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Climate change and fires in the Ukrainian Polissia region

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SUMMARY

Climate change accompanied by anomalously high temperatures and a decrease in precipitation during the warm season can have serious consequences for Ukrainian Polissia, including an increased risk of forest and peat fires, deterioration of ecosystem integrity, changes of biodiversity patterns, etc. An average temperature increase of 0.60°C per decade was observed in the Ukrainian Polissia region along with an annual precipitation decrease ranging from 2 to 4% over the period from 1990 to 2021. The prevailing weather conditions in 2020 included snowless warm winter, warm arid spring (in particular, in March and April), and certain accompanying synoptic conditions (e.g., high wind speeds up to 15-20 m/s). Such conditions contributed to the forest fires and a powerful dust storms in most regions of the Ukrainian Polissia. During the spring 2020, more than half of the territory of Ukrainian Polissia was exposed to fires. The climatic conditions of spring 2022 were not as dry as in 2020, however, due to the war, fires engulfed a significant part of the territory of Kyiv and Chernihiv Polissia. Analysis of the spatial distribution of the fire frequency in the regions of Ukrainian Polissia in 2020 and 2022 (based on the satellite data) points out the dominance of different fire-promoting factors: in 2020, it was weather anomalies, in 2022 - human activities (armed hostilities).

Introduction

The Ukrainian Polissia region is known for its abundant biodiversity, showcasing a variety of species, and it features diverse biotopes, representing various ecological niches *(Marynich, 1993)*. Natural ecosystems in the Ukrainian Polissia are not isolated from external influences. They are affected by both anthropogenic and natural factors. Human activities in the region, such as deforestation, urbanization, pollution, and human-caused wildfires represent significant anthropogenic factors that can impact the local ecosystems. Natural factors, including climate change, droughts, and other impact drivers, also play a role in shaping and influencing the region's ecosystems *(IPCC, 2021)*. The primary cause of the majority of fires in natural systems is attributed to human activities. Human negligence and deliberate actions can significantly contribute to the ignition and propagation of wildfires. Long periods of high temperatures and a lack of precipitation create a favourable condition for the occurrence and spread of fires. These climatic conditions can lead to dry vegetation, making it highly susceptible to ignition. Drought conditions and extended heatwaves can exacerbate the risk of wildfires by creating a conducive environment for the rapid spread of flames *(Zibtsev et al., 2019; Spinoni et al., 2016)*. Most of the countries of Europe in 2020 observed a waterless spring and dry summer, which contributed to the spread of multiple forest and peat fires, including the territory of the Ukrainian Polissia *(Pińskwar, et al., 2020, Semenova, et al., 2022)*. However, 2022 was not as low-water and dry as 2020 was and intensive forest fires in this area were caused mainly by war.

The purpose of this research was to analyse the features of climate change in the Ukrainian Polissia, consider climatic conditions in the springs of 2020 and 2022, and describe the spread of forest fires using satellite monitoring data.

Method and/or Theory

Empirical data from the weather stations shown in the Figure 1 were used in this work. The data include average annual and monthly surface air temperature and precipitation for the period 1990–2021. Some other data were used from the resource (*CGO, 2022*).

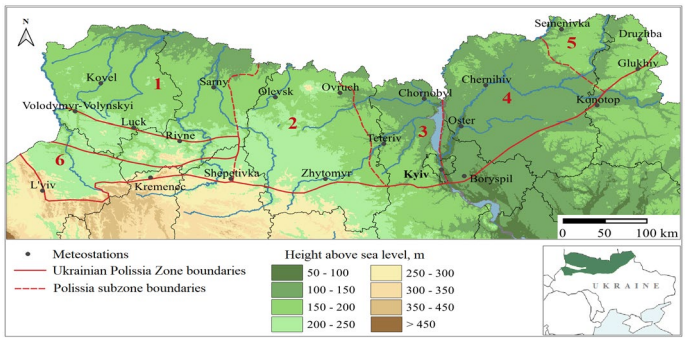

Figure 1 *Geographical subzones of the Ukrainian Polissia: 1 – Volynske Polissia; 2 – Zhytomyrske Polissia; 3 – Kyivske Polissia; 4 – Chernihivske Polissia; 5 – Novgorod–Siverske Polissia; 6 – Small Polissia. The meteorological stations used as a data source are reflected on the map.*

Meteorological parameters were averaged in accordance with the geographic subzones of the Ukrainian Polissia. Satellite data from the Fire Information for Resource Management System (FIRMS) (the National Aeronautics and Space Administration, NASA) for the period 2001-2022 was used for the analysis of forest fire frequency in the Ukrainian Polissia zone. The FIRM's dataset is based on satellite observations by MODIS and includes data regarding the time, location, and intensity of fires (FIRMS, 2023).

Results

The features of climate change in the Ukrainian Polissia region. The climate of the Ukrainian Polissia is characterized by location of the territory in a moderately continental climate zone with continentality indices in the Johanson–Ringleb range of 55–65 *(The Climate of Ukraine, 2002; Boychenko et al., 2018)*. It features a relatively mild and unstable winter with little snowfall, a warm

and humid summer, and relatively dry spring and autumn seasons. The average annual temperature in the Ukrainian Polissia for the period 1990–2021 was 8.2 ± 0.8°C with an average trend increase of +0.60°C/10 years. The annual amount of precipitation for the same period was 620 ± 62 mm per year with an average trend decrease of –6.7 mm per year (2–4 %) (Table 1). However, climate change has accelerated since the second half of the 20th century (IPCC, 2021).

Table 1 *The annual average temperature and the annual amount of precipitation and their trends for regions of Ukrainian Polissia for the period 1991–2020*

N	Regions	Temperature, °C		Precipitation, mm/year	
		Average for 1991–2020	Trend, °C per 10 years	Average for 1991–2020	Trend, mm/year per 10 years
1	Volynske Polissia	8.4±0.8	0.56	615±71	+7.6
2	Zhytomyrske Polissia	8.2±0.9	0.65	638±79	–3.4
3	Kyivske Polissia	8.6±0.8	0.63	597±75	–14.7
4	Chernigivske Polissia	7.9±0.8	0.60	591±73	–32.3
5	Novgorod–Siverske Polissia	7.5±0.9	0.60	591±84	–9.0
6	Small Polissia	8.4±0.8	0.60	705±98	+5.0
Ukrainian Polissia		**8.2±0.8**	**0.60**	**620±62**	**–6.7**

The change of the average monthly temperature for the period 1990–2021 was increasing during the whole year (by 0.1–1.2 °C/10 years), except for January, which is characterized by a decreasing trend (by −0.3 °C/10 years) (Figure 2, A). The monthly amount of precipitation for the period 1990–2021 was increasing for October, December–March, and May by 2–6%, however, for April, June, September, and November it was decreasing by 3–7% (Figure 2, B). Note that the above-described trends are averaged for the region under study, however, in certain years and months in the subzones of the Ukrainian Polissia, certain differences are registered, which is associated with interannual variability.

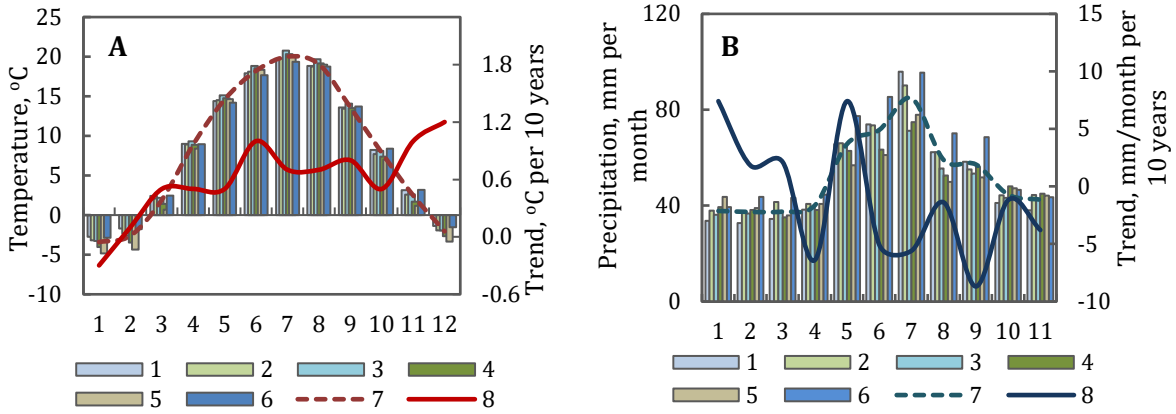

Figure 2 *Seasonal variation of temperature (A) and precipitation (B) of the Ukrainian Polissia for the period 1990–2021. 1–6 – geographical subzones as presented in the Figure 1; 7 – averaged for the Ukrainian Polissia; 8 – trend*

The trend of decreasing precipitation in April and June–September against the backdrop of anomaly high temperatures during the warm season leads to atmospheric and soil droughts, which intensify the risks of widespread forest fires and peat fires in the Ukrainian Polissia (Karamushka, et al., 2022).

The climatic conditions of the year 2020 exceeded all records in terms of their anomalies. In particular, the intensification of the meridional transport of warm and dry air from Asia and Africa against the backdrop of the dominant Western Atlantic transport became the cause of the anomalously warm winter and spring in Ukraine and Europe (*Pińskwar, et al., 2020, Semenova, et al., 2022*). The unusually warm (exceeding the climatic norm for the period 1961-1990 by 4-5°C) and relatively arid (with atmospheric precipitation amounts 20-40% below the climatic norm) winter of 2019-2020

became the most anomalous in over 140 years. The trend of recent decades with anomaly high temperatures and significant aridity during the summer months has also persisted. In particular, the summer of 2020 was quite hot, with temperatures exceeding the norm by 2-4°C and atmospheric precipitation amounts below the norm by up to 100% in June and up to 60% in July and August. In addition, Figure 3 presents a time series of daily relative humidity, precipitation, and temperature at the meteostation Kyiv for the months of March to May in both 2020 and 2022. These data confirm the meteorological anomalies in 2020. The prevailing weather conditions in 2020, such as snowless warm winter, warm arid spring, and certain accompanying synoptic conditions (high wind speeds up to 15-20 m/s) were the drivers promoting the forest fires and a powerful dust storm in the most zones of the Ukrainian Polissia (Figure 4, 2020).

The weather conditions of spring 2022 were not as dry as in 2020, however, due to the war, fires engulfed a significant part of the territory of Kyiv and Chernihiv Polissia (Figures 4 and 5).

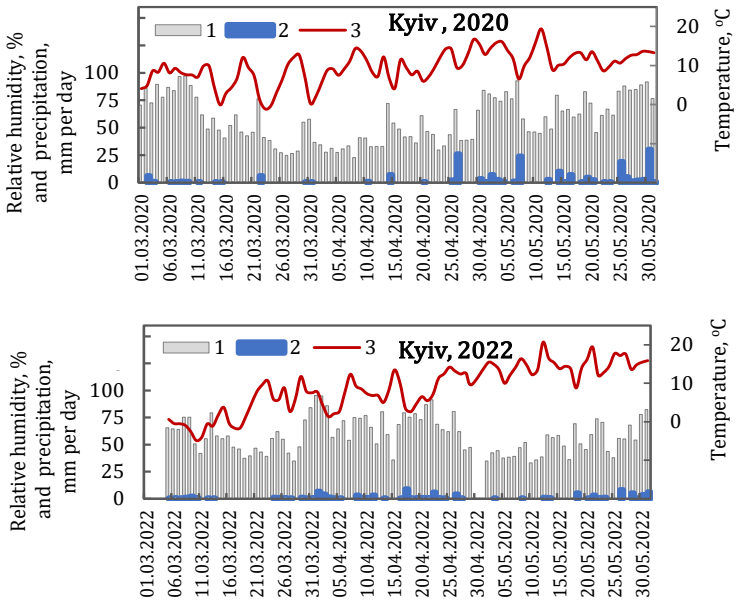

Figure 3 Time series of daily relative humidity (1), precipitation (2), and temperature (3) at the Kyiv meteostation for the period 01 March – 30 May in both 2020 and 2022

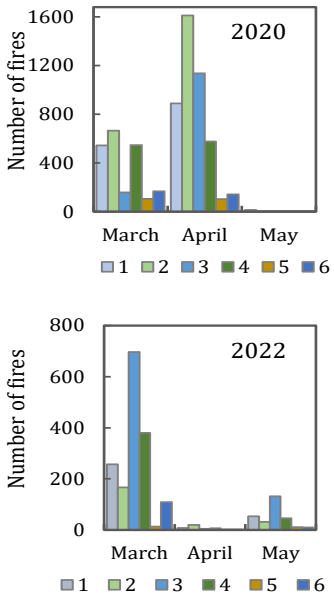

Figure 4 Number of fires in Ukrainian Polissya Subzones for the the period 01 March – 30 May in both 2020 and 2022

The fires in the Ukrainian Polissia region in 2020 and 2022. The spatial distribution of the fire frequency according to the satellite data (FIRMS) demonstrates differences in 2020 and 2022 (Figure 5). In 2020, fires were mainly provoked by weather conditions, but in 2022, the fires mainly were caused by armed hostilities.

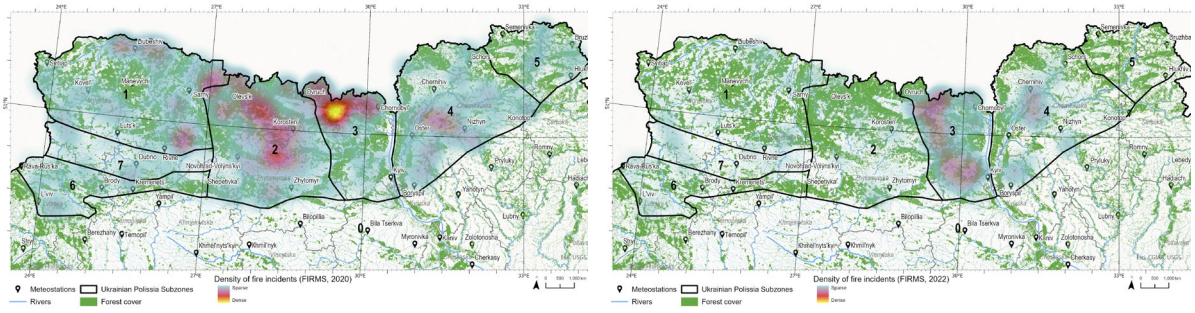

Figure 5 The spatial distribution of the fire frequency in 2020 and 2022 according to the satellite data (FIRMS) in Ukrainian Polissia.

In 2020, the anomalous weather conditions during the winter-spring period contributed to significant atmospheric pollution, not only by ground aerosol particles as a result of dust storms and dry winds but also by gas-aerosol impurities. The sources of such emissions were fires in northern Ukraine.

Conclusions

The presented data show a pronounced correlation of the intensity of fires in natural systems with climatic factors and anthropogenic activity. Anomalously high temperatures and a decrease in precipitation during the warm season can have and had serious consequences for the ecosystems of Ukrainian Polissia, including an increased risk of forest and peat fires, as well as the deterioration of ecosystem status. Long term increase of average temperature (0.60°C per decade) and an annual precipitation decrease (up to 4%) over the period 1990 – 2021 were less danger for the ecosystem than short-term abnormal changes in climatic parameters. In 2020, the prevailing weather conditions (snowless warm winter, warm arid spring, certain accompanying synoptic conditions like high wind speeds up to 20 m/s) promoted the forest fires and a powerful dust storm in Ukrainian Polissia. Due to this, more than half of the territory of Ukrainian Polissia was exposed to fires. The climatic conditions of spring 2022 were not as dry as in 2020, however, due to the armed hostilities, fires engulfed a significant part of the territory of Kyiv and Chernihiv Polissia. Spatial distribution of fire frequency in 2020 and 2022 shows dependence on different promoting factors – in 2020, it was weather anomalies, and in 2022 – human activities (armed hostilities).

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