphere breadbaskets, in addition to the conflict in Ukraine—prices will likely be volatile in 2023.[46]

This is especially probable given that fertilizer prices, though lower than they were in the immediate period post-invasion, remain nearly double what they were in 2021, on average.[47] High fertilizer prices disproportionately harm small-holder farmers in developing countries, many of whom have been forced to seek other means of ensuring their livelihoods.[48] In Kenya, for instance, increased fertilizer prices resulted in a 37-38% decline in maize production.[49] Because Russia and Belarus are the top producers of fertilizer, the longer the conflict goes on, the greater the impact on food producers in low- and middle-income countries.

It has been well established, in the year post-invasion, that the Ukrainian breadbasket is indispensable to global food security, especially given climate impacts. This means that the war, and its ecological impacts, will

41 "Infographic—Ukrainian grain exports explained," January 20, 2023, Council of the European Union, https://www.consilium.europa.eu/en/infographics/ukrainian-grain-exports-explained/.

42 Fatma Tanis, "Russia rejoins U.N. deal to ship grain from Ukraine, easing food insecurity concerns," November 2, 2022, NPR, https://www.npr.org/2022/11/02/1133486064/russia-returns-un-backed-grain-deal-ukraine.

43 Huseyin Hayatsever and Michelle Nichols, "Ukraine Black Sea grain deal extended for at least 60 days," *Reuters*, March 18, 2023, https://www.reuters.com/markets/commodities/black-sea-grain-deal-extended-turkey-ukraine-say-2023-03-18/.

44 "Russia smuggling Ukrainian grain to help pay for Putin's war," October 3, 2022, CNBC, https://www.cnbc.com/2022/10/03/russia-smuggling-ukrainian-grain-to-help-pay-for-putins-war.html.

45 Yacob Abrehe Zereyesus and Lila Cardell, "Global Food Insecurity Grows in 2022 Amid Backdrop of Higher Prices, Black Sea Conflict," November 28, 2022, U.S. Department of Agriculture Economic Research Service, https://www.ers.usda.gov/amber-waves/2022/november/global-food-insecurity-grows-in-2022-amid-backdrop-of-higher-prices-black-sea-conflict/

46 Rob Vos, Joseph Glauber, and David Laborde, "Is food price inflation really subsiding?," January 24, 2023, IFPRI, https://www.ifpri.org/blog/food-price-inflation-really-subsiding.

47 "Food Security Update | World Bank Response to Rising Food Insecurity," February 13, 2023, World Bank, https://www.worldbank.org/en/topic/agriculture/brief/food-security-update.

48 Brigitte Hugh, "Yellow Card: Global Food Crisis Underscores Need for Systemic Security," August 1, 2023, The Center for Climate and Security, an institute of the Council on Strategic Risks, https://climateandsecurity.org/2022/08/yellow-card-global-food-crisis-underscores-need-for-systemic-security/.

49 World Food Programme, "Estimated Likely Impact of Increased Fertilizer Prices on Cereal Production in Eastern Africa During the 2022 Cropping Year," https://www.resiliencelinks.org/resources/reports/estimated-likely-impact-increased-fertilizer-prices-cereal-production-eastern.

continue to adversely impact food security and climate resilience. Simultaneously, climate change impacts on food systems will only increase. With the converging triple impact of conflict, climate, and COVID-19, the need to invest in a resilient and diversified global food system has never been more apparent.

CONCLUSION

After meeting with European Union and NATO representatives at the Munich Security Conference, U.S. Special Presidential Envoy for Climate John Kerry said, "While we must confront the security risks the world faces head on, we must also do so with an eye to the climate crisis, which is making these dangers worse."[50]

Over the past year, many policymakers have stepped up to address the full range of security threats created by Russia's invasion of Ukraine, including the climate and ecological security challenges relating to emissions, energy, ecology, and food systems. Yet, as the risks continue to deepen, so must the resolve and action to respond holistically to these global and intergenerational challenges.

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50 John Kerry, Twitter Post, February 17, 2023, 7:38 am, https://twitter.com/ClimateEnvoy/status/1626561710973923329?s=20.