

FOREST FIRES AND CLIMATE CHANGES IN THE REPUBLIC OF SERBIA

Jelena Lazarevic¹, Nikola Vukojevic², Jovica Milicevic³

¹ University of Defence in Belgrade, Military Academy, Veljka Lukica-Kurjaka 33,
Belgrade, Republic of Serbia, jcrvenkov@gmail.com

² University of Defence in Belgrade, Military Academy, Veljka Lukica-Kurjaka 33,
Belgrade, Republic of Serbia, nikola_vukojevic@ymail.com

³ University of Defence in Belgrade, Military Academy, Veljka Lukica-Kurjaka 33,
Belgrade, Republic of Serbia, jovicamilicevic74@gmail.com

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Abstract: Nowadays, natural disasters represent an increasingly serious problem for humanity. The consequences, after their occurrence, are reflected in human losses, material and non-material damage. Forest fires, as natural disasters, represent the most extreme form of forest devastation, and lead to its complete destruction. In all regions of the world, changes in the regime of air temperature and precipitation were observed, as well as significant variability and changes in other climatic elements. The occurrence of forest fires depends on a number of factors, and one of them is the weather, the state of humidity and the amount of combustible plant material, as well as human activities. The connection between climate change and the increasing number of forest fires is obvious.

Forest ecosystems are exposed to the adverse effects of climate change, they are a significant carbon reservoir and an important potential for mitigating global warming, which is why they require a special management method that includes protection, improvement of the existing condition and establishment of new forests.

Protecting forests from forest fires, especially in extreme climatic conditions suitable for the occurrence of fires, is one of the most important goals of the entire society, considering the importance and functions of the forest.

Key words: natural disasters, forest fire, climate change, risk management

1. INTRODUCTION

Forests are a resource of incalculable importance for life, they play a key role in oxygen production and air purification, they mitigate the effects of climate change. In addition to ecological, forests also have economic and social importance. However, despite the fact that forests represent the lungs of our planet, man contributes to the degradation and disappearance of this resource with his daily activities.

Serbia is considered a medium-wooded country. According to the data of the Republic Institute of Statistics from 2020, as many as 2,261,386 ha are under forest, i.e. 29% of the total territory of the Republic of Serbia (without data for AP KiM).

In the first part of the work, the basic concepts of forest fires and a short research on forest fires that occurred in the Republic of Serbia in the period from 2012 to 2021 were analyzed. The research was conducted by analyzing the data of the Republic Institute of Statistics, ie Forestry Statistics. In the second part of the paper, an overview of the impact of climate change in the world and its basic characteristics on the territory of the Republic of Serbia is given. The third part connects the previous two units and presents an analysis of the obtained data and indicates the negative impact of climate change on forest fires. At the end, preventive measures to protect against forest fires were given.

2. FOREST FIRES

According to the Law on Fire Protection, a fire is defined as a process of uncontrolled combustion that endangers the life and health of people, material goods and the environment. A forest fire is an uncontrolled, spontaneous movement of fire across the forest surface and represents one of the most destructive natural forces (Aleksic & Jancic, 2011).

If we look at the place where the forest fire developed, we distinguish three types of fires, underground, ground and crown fires (crown/high). Forest underground fires are fires that take place without flames, which most often occur in dry underground deposits of peat. Progress is slow, they are difficult to detect and can quickly turn into an open surface fire. Ground fires are the most common type of forest fires, especially in deciduous forests. In the case of ground fires, the fire most often affects dry grass, bushes and dry trees. High fires are usually accompanied by strong winds, they spread quickly, because the fire quickly moves from one tree canopy to another and is difficult to extinguish. Most often, a ground fire is an integral part of a high fire, and burning tree tops without a ground fire is rare. High fires most often occur in the summer, when drought and strong winds can completely destroy affected trees (Aleksic & Jancic, 2011).

Damage from forest fires occurs in the entire ecosystem (plants, animals, soil). After a fire, we very often note the escalation of other destructive factors, such as the proliferation of insects and plant diseases, which further destabilize burned and unburned areas, thereby increasing the area without forest, and the reduction of areas under forest increases the risk of torrential flows in mountainous areas and floods in the lowlands, microclimatic changes, etc.

The consequences of forest fires are economic and ecological. Economic damages include fire extinguishing, reclamation and restoration of the destroyed forest. Environmental damage manifests itself over many years, and the damage that occurs after a fire is incalculable. In the world, it is a practice to calculate them as five or ten times the value of direct damages (Aleksic et al., 2011).

2.1. Forest fires in the Republic of Serbia

The analysis of statistical data on forest fires shows that the frequency of fires, as well as the total burnt area, increases from year to year. The increase in fire hazards and damage can be linked to climate change. Considering the climate scenarios that predict an increase in average temperatures of 4-6°C by the end of this century, a decrease in the total amount of precipitation and its uneven distribution during the year with long periods of drought during the summer, an additional increase in the frequency and burned areas in the territory of Serbia can be expected (Assessment of the risk of disasters in the Republic of Serbia, 2017).

Forest fires occur throughout the year, but three critical periods can be distinguished in our country: March - April, July - August and October - November. It is believed that about 95% of fires are caused by humans due to their own activities (negligence, inattention, and even deliberate burning), so that the daily rhythm of forest fires coincides with the daily activity of humans.

Table 1: The total number of forest fires by origin in the state forests of the Republic of Serbia in the period from 2012 to 2021 (Source: Authors)

Year	Place of origin		In total
	Down to earth	Tall	
2012	211	71	282
2013	37	6	43
2014	9	3	12
2015	38	9	47
2016	29	1	30
2017	59	10	69
2018	11	174	185
2019	32	9	41
2020	23	3	26
2021	29	5	34
In total	478	291	769
Annual average	48	29	77
%	62,16	37,84	100,00

Based on the available data of the Republic Institute of Statistics, in the period from 2012 to 2021, 769 fires occurred in state forests (table 1). In the total number of fires in state forests, ground fires account for 62.16% and tall fires for 37.84%. The highest number of fires was recorded in 2012, when 282 cases of forest fires were recorded. In the same year, the highest number of ground forest fires occurred on an annual basis in the observed period (211 cases). The lowest number of fires occurred in 2014, when only 12 cases of fires were recorded, of which 9 were ground fires and 3 high fires. The largest number of high fires occurred in 2018, as many as 174 cases.

Table 2: Total burned area and damaged wood mass (m³) in the forests of the Republic of Serbia in the period from 2012 to 2021 (Source: Authors)

Year	Burned surface (ha)	Damaged wood mass (m ³)	Number of fires
2012	7.460	63.118	282
2013	561	7.343	43
2014	284	10.256	12
2015	827	5.059	47
2016	296	37.114	30
2017	1002	11.415	69
2018	303	707	185
2019	1.079	3.397	41
2020	196	5.147	26

Year	Burned surface (ha)	Damaged wood mass (m ³)	Number of fires
2021	834	10.099	34
In total	12.842	153.655	769
Annual average	1284	15.366	77

In order to adequately assess the damage caused as a result of forest fires in the observed period, it is necessary to take into account the data on the total area of the land that was affected by the fire (burnt area) as well as the total damaged volume of wood mass (table 2).

The total burned area in the forests of the Republic of Serbia in the period from 2012 to 2021 was 12,842 ha. The smallest burned area in the relevant period was recorded in 2020 and was 196 ha. The largest burned area is 7,460 ha and was recorded in 2012. The second significant year in terms of burned area is 2019, in which 41 fires engulfed as much as 1,079 ha of forest land and forests. The biggest difference between the number of fires and the burned surface area was observed in 2018, when 185 recorded fires caused damage to 303 ha of surface area.

The total volume of damaged timber in the state forests of Serbia in the period from 2012 to 2021 was 153,655 m³. The smallest damaged volume of wood mass in the observed period was recorded in 2018. The most damaged volume of wood mass was recorded in 2012, when 63,118 m³ of wood mass was destroyed.

3. CLIMATE CHANGES

The Intergovernmental Panel on Climate Change – IPCC defines climate change as the greatest global environmental problem of modern civilization which, if appropriate and urgent measures are not taken, may result in a further increase in air temperature between 1.4°C and 5.8°C by the end of the 21st century compared to 1990. year.

According to reports from 2007, it is stated that there has been an increase in the global average temperature, as well as that the impact of climate change will increase in the coming period, which will increase the number of extreme weather events. Various products of human work that have led to an increase in the concentration of certain gases in the atmosphere result in the appearance of the greenhouse effect and lead to an increase in the average annual temperature at the global level (Contribution of Working Group II to the Fourth Assessment Report of the IPCC).

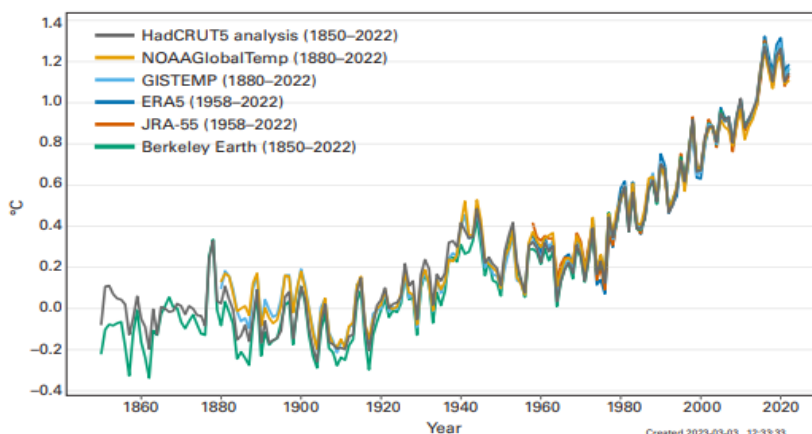


Figure 1. The global mean temperature
Source: WMO – State of the Global Climate 2022

The global mean temperature in 2022 was 1.15 [1.02 to 1.28] °C above the pre-industrial period (1850-1900). The six datasets used by WMO in the analysis are shown in figure 1 and place 2022 as the fifth or sixth warmest year globally (WMO, 2023).

According to the report of the World Meteorological Organization – WMO from 2022, the concentrations of the three main greenhouse gases (carbon dioxide, methane and nitrogen oxide) reached record values in 2021. Real-time data from specific locations shows that levels of the three gases will continue to increase in the future.

The climate of Serbia can be described as moderate-continental with more or less pronounced local characteristics. Spatial distribution of climate parameters is determined by geographical location, relief and local influence, as a result of a combination of relief, air pressure distribution on a larger scale, terrain exposure, presence of river systems, vegetation, urbanization, etc (RHMZ Republic of Serbia).

3.1. Temperature and precipitation regime in Serbia

The temperature regime as a measure of thermal conditions in the territory of Serbia is primarily conditioned by solar radiation, geographical position and relief. Also, depending on the relief and exposure of the slopes, we have local climate characteristics everywhere in our country RHMZ Republic of Serbia).

The Republic Hydrometeorological Institute of Serbia announced on 18.01.2023. annual newsletter for Reublica Serbia for 2022. According to him, the year 2022, with an average air temperature of 12.1°C, is the second warmest year (Figure 2) in the period from 1951 to the present day.

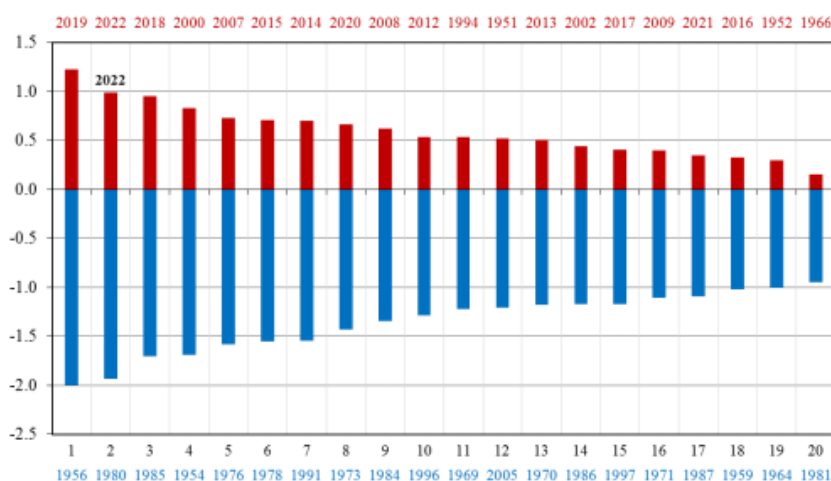


Figure 2. Ranking of the warmest and coldest years in the Republic of Serbia
Source: RHMZ of Serbia - Annual bulletin for Serbia for the year 2022

The annual temperature after 1980 tends to increase, that is, positive deviations in temperature are more frequent and their intensity increases. The last 10 years are ranked among the 15 warmest years (figure 2).

The highest daily air temperature during 2022 was measured on July 23 in Smederevska Palanka and was 40.6°C. In Negotin and Sombor, 2022 is the warmest year since the beginning of measurements at those stations. In most of Serbia, 40 to 70 tropical days were recorded, which is 5 to 26 tropical days more than the average number for the reference period 1991-2020. 40 tropical nights were registered in Belgrade, 14 nights more than the average.

According to the analysis of the summer season of 2022 for Serbia, the summer of 2022 is the third hottest summer in Serbia for the period of meteorological measurements from 1951 to 2022, and the hottest was in 2012 (RHMZ Republic of Serbia).

Precipitation is one of the most important climatic elements. Due to the atmospheric processes and features of the relief, precipitation is irregularly distributed in time and space on the territory of Serbia. The normal annual amount of precipitation for the whole country is 896 mm. Annual amounts of precipitation on average increase with altitude.



Figure 3: Normalized deviations of annual volumes. precipitation in Serbia period from 1950 to 2015

Source: RHMZ of Serbia

Looking at Figure 3, we can conclude that in the period from 1950 to 1981 in the Republic of Serbia, in most cases, the annual amount of precipitation is in accordance with the average or within normal limits. Exceptions were the rainy years 1954, 1955, and 1970, while 1953 and 1961 were moderately dry. After 1981, there are negative deviations, more precisely, the intensity of droughts increased. 1990, 1993 stand out as very dry years on an annual level and 2000 with an extremely severe drought. The years 2001, 2004 and 2005 stand out as rainy years in Serbia, while 2014 is presented as extremely rainy (Popovic et al., 2005).

According to the annual bulletin for the year 2022, in most of Serbia, the annual amount of precipitation was within the limits of the average, and in the west and in the part of eastern Serbia below the average. In Valjevo, 2022 is the second driest year, and in Pozega the fourth driest in the past 97 years (RHMZ Republic of Serbia).

4. NEGATIVE INFLUENCE OF CLIMATE CHANGES ON FOREST FIRES

In the Republic of Serbia, forest fires are among the most frequent natural disasters. It has already been noted that the intensity and duration of the drought has increased, as a result of the increase in temperature, the decrease in summer precipitation and a greater number of longer dry periods, which favor the occurrence and development of forest fires and represent a constant threat to the loss of forests and forest land (Zivkovic, 2018).

According to the statistical data of the Republic Institute for Statistics in state forests, in the period 2012-2021. in Serbia, 769 forest fires were registered in state forests, on an area of 12,842 ha.

From the attached pictures and tables in the previous chapters, it can be seen that the largest number of fires were registered in 2012 and 2018, as well as that 2018 is the third warmest year for the period of meteorological measurements from 1951 to 2022 (Figure 2). And if the year 2012 is "only" in tenth place, it is even more characteristic that the summer of 2012 was declared the hottest summer in the Republic of Serbia for the period of meteorological measurements from 1951 to 2022. The lowest number of forest fires was recorded in 2014, only 12, and according to the data of RHMZ of Serbia, 2014 was the rainiest year in the period from 1951 to the present day (Figure 3).

From the aforementioned analysis, it is clearly observed that changes in the thermal and precipitation regime have a great influence on the occurrence of forest fires.

5. PREVENTION OF FOREST FIRES

The basic tasks of forest fire protection are: forecasting the danger of fire, early detection of fires and their rapid localization and extinguishing.

Various researches have come to the conclusion that humans are the most common cause of fires, so effective measures to prevent fires would be raising the level of public awareness of the ecological, economic, social and cultural importance of forests, appealing to the increased risk of forest fires, placing prohibition signs and signs warnings at approaches to the forest, next to roads, picnic areas, tourist facilities;

The guard service should control the potential causers of forest fires, that is, farmers who burn stubble after harvest, weeds and other plant material, owners of weekend facilities, collectors of forest fruits, medicinal plants and mushrooms, hikers, visitors;

A forest fire can break out in very inaccessible terrain, it is difficult to spot it in time, report it and start extinguishing it. It is very important to quickly detect the occurrence of a fire, and it can be ensured by monitoring endangered forests and by introducing on-calls in critical periods of forest fires. After detection, it is necessary to ensure a quick response, i.e. extinguishing forest fires. A developed road network is needed, especially according to the areas that are most at risk, mobility and equipment of teams for quickly extinguishing forest fires, organized water intakes and water accumulations, maintenance and arrangement of water sources in forests with the obligation to preserve habitats with water sources; training and improvement of workers in the field of forest fire protection.

6. CONCLUSION

If we look at the causes of forest fires, we will easily conclude that prevention is key. In most cases, man is considered the main "culprit", through his direct action due to carelessness and negligence or indirectly through negative impact on the atmosphere and climate change..

A forest fire is an uncontrolled, spontaneous movement of fire across the forest surface and represents one of the most destructive natural forces. In our country, outdoor fires are one of the most frequent natural disasters. Depending on the type of fire, the form and speed of its spread, the configuration of the terrain on which it occurs and the existing climatic conditions, the type of fire varies, as well as the amount of damage it can cause.

The analysis of meteorological data indicates that the annual temperature has been continuously increasing in recent years and decades, and that there are oscillations in precipitation with more frequent occurrence of deficits. These two most important climate elements show that we are greatly witnessing climate change and that the increase in global temperature is becoming an increasingly serious problem.

It seems that forest fires will become a common occurrence for most countries in the future. Accordingly, it is necessary to strengthen resilience at the national level, enable integrated disaster risk management, but also ensure a sufficient number of resources and means to fight emergency situations of this nature.

In the Republic of Serbia, the reform of the management system in emergency situations began in 2009, when the Department for Emergency Situations was formed, and it needs to be continued. It would be of great importance to continuously educate the widest population, through educational activities, information about dangers and their consequences. Also, the tightening of legal regulations would certainly affect the awareness of citizens and further reduce the risks of fire.

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