



in cooperation with



The Global Fire Monitoring Center (GFMC)

<https://gfmc.online/>

Assessment of Impact of Russian Invasion into Ukraine on Landscape Fires

Serhii Sydorenko, Sergiy Zibtsev, Olexandr Soshenskii

Introduction. Due to the intensive combat operations during the war, which was unleashed by the Russian Federation, the number of fire sources (shelling, bombing, landmines) in natural ecosystems have increased on a significant part of the territory of Ukraine, which have led to the mass occurrence of landscape fires. Considering the limitations in the work of services responsible for the protection of forests and other landscapes from fires (especially in the occupied territories and in areas of active hostilities) and the beginning of the fire-hazardous period in Ukraine, perhaps the only means of fire monitoring in the entire territory of Ukraine is monitoring using methods of remote sensing of the Earth.

Method. To estimate the levels of flammability of landscapes in 2022 in different regions of Ukraine, data (number of fire incidents and polygons of each fire) obtained with the help of the Orora service (<https://ororatech.com/>), which is based on remote sensing of the Earth data, was used. Statistical data on the number of fire incidents was obtained by counting the number of fire polygons. The distribution of the area covered by the fire according to the type of landscape was carried out with the help of an overlay analysis by means of GIS using a land cover map (Copernicus Global Land Service: Land Cover 100m: Version 3 Globe 2015-2019). After that, the initial land cover map was reclassified into 5 classes: coniferous forests, other forests, other natural landscapes, agricultural lands, settlements (buildings). Statistical reports on landscape fires are summarized in a table for each month separately. Each area in which active hostilities were conducted during the audit period was classified as an area with the attribute “hostilities”. Thus, calculations of the average fire area and indicators of fire density and combustibility of each type of landscape were carried out separately for groups of regions with and without active hostilities.

The indicators of fire density (R_{dens}) for each type of landscape and combustibility by area ($R_{f.comb}$) were determined (Asenova, 2018). The density of forest fires ($R_{dens.}$) was calculated according to the formula (1):

$$R_{dens.} = \frac{1000 \sum_{i=1}^n N_i}{n \times F_{for.area}}, \quad (1)$$

where: $R_{dens.}$ – average annual density of fires per 1,000 hectares of a certain type of landscape, number of cases / years / 1,000 hectares;

N_i – annual number of fires, number of cases / years;

n is the number of years during the research period (the calculation was made for the period from February to June 2022);

$F_{for.area}$ – the total area of each type of landscape, ha.

The actual combustibility of forests by area ($R_{f.comb}$) was calculated according to the formula (2):

$$R_{f.comb} = \frac{1000 \sum_{i=1}^n F_{burnt.area}}{n \times F_{for.area}}, \quad (2)$$

where $R_{f.comb}$ – average annual value of actual combustibility per 1,000 ha, ha/years/1,000 ha;

$F_{burnt.area}$ – annual area of fires on a certain type of landscape, ha/ears;

n is the number of years during the research period (the calculation was made for the period from February to June 2022);

$F_{for.area}$ - the total area of a certain type of landscape in the research region, ha.

Results. According to preliminary data, 2,878 fires have occurred since 24 February 2022, and the area of fire-damaged territories as of 01 July 2022 approximately reaches more than 1,513,286 ha (all types of landscapes) (Table 1).

Table 1. Number and area of landscape fires in Ukraine from 24 February to 01 July 2022

Oblast	Total Fires		Distribution of the Area of Fires by Types of Landscapes (ha)					Average area per fire (ha)
	Number	Area (ha)	Forest landscapes	Including forest landscape with dominating pine forests	Agriculture lands	Other natural landscapes	Settlements	
Crimea	80	25 762	899	23	20204	3902	757	322.0
Vinnyska	6	1 395	40	0	1295	60	0	232.5
Volynska	76	31 324	2755	568	16516	11216	837	412.2
Dnipropetrovska	104	49 870	768	109	26053	12921	10128	479.5
Donetska	283	197 000	30685	19830	96613	49258	20444	696.1
Zhytomyrska	145	77 283	17744	11366	35224	23089	1226	533.0
Zakarpatska	123	53 842	13727	19	25589	10596	3930	437.7
Zaporizhzhvska	74	34 827	376	0	20706	8635	5110	470.6
Ivano-Frankivska	160	50 671	5875	161	26489	15584	2723	316.7
Kyivska	258	209 203	49383	34376	85816	61075	12929	810.9
Kirovohradska	83	26 981	81	31	23633	2058	1209	325.1
Luhanska	199	160 591	45583	28644	35114	56164	23730	807.0
Lvivska	301	127 282	15232	981	56261	49877	5912	422.9
Mykolayivska	69	28 205	956	242	20481	5664	1104	408.8
Odeska	122	55 728	1389	70	34017	19777	545	456.8
Poltavska	39	17 530	1349	132	8589	7097	495	449.5
Rivnenska	119	50 244	7265	1994	18992	22680	1307	422.2
Sumska	17	4 542	529	111	1572	2318	123	267.2
Ternopil'ska	43	9 417	713	43	7208	1221	275	219.0
Kharkivska	177	119 204	47812	33474	28496	39044	3852	673.5
Khersonska	68	43 829	5012	1467	11685	26289	843	644.5
Khmelnyska	98	27 923	799	82	23995	2660	469	284.9
Cherkaska	43	12 929	861	190	9153	2432	483	300.7
Chernivetska	71	19 633	764	0	13136	4566	1167	276.5
Chernihivska	120	78 071	10907	1962	28412	32819	5933	650.6
Total	2878	1513286	261504	135875	675249	471002	105531	525.8
Thereof in the war zone	1184	825435	168858	104052	318202	264824	73551	697.2

Taking into account the uneven distribution of the territory of the regions by landscape types, data normalization and calculations of their flammability were carried out in translation per 1000 hectares of each of the surface types (Table 2) and taking into account the conduction of active hostilities in each of the regions of Ukraine.

Table 2. Distribution of land surface areas (based on the reclassified Copernicus Global Land Service: Land Cover 2019 map) by regions of Ukraine

Oblast	Area of each type of land surface (x 1,000 ha)				
	Forests	Pine forest	Agricultural lands	Other natural landscapes	Settlements
Crimea	275.91	8.73	2693.38	1119.00	100.69
Vinnytska	244.87	3.33	2653.07	217.87	80.79
Volynska	698.89	295.45	2028.84	392.87	45.67
Dnipropetrovska	70.00	15.25	3190.67	443.64	163.89
Donetska	141.67	19.34	2656.47	572.33	164.38
Zhytomyrska	979.64	440.12	2988.13	531.75	63.17
Zakarpatska	777.32	0.8	1291.08	202.53	49.40
Zaporizhzhska	21.70	1.06	2723.48	348.37	85.38
Ivano-Frankivska	639.30	9.9	1404.16	268.08	53.45
Kyivska	611.54	343.03	2897.64	559.01	162.53
Kirovohradska	64.98	4.18	2455.19	111.59	54.18
Luhanska	229.10	52.86	2678.84	837.03	95.97
Lvivska	743.68	93.3	2203.97	486.88	92.37
Mykolayivska	15.86	4.16	2433.93	181.42	60.19
Odeska	76.94	1.15	3337.70	322.21	101.2
Poltavska	285.54	52.59	2870.11	532.62	90.02
Rivnenska	732.79	367.12	2014.24	455.13	54.65
Sumska	536.94	87.24	2382.12	598.86	58.88
Ternopil'ska	177.41	9.66	1391.93	113.04	49.03
Kharkivska	387.76	85.05	3146.10	623.95	104.38
Khersonska	40.89	11.65	2735.78	591.48	66.59
Khmelnyska	234.68	37.15	2070.188	177.83	63.78
Cherkaska	238.69	59.66	2093.58	272.18	75.16
Chernivetska	246.492	0.9	814.06	131.54	44.82
Chernihivska	823.71	275.24	3186.39	884.31	63.58

Thus, it was found that the density of fires is 37.5% higher in regions where hostilities were actively conducted, which is caused by an increase in the number of fire sources in the landscape. The total flammability of landscapes increased by 2.3 times. The flammability of forests increased the most compared to areas where there were no combat operations: by 9 times (forests), in coniferous forests the flammability increased by 15 times. The average fire area increased by 32.6% to 697.2 hectares, which is caused by the difficulties and often the impossibility of extinguishing fires due to risks to the life and health of firefighters and the impossibility of fully implementing fire prevention measures in the frontline forests.

Table 3. Flammability of landscapes in regions with active hostilities in compare with absence of them (not occupied, no hostilities)

Military battles in the regions	Density of fires (No. /1000 ha)	Specific area of landscape fires, area of fires /1000 hectares per type of landscape						Average area of fires, ha
		General	Forests	Pine Forests	Agricultural lands	Other natural landscapes	Settlements	
Absent	0.012	4.7	3,4	4.9	2.4	8.3	6.4	525.8
Active	0.016	11.1	31.7	74.2	4.3	18.1	28.4	697.2
%	137.5	236.0	943.1	1506.1	177.0	218.5	440.3	132.6

Reference

- Buchhorn, M.; Smets, B.; Bertels, L.; De Roo, B.; Lesiv, M.; Tsendbazar, NE, Linlin, L., Tarko, A. (2020): Copernicus Global Land Service: Land Cover 100m: Version 3 Globe 2015-2019: Product User Manual; Zenodo, Geneva, Switzerland, September 2020; doi: 10.5281/zenodo.3938963
- [GFMC Website](#) – jointly updated by information supplied by [REEFMC: Regularly published information on wartime-related landscape fires](#)