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COMPARATIVE ANALYSIS OF DETECTED FIRES IN THE REPUBLIC OF SERBIA AND NEIGHBOURING COUNTRIES (2012–2024)

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Abstract: This study aims to provide an overview of fire occurrences in the Republic of Serbia over the past twelve years and to compare these findings with those from neighbouring countries. The analysis is based on data obtained from the online platform Global Forest Watch, sourced from Copernicus Sentinel-2 and processed by the European Space Agency (ESA). In comparison with the selected neighbouring countries, Serbia demonstrates moderate to slightly above-average values in terms of the annual number of fires, the total number of fires, and fire density per square kilometre. A significant proportion of the fires detected by satellite imagery are associated with agricultural areas. The period with the highest number of fire events is the fourth quarter of the year, which numerous sources attribute to the burning of agricultural residues following the harvest. Beyond providing numerical indicators of the fire situation in Serbia, this study also serves as a foundation for more detailed analyses that may inform strategies for the prevention and mitigation of fire spread into forests and forest land.

Keywords: fires, satellite fire detection, forest fires, fire occurrence density

КОМПАРАТИВНА АНАЛИЗА ДЕТЕКТОВАНИХ ПОЖАРА У РЕПУБЛИЦИ СРБИЈИ И ЗЕМЉАМА ОКРУЖЕЊА У ПЕРИОДУ 2012-2024. ГОДИНА

Izvod: Овај рад има за циљ да пружи приказ појаве пожара у претходних 12 година у Републици Србији као и да уради поређење са земљама окружења. У раду су коришћени подаци доступни на online платформи Global Forest Watch. Извор података добијен је од стране Copernicus Sentinel-2, а подаци сајта су обрађени од стране Европске Свемирске Агенције (European space agency ESA). У поређењу са земљама окружења за које су подаци обрађени Република Србија по броју пожара на нивоу године, укупном броју пожара као и густини пожара по km^2 има средње вредности или вредности које су мало изнад просека. Велики број пожара који је евидентиран путем сателита везује се углавном за пољопривредне површине, а период настанка пожара са највећим бројем пожара је четврти квартал што бројни извори потврђују и везују за паљење пољопривредних површина након жетве. Овај рад осим што пружа нумеричке показатеље стања у Републици Србији служи и као основ за

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детаљнију анализу која може да има утицаја на превенцију и ширење пожара на шуме и шумско земљиште.

Кључне речи: пожари, сателитска детекција пожара, шумски пожари, густина пожара

1. INTRODUCTION

The Forest Law of the Republic of Serbia (Article 47) strictly prohibits the ignition of open fires within forests or on land situated less than 200 meters from the forest boundary (*Official Gazette of the Republic of Serbia*, Nos. 30/2010, 93/2012, 89/2015, and 95/2018). Predicting fire spread represents a critical task for fire management and mitigation, with satellite-derived data being an up-and-coming source of information for these purposes (Shadrin et al., 2024).

In the Republic of Serbia, forest fires are recognised as one of the most severe disturbances to forest ecosystems and the most significant challenges to sustainable forest management practices (Brovkina et al., 2019). In order to deepen the understanding of both the causes and the potential consequences of fire events, this study conducts an analysis of data spanning the period from 2012 to 2024, sourced from the *Global Forest Watch* platform.

By examining the current situation through data analysis, the underlying causes of fires can be better understood, enabling adjustments to forest management practices to help prevent fires. Forest trees absorb atmospheric carbon dioxide (CO₂) and store it within living biomass, dead organic matter, and soils, thereby substantially contributing to the mitigation of climate change (Osman et al., 2023).

The devastating scale of forest fires is exemplified by the massive wildfire event in eastern Siberia, where approximately 22 million hectares of forested land were lost, as reported by the California Institute of Technology. Given the above, it is crucial to monitor fire events that can threaten forests or lead to large-scale destruction of forested areas.

2. MATERIAL AND METHODS

This study analyses data on fire occurrences in the Republic of Serbia for the period 2012–2024, obtained from the *Global Forest Watch* platform. The dataset includes nine countries Bosnia and Herzegovina, Bulgaria, Montenegro, Croatia, the Czech Republic, Hungary, Romania, Slovenia, and the Republic of Serbia and incorporates only those records with a high confidence level (>80% CI).

All data were consolidated into a single file and subsequently analysed to identify extreme values, fire occurrence frequency, and the locations of fires that could potentially threaten forested areas in the Republic of Serbia. The analysis was conducted across several categories: the number of fires per year, the total number of fires over the entire observation period, fire counts for each country annually and cumulatively, extreme values (maximum and minimum), and fire density per square kilometre relative to each country's total area. Corresponding graphs and a thematic map were generated to visually represent the results.

The analysis was performed using comparative analysis and descriptive statistics, which is shown in the part related to the research results.

It is important to note that each recorded fire is associated with the exact week of occurrence; using these data, calculations were performed to determine the corresponding month and quarter, which served as the basis for further statistical analysis.

3. RESULTS

During the observation period from 2012 to 2024, a total of 17,975 fires were recorded across the nine countries analysed, based on data from the *Global Forest Watch platform*. The highest number of fires was detected in Romania (6,832), followed by Bulgaria (3,928) and the Republic of Serbia (2,422), while the lowest number was recorded in the Czech Republic (97). The average number of fires detected over the past 12 years was 1,997.22, placing the Republic of Serbia slightly above the regional average.

As shown in Figure 1, a decreasing trend in the number of recorded fires can be observed from 2012 toward 2024, with the exception of 2017 and 2019, when an increase in fire activity was registered, particularly in Romania and Bulgaria. Map 1 illustrates the spatial distribution of fires across the countries, where lighter shades indicate a lower number of fires, while darker shades represent higher values.

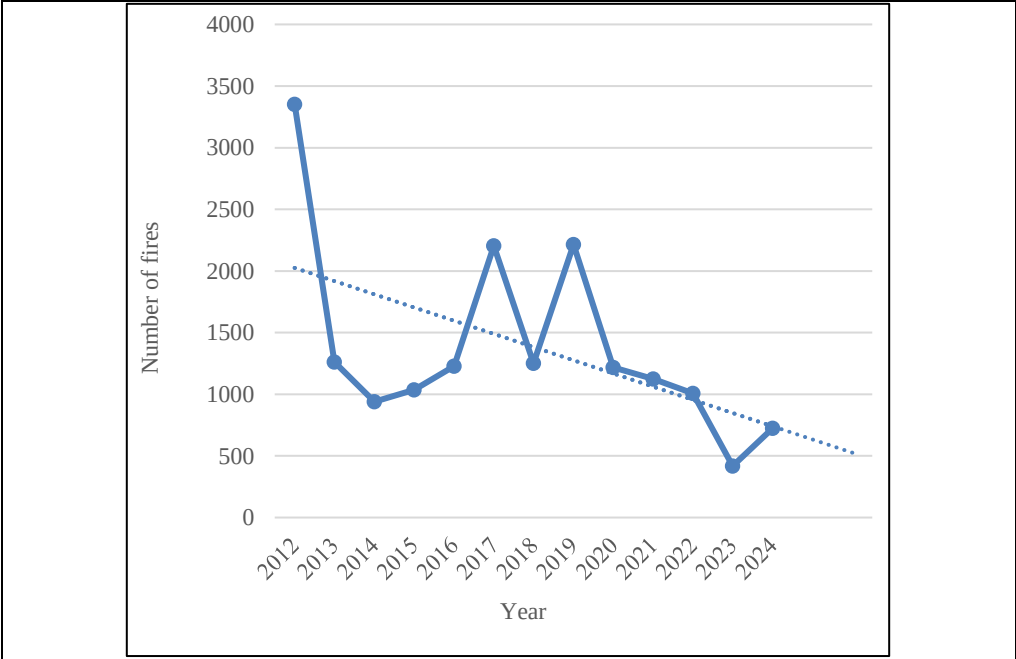
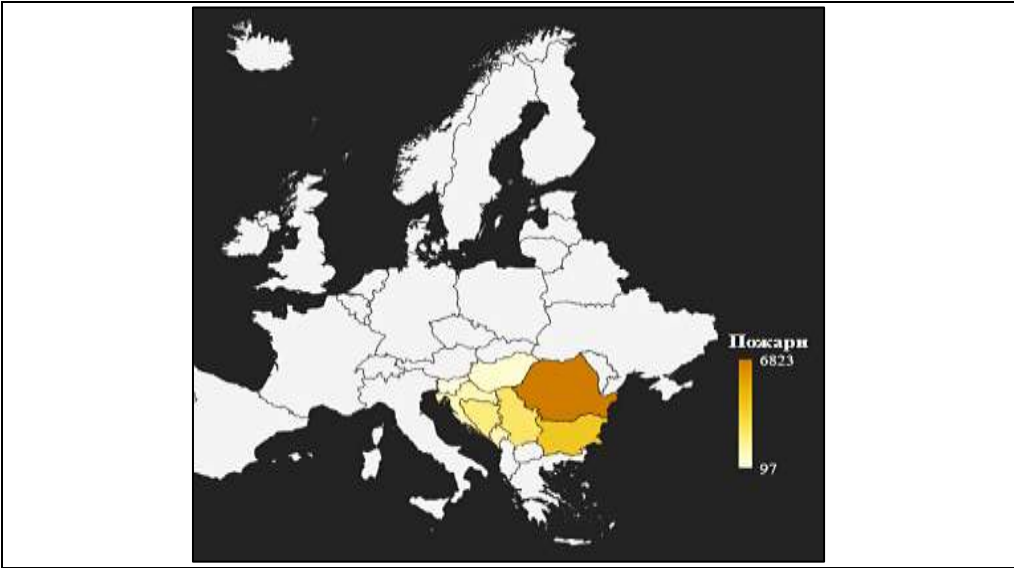


Figure 1. Number of Recorded Fires by Year of Detection



Map 1. *Distribution of Recorded Fires across Europe*

In addition to the total number of fires, it is important to consider fire density relative to the area of the selected countries. This approach reveals that although Romania and Bulgaria lead in the total number of recorded fires, Montenegro has the highest fire density, while the Czech Republic has the lowest. The average fire density across these countries is 0.0256 fires per km². The Republic of Serbia again shows values slightly above the average, positioning it near the middle among the observed countries.

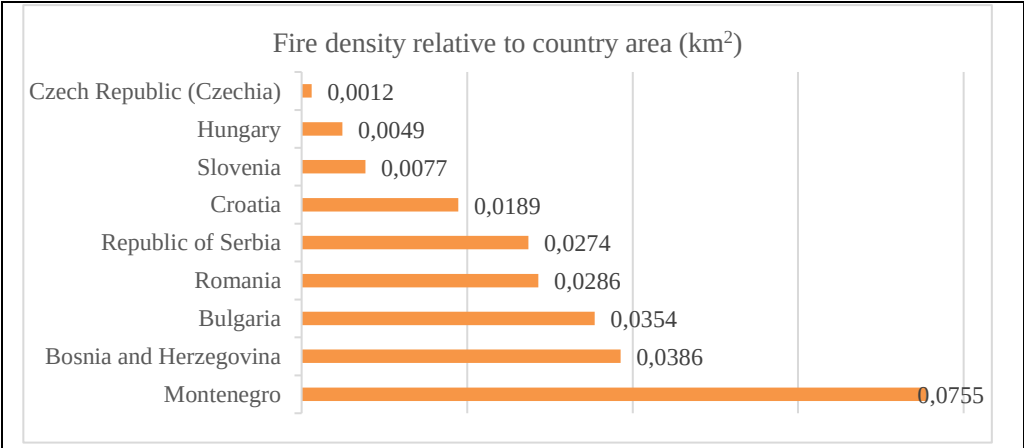


Figure 2. *Fire Density Relative to Country Area*

Maps 2 and 3 illustrate the periods from 1 September to 1 December in 2018 and 2019, respectively, which, according to the data, represent the intervals with the highest number of fires recorded in the Republic of Serbia over the past 12 years.

The maps reveal that the majority of fires were concentrated in the Autonomous Province of Vojvodina, as well as along the A1 motorway.



Map 2. Fire Incidents adjusted Map for the Period 1 September – 1 December 2018



Map 3. Fire Incidents adjusted Map for the Period 1 September – 1 December 2019

As the majority of fires were concentrated in the territory of the Autonomous Province of Vojvodina, and given that the *Global Forest Watch* platform recorded these fires in the fourth quarter of both 2018 and 2019, it can be assumed that they were primarily caused by the burning of agricultural land following harvest. Another fire event clearly observable on Map 2 is along the A1 motorway, which may be attributed to human activity. The fire incident, along with numerous others, was documented in newspaper articles from 2019 and 2023, which consistently emphasised the need to refrain from burning crop residues and agricultural land during the autumn period after harvest operations.



Figure 3. A1 Motorway, 10 October 2023.

Photo:

<https://x.com/i/status/1711474713732489482>



Figure 4. E75 Motorway, 9 October 2023.

Photo:

<https://x.com/i/status/1711819491460423939>



Figure 5. Mala Kamenica near Negotin, 29 August 2024.

Photo: Bojan Konatar



Figure 6. Burning of land near the forest edge, Sjenica, 11 April 2025.

Photo: Bojan Konatar



Figure 7. Burning of land near the forest edge, Sjenica, 11 April 2025.

Photo: Bojan Konatar

4. DISCUSSION

The primary focus of the analysis is on the territory of the Republic of Serbia, while data from the other countries are used for comparative purposes and to encourage further research on this topic.

As previously stated, the Forest Law prohibits the use of open fires within 200 metres of the forest edge. This regulation aims to protect natural resources, flora and fauna, property, and human lives. Open fires near forests pose a significant risk, particularly under adverse meteorological conditions such as prolonged drought, low humidity, or strong winds. According to a 2020 WWF report titled *Fires, Forests and the Future*, human activity—either intentional or accidental—was estimated to be responsible for 75% of open fires globally. In Europe, approximately 95% of fires are caused by human negligence, compared to 84% in the United States. The report also highlights that the *slash and burn* method, often used to prepare land for agricultural purposes, frequently escapes control. Fire-favourable weather conditions—high temperatures, low humidity, and strong winds—have become increasingly common, fuelling wildfires worldwide. Such conditions are associated with the most dangerous types of fires (Jolly et al., 2015).

A study conducted across Europe, including Estonia, Finland, Latvia, Lithuania, Sweden, Bulgaria, Germany, Poland, Romania, Slovenia, Slovakia, Switzerland, France, Greece, Italy, Portugal, and Spain, found that for 79.33% of recorded fires the cause was known. Of these, 4.17% were attributed to natural causes, 7.97% to accidental causes, 45.83% to human negligence, and 42% to deliberate actions.

In 2017, Portugal experienced a record-breaking wildfire that burned approximately 500,000 hectares (Turco, 2019), of which 213,633 hectares were forested areas (San-Miguel-Ayanz et al., 2017). Unprecedented weather conditions, including strong winds that contributed to the formation of Hurricane Ophelia and extremely low relative humidity, facilitated the rapid spread of fires (San-Miguel-Ayanz et al., 2017).

Numerous studies have demonstrated that wildfires significantly affect human health through the emission of smoke during burning events. Consequences include increased concentrations of nitrogen, phosphorus, and dissolved organic carbon in the environment. In addition, noticeable changes occur in plant species composition, geology, topography, water bodies, and lakes near burned areas (Bolan et al., 2025).

5. CONCLUSIONS

The results of this study indicate that, although the Republic of Serbia records a relatively high number of wildfires annually compared to the other analysed countries, it does not represent an extreme case. Instead, it ranks near the middle among the observed countries. The concentration of fires in specific regions and periods suggests cyclical patterns, highlighting areas that should be prioritised during the development of strategic planning documents. Prolonged periods of extremely high temperatures, a lack of precipitation, and strong winds create optimal conditions for wildfire spread, underscoring the need for special attention to regions

with higher fire occurrence rates. The observed positive trend of decreasing wildfire detection over the years, despite noticeable climate change effects, reflects the success of efforts and methods implemented over the past twelve or more years.

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Summary

This research aims to analyze the occurrence of fires in the Republic of Serbia in the period 2012–2024 using data from the online platform Global Forest Watch. The focus of the research is the temporal and spatial distribution of fire occurrence in the Republic of Serbia and a comparison of the results with eight other European countries. The analysis showed 17,975 recorded fires, of which 2,422 fires were detected in Serbia, which ranks it in the middle of the analyzed countries in terms of the number and density of fires per square kilometer. The largest number of fires was detected in the period 2018 and 2019 in the third and fourth quarters, the fires were mostly concentrated in the part of the AP Vojvodina and along the A1 highway. The data analysis determined that there are indications of seasonal and regional fires, and the attached maps show which critical areas are. The text draws attention to the importance of the human factor as the main cause of fires and the need to comply with regulations, legal prohibitions on lighting fires near forests, and the importance of preventive planning and management of forest resources, especially in conditions of climate change and long-term dry periods without rainy days.

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Резиме

Ово истраживање за циљ има да анализира појаву пожара у Републици Србији у периоду 2012-2024. година користећи податке online платформе Global Forest Watch. Фокус истраживања је временска и просторна дистрибуција појаве пожара у Републици Србији и поређење резултата са осам других земаља Европе. Анализа је показала 17.975 евидентираних пожара од чега 2.422 пожара који су детектовани у Србији, што је по броју и густини пожара по квадратном километру сврстава у средину анализираних земаља. Највећи број пожара детектован је у периоду 2018 и 2019. године у трећем и четвртном кварталу, пожари су највећим делом концентрисани у делу АП Војводине и дуж аутопута А1. Анализом података је утврђено да постоје индикације сезонских и регионалних пожара а на приложеним мапама се може видети која су критична подручја. У тексту се скреће пажња на значај људског фактора као главном узрочника појаве пожара и потреба за поштовањем прописа, законских

забрана паљења ватре у близини шума и значај превентивног планирања и управљања шумским ресурсима, посебно у условима климатских промена и дуготрајних сушних периода без кишних дана.