Received: 06/12/2021; Revised: 07/25/2021; Accepted: 08/22/2021

UKRAINIAN JOURNAL OF FOREST AND WOOD SCIENCE

Journal homepage: https://forestscience.com.ua/en
Ukrainian Journal of Forest and Wood Science, 12(3), 21-34

UDC 630*43(477)"2020"
DOI: 10.31548/forest2021.03.002

Consequences of Catastrophic Landscape Fires in Ukraine for Forest Ecosystems and Population

Oleksandr Soshenskyi*, Sergiy Zibtsev, Andrii Tierientiev, Oleksandr Vorotynskyi

National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine

Abstract. According to the latest research and publications of international organisations, since the end of the 20th century, the number and frequency of catastrophic forest fires in the world have been increasing, which lead to large economic and environmental losses and human casualties. According to forecasts, negative changes in weather conditions should be expected on the territory of Ukraine, from the standpoint of fire danger: an increase in air temperature, a shift in seasons, an increase in the duration of vegetation and fire-hazardous periods, an increase in the frequency and intensity of heat waves and natural hydrometeorological phenomena, changes in water resources of local runoff. In 2020, several catastrophic fires occurred on the territory of Ukraine in the natural landscapes of different regions. Among the largest and most catastrophic fires that led to human casualties, and substantial economic, environmental, and social consequences are fires in Zhytomyr, Luhansk, Kharkiv, and Kyiv regions. The main prerequisite for such large fires was weather conditions, namely a long period without precipitation, high air temperature and wind gusts of 15-25 m/s. In Ukraine, there are two main critical periods in terms of the frequency and danger of forest fires: the first is in spring after the snow cover descends and before the formation of new greenery; the second is in late summer – in the first half of autumn when dry combustible materials appear on agricultural land, and people burn plant remains in the fields. The events of 2020 showed that the current system is not ready to effectively resist large forest fires and the need for its continuous improvement in accordance with new challenges. In the study based on available official information, data obtained through remote sensing and from the Geoportal "Landscape fires of Ukraine" (wildfires.org.ua) information is provided on the most catastrophic fires that occurred in the natural landscapes of Ukraine in 2020. The components of the system of protection of natural landscapes from fires are considered, the main shortcomings are identified and key recommendations for its improvement are formulated

Keywords: forest fires, emergencies, weather conditions, climate change, damage, human casualties

Suggested Citation:
Soshenskyi, O., Zibtsev, S., Tierientiev, A., & Vorotynskyi, O. (2021). Consequences of catastrophic landscape fires in Ukraine for forest ecosystems and population. *Ukrainian Journal of Forest and Wood Science*, 12(3), 21-34.

**Corresponding author*

Introduction

In 2020, several catastrophic fires occurred on the territory of Ukraine in the natural landscapes of different regions of the country. Among the largest and most catastrophic fires that led to human casualties, and substantial economic, environmental, and social consequences are fires in Zhytomyr, Luhansk, Kharkiv, and Kyiv regions. The main prerequisite for such large fires was weather conditions, namely a long period without precipitation, high air temperature and wind gusts of 15-25 m/s.

The issue of fires in natural landscapes at the international level began to be considered more than 30 years ago, which indicates the global nature of this problem (Goldammer, 2021). During this period, hundreds of international conferences dedicated to landscape fires were held, among which the most substantial are: the 1st International Wildland Fire Conference (IWFC) (1989, Boston, USA) (U.S. Forest Service, 1990); "Fires in the environment: ecological, atmospheric, and climatic importance of landscape fires" (1992, Berlin, Germany) (Crutzen & Goldammer, 1993); "Biomass combustion and global changes" (1995, Williamsburg, Virginia, USA) (Levine, 1996); 2nd IWFC (1997, Vancouver, Canada) (Goldammer, 2021); 3rd IWFC (2003, Sydney, Australia) (GFMC, 2003a); 4th IWFC (2007, Seville, Spain) (GFMC, 2007); 5th IWFC (2011, Sun City, South Africa); 6th IWFC (2015, PyeongChang, Gangwon Province, Korea) (Goldammer, 2021); 7th (2019, Campo Grande, Brazil) (Steil, 2020).

Ukraine joined the international community and global dialogue to promote international cooperation and develop new approaches to fire management in 2007 (4th IWFC). In 2013, a regional Eastern European Fire Monitoring Centre was opened in Ukraine based on the National University of Life and Environmental Sciences of Ukraine (https://nubip.edu.ua/node/9083/1), which is part of a global network with a central authority – the Global Fire Monitoring Centre (GFMC, https://gfmc.online). Now in Ukraine, the issue of fires in natural landscapes has become very important and is being discussed by production workers, managersб and researchers at all levels – local, regional, and national: The First National Coordination Meeting on improving the prevention and extinguishing of forest fires in the exclusion zone (2016, Kyiv, https://nubip.edu.ua/node/30993); National Round Table "Fires in natural and cultural landscapes of Ukraine: development of National Fire Management Policy" (2017, Kyiv, https://nubip.edu.ua/node/38179); The Fifth National Coordination Meeting on improving the prevention and safe extinguishing of forest fires in the exclusion zone (2019, Kyiv, https://nubip.edu.ua/node/42818); Belarusian-Ukrainian staff exercises on joint extinguishing of large cross-border fires (2018, Gomel, Belarus, https://nubip.edu.ua/node/48594); The Second National Round Table "Fires in natural and cultural landscapes of Ukraine: development of an integral system of protection against fires in forests, agricultural lands, and other natural ecosystems" (2019, Kyiv, https://nubip.edu.ua/node/59286), etc.

Experts predict that from the standpoint of fire danger on the territory of Ukraine, negative changes should be expected, such as a change in seasons, an increase in air temperature, the duration of the fire danger period, frequency and intensity of heat waves and natural hydrometeorological phenomena, changes in water resources of local runoff (Balabukh et al., 2016; Shevchenko et al., 2014).

According to recent studies (Williams et al., 2011; Dowdy et al., 2019) and papers by international organisations (FAO, 2005, 2006, 2015; Goldammer, 2021; Tedim, 2015; Zibtsev & Goldammer, 2019; San-Miguel-Ayanz et al., 2020, 2021), since the end of the 20th century, the number and frequency of catastrophic forest fires in the world has been increasing, which lead to large economic and environmental losses, human casualties (San-MiguelAyanz et al., 2013, 2020). These large forest fires are unusually large-scale and have catastrophic consequences. According to Williams (2013), 0.1% of forest fires account for about 95% of the total area covered by the fire and 85% of the total cost of extinguishing them. In particular, the fire in China in 1987, which destroyed approximately 1.2 million hectares of forests and which killed more than 200 people was such (Salisbury, 1989). In the Republic of Botswana in 2008, fires covered a total area of 3.6 million hectares (Williams et al., 2010). During "Black Saturday" in February 2009, fires occurred in an area of about 2 million hectares, which destroyed entire cities and killed 173 people (Nolan et al., 2020). In the russian Federation in 2010, fires burned about 2.3 million hectares,

killed 62 people, and destroyed hundreds of homes (Williams et al., 2011). In 2018, in the United States, California, during a fire that covered 92.9 thousand hectares, eight people were killed (Wikipedia, 2020). In 2019, fires in Australia covered about 10.7 million hectares, killing 33 people and destroying more than a thousand homes (Morris, 2020).

The dynamics of forest fires in Ukraine are characterised by a certain frequency, in particular, during 1990-2020, on average, 3-4 catastrophic fires occur in each decade (Soshenskyi et al., 2021; Zibtsev et al., 2019). Based on remote sensing methods, it was established that in 2001-2019, in Ukraine, fires covered 38.4 million hectares of natural territories (2.0 million hectares annually). The total number of fires during this period is 223 thousand cases (an average of 11.7 thousand a year) (Zibtsev et al., 2020). According to official data, during 1990-2019, an average of 3 thousand forest fires occurred in Ukraine on an area of about 4 thousand hectares annually (Zibtsev et al., 2019; Soshenskyi et al., 2021). The new era of climate change has increased average statistics. Considering the extreme year 2020, for the period of 1990-2020, the average annual fire area increased to 7 thousand hectares (Soshenskyi et al., 2021). The catastrophic scale of forest fires in Ukraine that occurred in 2020 will be covered in this study.

Materials and Methods

The data from official reports of organisations and enterprises, local authorities, and the state emergency service of Ukraine were used to reflect the fires of 2020 and their consequences. The information about the main climate indicators obtained from local weather stations was used to analyse the climate indicators that preceded catastrophic fires. The information from the Geoportal "Landscape fires of Ukraine" (wildfires.org.ua) was used to analyse spatial information about fires, which was developed within the framework of the implementation by the National University of Life and Environmental Sciences of Ukraine of the study No. 110/9-PR-2018 "Scientific-methodological support for the creation of a geoportal for risk assessment, forecasting, and prevention of wildfires in Polesia of Ukraine". The geoportal uses the data of *MODIS* system (earthdata.nasa.gov), which are available in bitmap format in the repositories of the cloud platform *Google Earth Engine (GEE)*, and *MOD14* / *MYD14* and *MCD64A1* products (NUBIP of Ukraine, 2020).

Results and Discussion

In 2020, several catastrophic fires occurred on the territory of Ukraine in the natural landscapes of different regions. Among the largest and most catastrophic fires that led to human casualties, and substantial economic, environmental, and social consequences are fires in Zhytomyr, Luhansk, Kharkiv, and Kyiv regions.

In the Zhytomyr region in April 2020, two regional emergencies occurred due to forest fires in the Narodytsky and Ovrutsky districts. The first large-scale fire occurred on April 3 near the village of Zvizdal of the Narodytsky district on the territory of the Narodytsky and Klishchivsky forest districts of the state enterprise "Narodytsky Spetslishosp" with the subsequent spread of fire through the territory of the Narodytsky, Davidkivsky, Klishchivsky forest districts of the Narodytsky district of the Zhytomyr region and to the territory of the Exclusion Zone and Unconditional (Mandatory) Resettlement (EZ and ZU(M)R). The fire developed for 9 days and reached an area of 7 thousand hectares, it was liquidated on April 14. On the night of April 16-17, 2020, a second emergency situation occurred in the Berezhestsky forestry of the state enterprise "Ovrutsky Lishosp" of the Zhytomyr region due to forest fires, which were caused by difficult weather conditions (strong winds of 20-25 $m*s^{-1}$) spread to the territory of eight forestry enterprises of the region (SE "Belokorovitsky Lishosp", SE "Luhynsky Lishosp", SE "Narodytsky Spetslishosp", SE "Olevsky Lishosp", SE "Ovrutsky Lishosp", SE "Ovrutsky Spetslishosp", SE "Slovechansky Lishosp", and SE "Slovechansky Lishosp agro-industrial complex").

The fire developed from seven blazes:

1 – the eastern outskirts of the village of Rudnia (ignition from a damaged power line);

2 – in the area of the villages of Verkhnia Rudnia, Serednia Rudnia, Nizhnia Rudnia (a blaze along the roadway);

3 – a forest area between the villages of Ostrov, Kosuli, Matsky (a source of fire near smouldering peat bogs);

4 – a forest area of the Povchansky forestry;

5 – the south-eastern outskirts of the village of Pershotravneve;

6 – a forest area between the settlements of Pischanytsia, mochulnya;

7 – Slobidske forestry between the settlements of Voznychi and Lchanky (smouldering peat bogs).

The total area of fires of the "second wave" reached 35 thousand hectares. More than 1 thousand people and 150 pieces of equipment, including three aircraft of the State Emergency Service, were involved in extinguishing fires every day. According to the Zhytomyr regional state administration, fires (during the second emergency) caused damage in the amount of more than 700 million hryvnias (SES of Ukraine, 2021b). The fire was extinguished on May 4. As a result of the fires, seven settlements were damaged – Lychmany village, Mahdyn village, Vystupovychi village, Berkivske village, Srednia Rudnia village, Nizhnia Rudnia village, Ostrovy village, where 82 households were destroyed and damaged, including 42 residential buildings, one church, and one sawmill. The contours and spatial location of fires obtained based on remote sensing data and using the tools of the geoportal "Landscape fires of Ukraine" are shown in Figure 1.

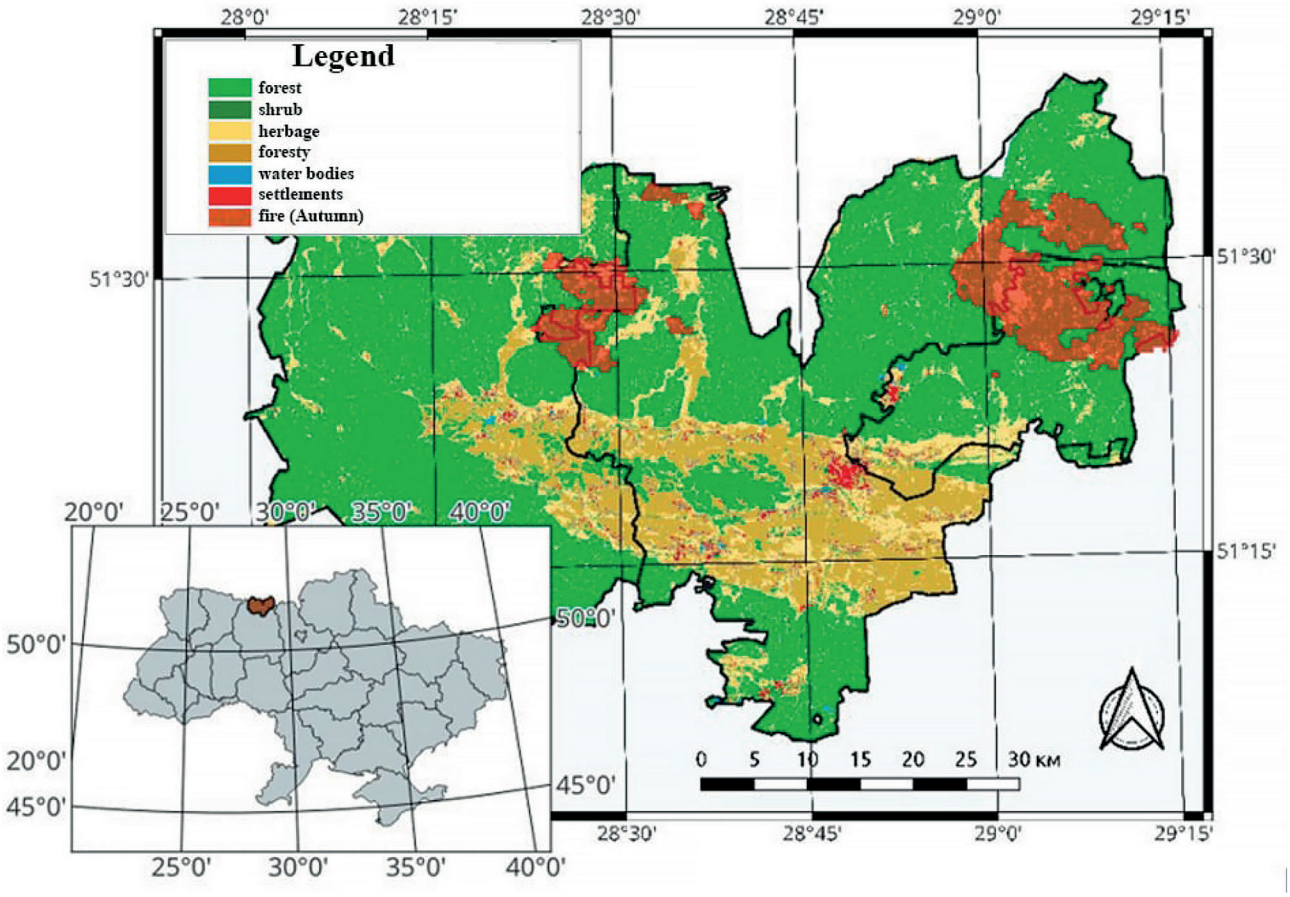

Figure 1. Forest fires in the territory of Ovrutsky and Narodytsky districts of Zhytomyr region, which occurred on April 3 and 16-17, 2020

The main reason for the development of fires to such catastrophic proportions was weather conditions, in particular, lack of precipitation for a long time (about one month without precipitation), wind gusts of 20-25 $m*s^{-1}$ during the development of a fire, and high air temperature. The dynamics of average air temperature and precipitation during the period of fire hazard formation in the weather and during the development of fires are illustrated in Figure 2.

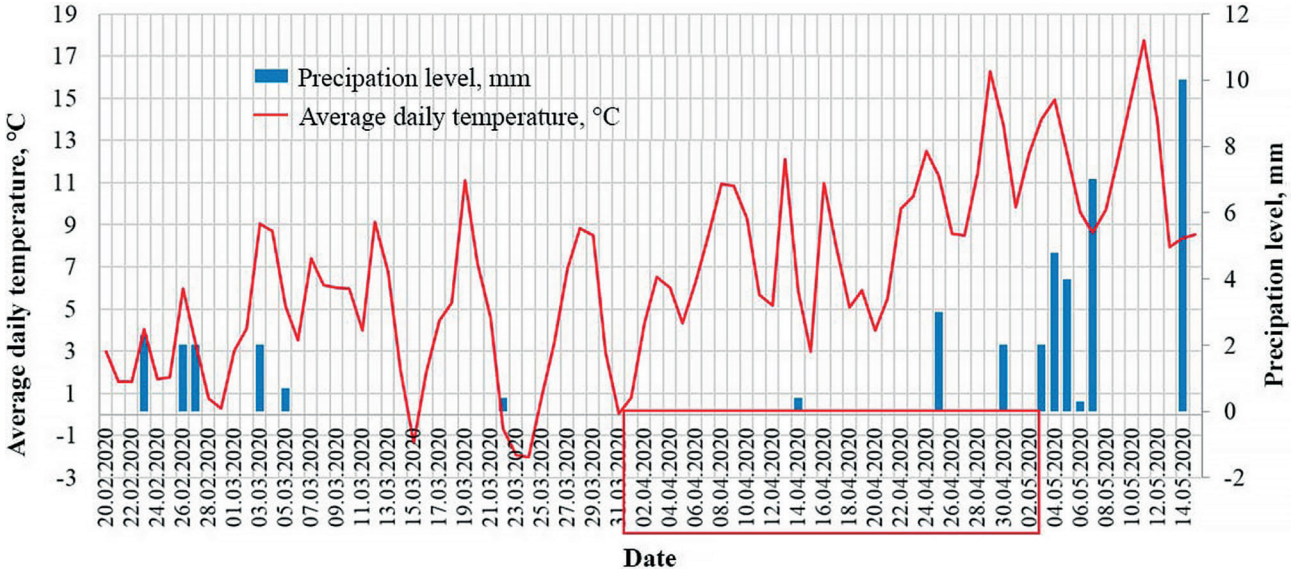

Figure 2. Dynamics of the average daily air temperature and precipitation for the analysed period (weather station of Ovruch, https://rp5.ua)

In the Kyiv region on the territory of the Chornobyl Radiation and Ecological Biosphere Reserve (hereinafter – Reserve) on April 3, a forest fire began, which spread from the south-west from the territory of the Drevliansky reserve, on April 7 reached the floodplain of the Uzh River, in the following days it spread in the northern and eastern directions. In another source of fire on April 8, a fire started in the central part of the Reserve, near the village of Chystogalivka, which approached the city of Chornobyl on April 10, and on April 13 approached the Chornobyl nuclear power plant (CHNPP), where it was stopped. On April 16, the fire broke out with renewed vigour due to the gusts of wind and spread to nearby villages in a south-easterly direction. The fire was contained on April 21. In another source of fire, in the southern part of the Reserve near the villages of Ivnytsia and Rozsokha, a fire started on April 13, which developed in the eastern and southern directions; it was localised on April 24. The fourth source of the fire was a fire that occurred on April 16 in the eastern part of the Reserve, near the village of Kryva Hora and developed in the eastern and south-eastern directions; it was localised on April 30 (Fig. 3).

According to official data, the total area covered by the fire for the period from April 3 to May 7 was 67.4 thousand hectares, in particular: on the territory of the Reserve – 51.8 thousand hectares; forest fund and ecosystem – 15.6 thousand hectares. As a result of the fire on the territory of the reserve, the following areas were covered by fire: 32,413.1 ha – forests (23% of the total forest area); 10,721.8 ha – fallow forests; 3,530.5 ha – swamps; 5,200 ha – other territories (coastal strip of rivers, meadows, etc.). The damage caused by fire on the territory of the Reserve is approximately 8523.677 million UAH, among them – from damage to forests 8075.114 million UAH, damage to natural renewal – 441.874 million UAH, damage and destruction of swamps – UAH 4.975 million, destruction of bird nests – UAH 1.714 million (SAUEZM, 2021). Fires substantially damaged a number of rare biotopes that are listed in the Berne Convention, plant groups that are listed in the Green Book of Ukraine, pine-juniper hylocomiosum forests, and seicheuchzeria-sphagnum swamps (SAUEZM, 2020). More than 1,300 people and 300 pieces of equipment, including three planes and three helicopters of the State Emergency Service of Ukraine, were involved in extinguishing the fire every day. More than 1 thousand km of mineralised lanes and roads have been created in cluttered woodlands with heavy engineering equipment of the State Emergency Service of Ukraine, the Armed Forces, and the National Guard of Ukraine (SES of Ukraine, 2021b).

The contours and spatial location of fires obtained based on remote sensing data and using the tools of the geoportal "Landscape fires of Ukraine" are shown in Figure 4.

Figure 3. Remnants of Kriva Hora after a fire in April 2020
(shooting date – April 23, 2020, photo by Denys Vyshnevskyi)

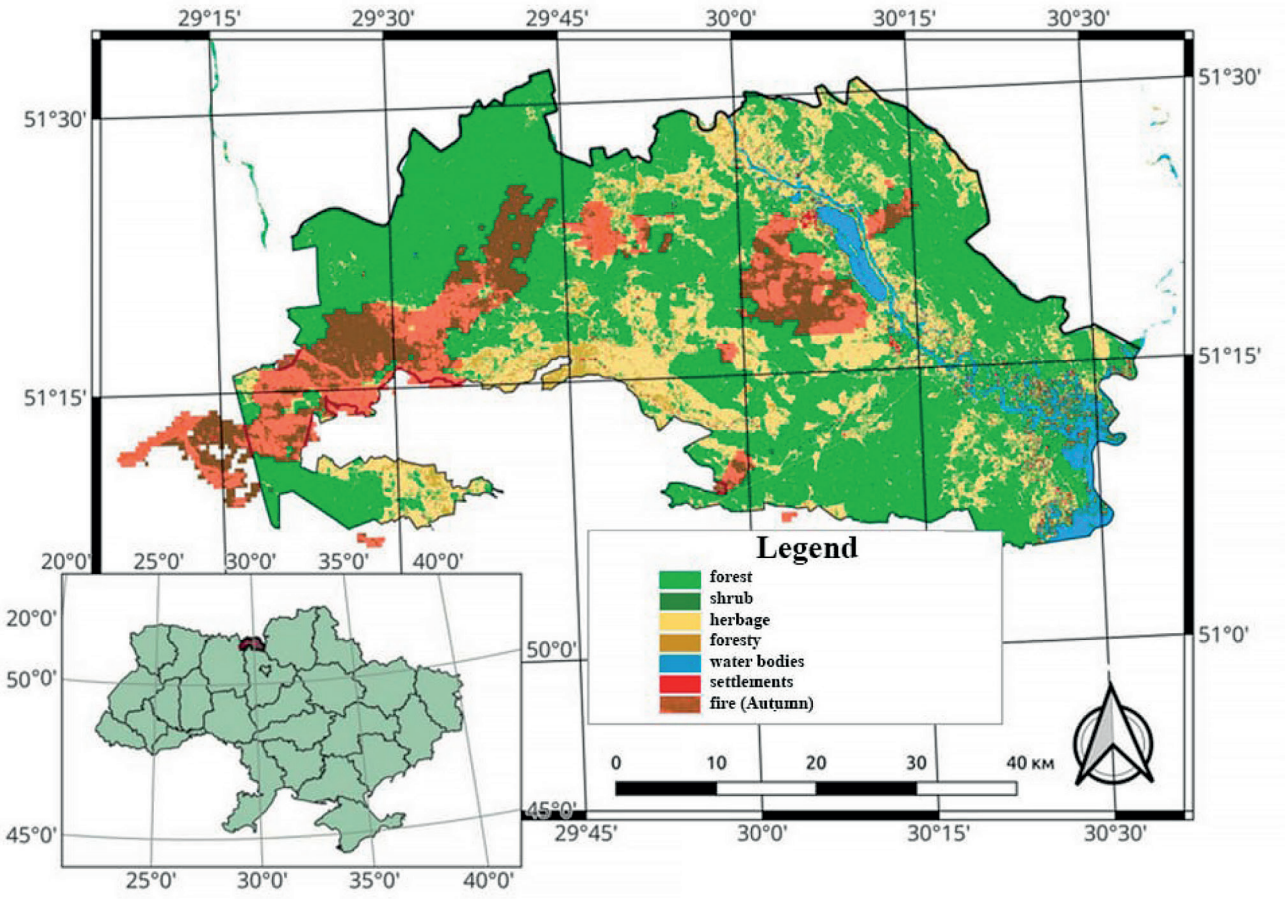

Figure 4. Fires in the territory of EZ and ZU(M)R,
which occurred in April 2020

Analysing the climate indicators obtained from the Chornobyl weather station, a long rainless period was not observed – from March 12 to April 3, 2 mm of precipitation fell, which formed high risks of fire occurrence and development (Fig. 5). In addition, on April 3-4, at the initial stage of the fire development, substantial wind gusts were observed – more than 10 $m*s^{-1}$.

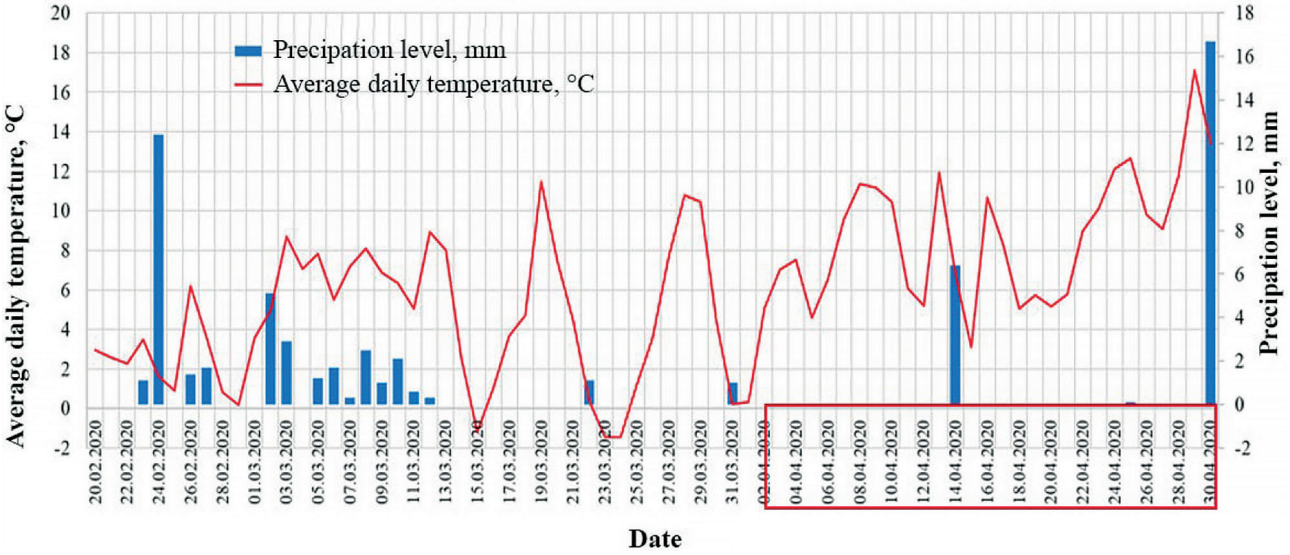

Figure 5. Dynamics of the average daily air temperature and precipitation for the analysed period (weather station of Chornobyl)

As shown in Figure 5, on April 14, 6.4 mm of precipitation fell, but this did not stop the fire, which developed until April 30, when 16.7 mm of precipitation fell.

In the Kharkiv region, on September 2, a forest fire broke out on the territory of the Dvorichansk forestry of the state enterprise "Kupiansk Lishosp" between the settlements of Hororbivka and Hrianukivka of the Dvorichansk district, which was caused by strong gusts of wind (up to 15 $m*s^{-1}$) of variable directions and quickly spread to the territory of neighbouring localities – Horobivka and Hrianukivka, which border the forest area. The weather conditions that formed during this period in the territory where the fire occurred contributed to the formation of high risks of fires and their development: almost a month without precipitation (with the exception of August 28 – 3 mm of precipitation) and an average daily air temperature of 15-25°C (Fig. 6).

As a result of the fire, 22 private households were destroyed, the gas supply to four settlements (the villages of Horobivka, Hrianukivka, Kutkivka, Kasianivka) was cut off, 52 people were evacuated, and one person was injured. More than 479 people and 78 pieces of equipment were involved in extinguishing the fire, including two fire planes, one helicopter, and two fire trains from the "Kupiansk vuzlovy" and "Osnova" railway stations. The amount of damage caused exceeds UAH 75 million (SES of Ukraine, 2021b, 2020). The fire was extinguished on September 5. The total area of the fire was 500 hectares, of which 100 hectares were covered by crown fire (Kharkiv OULMG, 2020).

In the Luhansk region, in the Novoaydar district on the territory of the Boriv and Akhtyr forest districts of the state enterprise "Sievierodonetsk LMH" on July 6, 2020, a forest fire broke out, which was caused by a strong gusty wind (up to 25 $m*s^{-1}$) of variable directions and high air temperature (+38°C) (Fig. 7), and spread to coniferous forests near the villages of Kapitanove and Voronove, and to the territory of the village of Smolianynove.

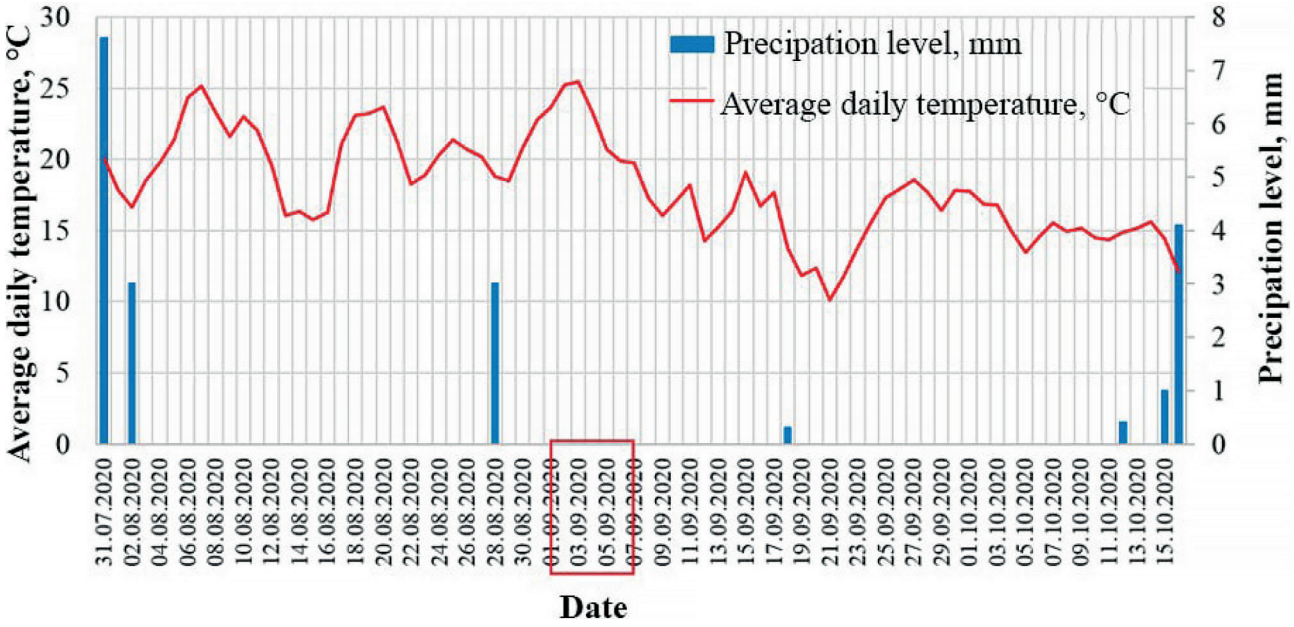

Figure 6. Dynamics of the average daily air temperature and precipitation for the analysed period (weather station of Velykyi Burluk, https://rp5.ua)

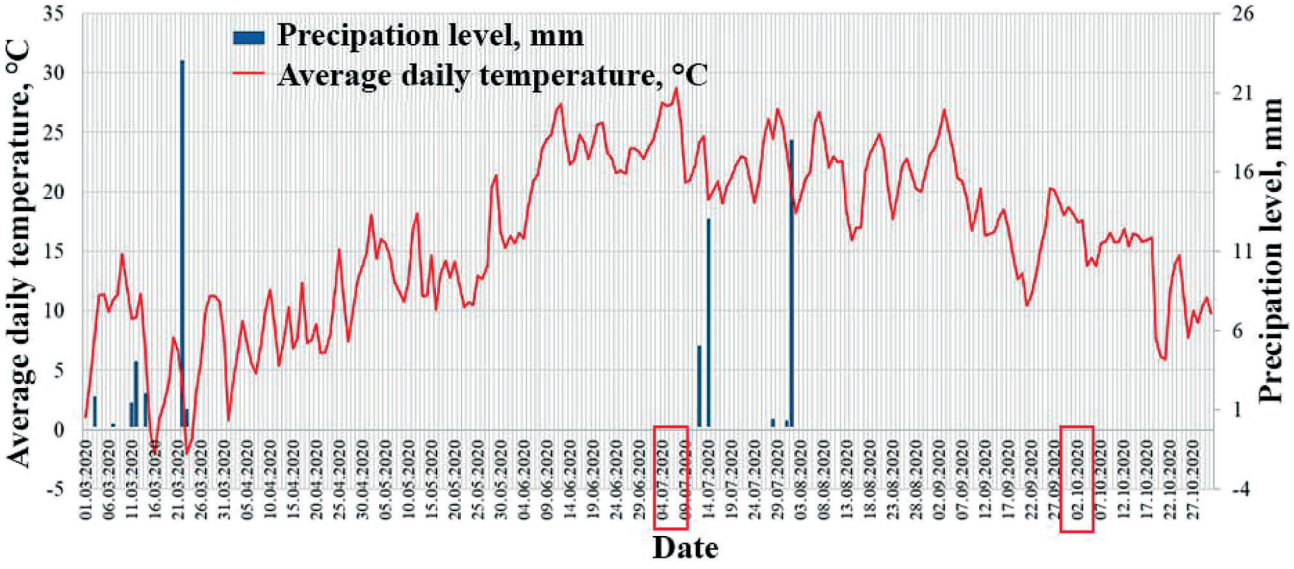

Figure 7. Dynamics of the average daily air temperature and precipitation for the analysed period (weather station of Bakhmut, https://rp5.ua)

According to official data, the total area of the fire was about 5 thousand hectares, as a result of the fire, 35 residential buildings were destroyed and 24 were damaged in the village of Smolianynove (Fig. 8), and 49 country houses in the horticultural society "Lake Vovche" of the Novoaidar district were completely destroyed (SES of Ukraine, 2021b). As a result of the emergency, five people were killed and 471 people were injured. More than 1.4 thousand people and 250 pieces of equipment, including two AN-32P aircraft, were involved in extinguishing the fire (SES of Ukraine, 2021b). According to the Luhansk Regional State Administration, the forestry sector of the region suffered damage in the amount of about 5,304 mln UAH.

Figure 8. Destruction of residential buildings in Smolianynove village as a result of a forest fire (Photo by Oleksiy Kovaliov)

After the July catastrophic fires that occurred in the Luhansk region, the second series of large fires occurred in the fall: September 30 – October 1 on the territory of Stanychno-Lugansk, Sievierodonetsk, and Novoaydar forest hunting farms of the Luhansk region, there were 146 fires in ecosystems. Due to extremely difficult weather conditions (wind with hurricane gusts up to 25 $m*s^{-1}$, long dry period), fires quickly spread to an area of more than 20 thousand hectares and became threatening to settlements. The most difficult situation was along the demarcation line in the territory of Stanichno-Lugansk, Novoaydar, and Sievierodonetsk districts, where 32 settlements were affected. According to the Luhansk regional state administration, as a result of the fire, 12 people were killed and 390 people were injured, 573 residential buildings were destroyed and 60 were damaged. 22 settlements were affected by the fire. The estimated amount of losses amounted to about UAH 12,228.375 million. More than 2.5 thousand people and more than 250 pieces of equipment, including three AN-32P fire planes and two helicopters, were involved in extinguishing the fire (SES of Ukraine, 2021a).

Based on the spatial-temporal information obtained from the geoportal "Forests of Ukraine" and remote sensing methods, the total area of forest fires was calculated, which amounted to 39.5 thousand hectares (Myroniuk et al., 2021). The spatial location of forest fires is shown in Fig. 9.

The number, size, and intensity of wildfires have increased substantially in many parts of the world in recent decades, and they are expected to continue to increase in the coming decades due to projected climate change (Moritz et al., 2012; Stephens et al., 2013). In the United States, only 1-2% of all fires are catastrophic, but they account for about 85% of the total cost of extinguishing fires and more than 95% of the total area of fires (Williams and Hyde, 2009).

A key factor contributing to the increase in the frequency and size of fires is climate, in particular, rising temperatures, uneven precipitation distribution, and longer fire-prone seasons. According to forecasts, negative changes in weather conditions in terms of fire danger should be expected in the territory of Ukraine (Balabukh et al., 2016; Shevchenko et al., 2014).

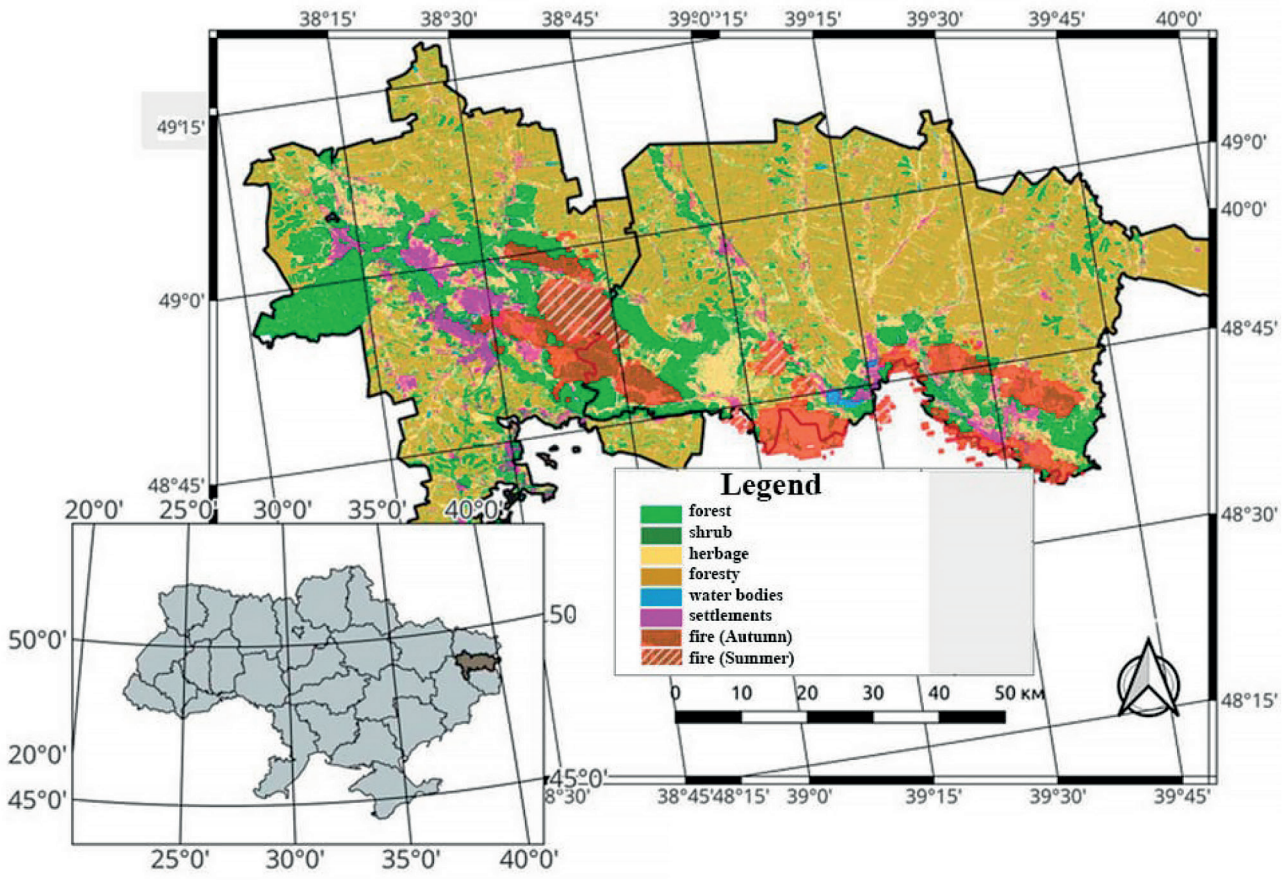

Figure 9. Fires that occurred in the Luhansk region, on the territory of the SE "Sievierodonetsk LMH", the SE "Novoaydar LMH", the SE "Stanichno-Lugansk DLMH", and the SE "Kreminsk LMH"

Fires of 2020 in Ukraine have become a new type of fire. As a result of climate change, landscape changes, and economic causes, in particular, due to a lack of adequate forestry funding, fires occur that are difficult to control. The events of 2020 showed that the current system is not ready to effectively resist large forest fires. The State Emergency Service of Ukraine is best equipped with fire equipment, but the protection of forests from fires and extinguishing at an early stage is provided by foresters who directly depend on economic activities, that is, the material support and resource potential of each enterprise are different – less in low-forest areas and more in areas with a large share of forests, in particular, operational forests. Currently, forestry enterprises are experiencing a shortage of funding for the protection of forests from fires, so they are limited in implementing proactive measures and responding with modern technologies. Only economically developed forestry enterprises are able to install video surveillance systems for detecting fires and forming mobile teams for early response to fires. The vast majority of forest fire stations today are equipped with vehicles from the 1980s and 1990s (mostly GAZ and ZIL brands). In modern conditions, one of the main stages of successful fire control is the use of fire modules that provide the fastest possible response and with which the fire at an early stage can be effectively resisted (Soshenskyi et al., 2021). In the system of forest protection from fires should use both light fire modules and large fire trucks (tank trucks). In conditions of high fire danger of the weather and high risks of fire development, it is necessary to launch an aggressive attack, when the maximum amount of equipment is used in the shortest possible time. It is important not only to

update the equipment but also to replace outdated hand tools with new modern ones, to use forestry methods to increase the fire resistance of forests and to learn how to use controlled fire technologies that can prevent large-scale fires in the future.

The number and area of fires in open landscapes are much larger than in forests, and they are often the cause of large forest fires. In fact, there is no system of fire protection of agricultural land, and land users are not interested in protecting land from fires. As a rule, in such areas, fires are extinguished by units of the state emergency service of Ukraine.

Conclusions

Analysis of the dynamics of forest fires over a long period of time indicates an increase in the frequency of large fires in the territory of Ukraine. Forest fires in 2020, which occurred in Zhytomyr, Kyiv, Kharkiv, and Luhansk regions and led to substantial economic, environmental, and social consequences, destruction of residential buildings, infrastructure, and human casualties, indicate that the current system is not ready to withstand large fires. Given the new climatic conditions, changes in society and land use, it is necessary to develop a new National Fire Management System and take urgent legislative, organisational, scientific, and educational measures at the state level. One of the main elements of effective fire management is the management of combustible materials, in particular, the use of controlled firing to reduce the risk of fires. The forest fire management system needs to be substantially updated and improved, considering the current and future scenarios of fire danger. The very diverse and complex causes of fires indicate the need to consider not only natural fire and weather hazards but also the social and cultural aspects of the population.

References

[1] Balabukh, V. O., & Zibtsev, S. V. (2016). Climate change impact on number and area of forest fires in northern Black sea region. *Ukrainian Hydrometeorological Journal*, 18, 60-71 [in Ukrainian].

[2] Crutzen, P. J., & Goldammer, J. G. (1993). *Fire in the environment: the ecological, atmospheric, and climatic importance of vegetation fires: report of the Dahlem Workshop, held in Berlin, 15-20 March 1992*. Chichester, England; New York: Wiley.

[3] Dowdy, A. J., Ye, H., Pepler, A., et al. (2019). Future changes in extreme weather and pyroconvection risk factors for Australian wildfires. *Sci Rep 9*, 10073. doi:10.1038/s41598-019-46362-x

[4] FAO. (2005). *Global Forest Assessment 2005 – Global Fire Management Assessment*. GFMC and the Food and Agriculture Organization of the United Nations (FAO). Available at https://gfmc.online/programmes/un/fao /fao_5.html.

[5] FAO. (2006). *Global Forest Resources Assessment 2005*. Main Report. Progress Towards Sustainable Forest Management FAO Forestry paper 147, Rome. Available at http://www.fao.org/3/a0400e/a0400e00.htm.

[6] FAO. (2015). *Global Forest Resources Assessment 2015*. Desk reference. Rome: FAO forestry paper. Available at http://www.fao.org/3/a-i4808e.pdf.

[7] GFMC. (2007). Wildfire 2007 – 4th International Wildland Fire Conference. Available at https://gfmc.online/iwfc/sevilla-2007.html.

[8] Goldammer, J. G. (2021). Thirty Years International Wildland Fire Conferences: Review and Achievements of a Circumglobal Journey from Boston to Campo Grande. *Biodiversidade Brasileira*, 11 (2), 6–52.

[9] Kharkiv OULMG. (2020). Website of the Kharkiv Regional Department of Forestry and Hunting. Available at https://bit.ly/3Aanvfx.

[10] Levine, JS. (Ed.) (1996). *Biomass burning and global change* (Vol. I). The MIT Press, Massachusetts Institute of Technology, Cambridge.

[11] Moritz, M.A., Parisien, M.-A., Batllori, E., Krawchuk, M.A., Van Dorn, J., Ganz, D.J., & Hayhoe, K. (2012). Climate change and disruptions to global fire activity. *Ecosphere*, 3 (6), 49. doi: 10.1890/ES11-00345.1

[12] Morris, A. (2020). The bushfires in Australia and housing. *Housing Finance International, XXXIV* (3). Available at https://www.housingfinance.org/ housing-finance-international/archive/?y=2020.

[13] Myroniuk, V., Soshenskyi, O., & Gumeniuk V. (2021). *Methodology for mapping fire intensity and soil burn severity*. Project USAID "Economical support of Eastern Ukraine".
[14] Nolan, R., Boer, M., Collins, L., de Dios, R. Clarke, H., Jenkins, M., Kenny, B., & Bradstock, R. A. (2020). Causes and consequences of eastern Australia's 2019–20 season of mega-fires. *Global Change Biology*, 26, 1039–1041. https://doi.org/10.1111/gcb.14987.
[15] NUBIP of Ukraine. (2020). Research report. Scientific and methodological support for the creation of geoportal for risk assessment, forecasting and prevention of Wildfire in the Polissya of Ukraine. Ministry of Education and Science of Ukraine. State registration number: 0118U000312 [in Ukrainian].
[16] Salisbury, H. (1989). *The Great Black Dragon Fir*e. A Chinese inferno. Little, Brown and Company. Boston.
[17] San-Miguel-Ayanz, J., Durrant, T., Boca, R., Maianti, P., Libertá, G., Artés Vivancos, T., … & Leray, T. (2020). *Forest Fires in Europe, Middle East and North Africa 2019*. Publications Office of the European Union, Luxembourg, 2020. doi: 10.2760/893
[18] San-Miguel-Ayanz, J., Durrant, T., Boca, R., Maianti, P., Libertá, G., Artés-Vivancos, T., … & Onida, M. (2021). *Advance EFFIS Report on Forest Fires in Europe, Middle East and North Africa 2020*. Publications Office of the European Union, Luxembourg, 2021. doi: 10.2760/344684
[19] San-Miguel-Ayanz, Jesús, Durrant, Tracy, & Boca, Roberto, et al. (2019). Forest Fires in Europe, Middle East and North Africa 2018. *EUR 29856 EN*. doi: 10.2760/1128
[20] SAUEZM. (2020). Report of the commission on the assessment of the consequences of the fire in the ecosystems of the Chernobyl Radiation and Ecological Biosphere Reserve during April 2020. State Agency of Ukraine on Exclusion Zone Management. The Chernobyl Radiation and Ecological Biosphere Reserve [in Ukrainian].
[21] SAUEZM. (2021). The public report of the State Agency of Ukraine on Exclusion Zone Management on the activities in 2020. Available at https://dazv.gov.ua/images/materials/2021/02.17-anons/zvit2020.pdf [in Ukrainian].
[22] SES of Ukraine. (2020). Dvorichansky region: large forest fire suppression is being. State Emergency Service of Ukraine in Kharkiv Oblast (Region). Available at https://kh.dsns.gov.ua/ua/Nadzvichayni-podiyi/14725.html [in Ukrainian].
[23] SES of Ukraine. (2021a). Analytical information on the emergencies in Ukraine in 2020. State Emergency Service of Ukraine. Available at https://www.dsns.gov.ua/ua/Dovidka-za-kvartal/119288.html [in Ukrainian].
[24] SES of Ukraine. (2021b). Report on the main results of the State Emergency Service of Ukraine in 2020. Available at https://bit.ly/2VCPp55 [in Ukrainian].
[25] Shevchenko, O., Vlasiuk, O., Stavchuk, I., Vakoliuk, M., Illiash, O., & Rozhkova, A. (2014). *Climate Vulnerability Assessment: Ukraine. Climate Forum East (CFE)*. Working Group on Climate Change Civic Organizations. Myflaer. Kyiv. Available at: https://climateforumeast.org/uploads/other/0/708.pdf [in Ukrainian].
[26] Soshenskyi, O., Zibtsev, S., Gumeniuk, V., Goldammer, J. G., Vasylyshyn, R., & Blyshchyk, V. (2021). The current landscape fire management in Ukraine and strategy for its improvement. *Environmental & Socio-economic Studies*, 9 (2), 39–51.doi: 10.2478/environ-2021-0009
[27] Steil, L. (2020). 7th International Wildland Fire Conference. *BioBrasil, 1. Special Issue*. doi: 10.37002/biobrasil.v10i1.1612
[28] Stephens, S. L., et al. (2013). Managing forests and fire in changing climates. *Science*, 342, 41–42. doi: 10.1126/science.1240294
[29] Tedim, F., Xanthopoulos G., & Leone V. (2015). Chapter 5 – Forest Fires in Europe: Facts and Challenges. *Wildfire Hazards, Risks and Disasters*, 77–99.

[30] U.S. Forest Service. (1990). International Wildland Fire Conference: "Meeting Global Wildland Fire Challenges: The People. The Land. The Resources". July 23–26, 1989, Boston, Massachusetts, USA. Available at https://gfmc.online/wp-content/uploads/First-Int-Wildland-Fire-Conference-Boston-1989-Proceedings.pdf.

[31] Wikipedia. (2020). Carr Fire. In Wikipedia, The Free Encyclopedia. Wikipedia contributors. Available at https://en.wikipedia.org/w/index.php?title=Carr_ Fire&oldid=936156109.

[32] Williams, J. (2013). Exploring the Onset of High-Impact Mega-Fires through a Forest Land Management Prism. *Forest Ecology and Management*, 294, 4–10. doi: 10.1016/j.foreco.2012.06.030

[33] Williams, J. A., et al. (2010). *Findings and Implications from a Coarse-Scale Global Assessment of Recent Selected Mega-Fires*. FAO. Available at https://www.preventionweb.net/publications/view/20529.

[34] Williams, J., & Hyde, A. (2009). The mega-fire phenomenon: observations from a coarse-scale assessment with implications for foresters, land managers, and policy-makers. In *Proceedings of the Society of American Foresters 89th National Convention, Orlando, FL (September 30–October 4, 2009)*. Society of American Foresters, Bethesda, MD.

[35] Williams, J., Albright, D., Hoffmann, A., et al. (2011). Findings and implications from a coarse-scale global assessment of recent selected mega-fires. In *5th International Wildland Fire Conference. Sun city, South Africa, 9-13 may 2011*. 19 p. Available at http://foris.fao.org/static/pdf/fm/5thIWFConference2011.pdf

[36] Zibtsev, S. V., Soshenskyi, O. M., Myroniuk, V. V., & Gumeniuk, V. V. (2020). Wildfire in Ukraine: an overview of fires and fire management system. *Ukrainian Journal of Forest and Wood Science*, 11 (2), 15–31 [in Ukrainian]. doi: 10.31548/forest2020.02.015

[37] Zibtsev, S., & Goldammer, J. G. (2019). Challenges in managing landscape fires in Eastern Europe. *Fire Management Today*, 77 (1), 48–61.

[38] Zibtsev, S., Soshenskyi, O., Gumeniuk, V., & Koren, V. (2019). Long-term dynamics of forest fires in Ukraine. *Ukrainian Journal of Forest and Wood Science*, 10 (3), 27–40 [in Ukrainian]. doi: 10.31548/forest2019.03.027

[39] Zibtsev, S., Soshenskyi, O., Myroniuk V., & Gumeniuk, V. (2019). Monitoring of landscape fires of the Cross-border Ramsar Territory "Olmany-Perebrody" according to remote sensing. *Forestry and agroforestry*, 134, 88–95 [in Ukrainian].

Наслідки катастрофічних ландшафтних пожеж в Україні для лісових екосистем та населення

Олександр Михайлович Сошенський, Сергій Вікторович Зібцев, Андрій Юрійович Терентьєв, Олександр Геннадійович Воротинський

Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна

Анотація. Згідно з останніми дослідженнями та публікаціями міжнародних організацій, з кінця XX ст. у світі збільшується кількість і частота катастрофічних лісових пожеж, які призводять до великих економічних та екологічних втрат, людських жертв. За прогнозами, на території України слід очікувати негативних змін погодних умов, з погляду пожежної небезпеки: підвищення температури повітря, зміщення сезонів, зростання тривалості вегетаційного і пожежонебезпечного періодів, зростання повторюваності та інтенсивності хвиль тепла та стихійних гідрометеорологічних явищ, зміну водних ресурсів місцевого стоку. В 2020 році на території України відбулося кілька катастрофічних пожеж у природних ландшафтах різних регіонів. Серед найбільших і найкатастрофічніших, які призвели до людських жертв, значних економічних, екологічних та соціальних наслідків, – пожежі в Житомирській, Луганській, Харківській і Київській областях. Основною передумовою таких великих пожеж були погодні умови, а саме тривалий період без опадів, висока температура повітря та пориви вітру 15–25 м/с. В Україні існує два основні критичні періоди, з погляду частоти та небезпеки виникнення лісових пожеж: перший – весняний, після сходження снігового покриву й до утворення нової зелені; другий – наприкінці літа – у першій половині осені, коли з'являються сухі горючі матеріали на сільськогосподарських угіддях, а люди спалюють рослинні рештки на полях. Події 2020 р. засвідчили неготовність чинної системи ефективно протистояти великим лісовим пожежам та потребу в її постійному удосконаленні відповідно до нових викликів. У статті на основі доступної офіційної інформації, даних, отриманих за допомогою ДЗЗ та з геопорталу «Ландшафтні пожежі України» (wildfires.org.ua) подано інформацію про найбільш катастрофічні пожежі, які трапилися в природних ландшафтах України у 2020 р. Розглянуто компоненти системи охорони природних ландшафтів від пожеж, виокремлено основні недоліки та сформульовано ключові рекомендації з її удосконалення

Ключові слова: лісові пожежі, надзвичайні ситуації, погодні умови, зміни клімату, збитки, людські жертви