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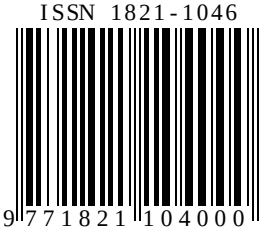

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SPATIO-TEMPORAL ANALYSIS OF LARGE WILDFIRES IN SERBIA BASED ON GIS AND VIIRS REMOTE SENSING DATA

Uroš DURLEVIĆ[1], Nina ČEGAR[1], Ljiljana BRAŠANAC-BOSANAC[2]*

Abstract: *The paper presents the results of spatio-temporal analysis of large wildfires in Serbia for the period 2012–2024, conducted using Geographic Information Systems (GIS) and Visible Infrared Imaging Radiometer Suite (VIIRS) satellite data from NASA's FIRMS (Fire Information for Resource Management System) platform. The research integrates fire radiative power (FRP) indicators with environmental and anthropogenic factors to examine patterns of wildfire occurrence and intensity.*

The results show that most wildfires occur between July and October, when vegetation is dry, temperatures are high, and precipitation is scarce, while a secondary peak is observed in April due to agricultural burning practices. At the municipal level, wildfires were recorded across diverse regions, with higher concentration in Vojvodina and Kosovo and Metohija, while large wildfires were absent in western and most of eastern Serbia.

Research results highlight that areas at highest wildfire risk in Serbia are characterized by low to medium elevation, gentle slopes, southern exposure, moderate annual precipitation, and proximity to agricultural activities and human infrastructure. The integration of GIS and VIIRS remote sensing data provides valuable insights into the spatial and temporal dynamics of wildfires, supporting improved wildfire risk assessment and management.

Keywords: wildfires, remote sensing, GIS, environmental protection.

PROSTORNO-VREMENSKA ANALIZA VELIKIH POŽARA U SRBIJI ZASNOVANA NA GIS I VIIRS PODACIMA DALJINSKE DETEKCIJE

Sažetak: *U radu su prikazani rezultati prostorno-vremenske analize velikih-požara u Srbiji za period 2012–2024, dobijenih korišćenjem satelitskih podataka Geografskih informacionih sistema (GIS) i Vidljivog infracrvenog radiometarskog senzora (VIIRS) sa NASA platforme FIRMS (Fire Information for Resource Management System). Istraživanje integriše indikatore radijativne snage požara sa faktorima životne sredine i antropogenim uslovima kako bi se ispitali obrasci pojave i intenziteta požara.*

Rezultati pokazuju da se većina požara dešava između jula i oktobra, kada je vegetacija suva, temperature visoke, a padavine oskudne, dok se sekundarni vrhunac primećuje u aprilu zbog poljoprivrednih aktivnosti (spaljivanja). Prostorno posmatrano,

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veliki požari su zabeleženi u različitim regionima, sa većom koncentracijom u Vojvodini i na Kosovu i Metohiji, dok u zapadnoj i većem delu istočne Srbije nisu registrovani.

Rezultati istraživanja pokazuju da područja sa najvećim rizikom nastanka velikih požara u Srbiji karakterišu: mala nadmorska visina, relativno ravni tereni, južna ekspozicija, umerene godišnje količine padavina i blizina poljoprivrednih parcela i naselja. Integracija GIS i VIIRS podataka daljinske detekcije pruža dragocene uvide u prostornu i vremensku dinamiku požara, podržavajući poboljšanu procenu i upravljanje rizikom nastanka šumskih požara.

Ključne reči: požari, daljinska detekcija, GIS, zaštita životne sredine.

1. INTRODUCTION

The territory of the Republic of Serbia is prone to natural hazards, including wildfires. According to Statistical Office of the Republic of Serbia (2025), in 2024 98 fires were recorded only in states forests, excluding private forests and agricultural land. Fired area was 3,573 ha, and damaged timber volume was 19,121 m^3. Fired area in private forests amounted to 2,497 ha and damaged timber volume was 13,613 m^3.

Wildfires are complex phenomenon not only in terms of ecological and material damage (Sekulić et al., 2012), but also in terms of suitable conditions for their occurence (Pishahang et al., 2023), as well as spatial and temporal varibility.

Marković et al. (2016), Ratknic et al. (2018), Tošić et al. (2019), Tošić et al. (2020), Živanović & Gocić (2022) emphasize the influence of climate conditions. Among the climatic conditions, temperature and humidity are considered the most important and are studied through indices – SPI (Živanović & Gocić, 2022), Ångström (Tošić et al., 2019; Tošić et al., 2020), Nesterov (Tošić et al., 2019), the Lang precipitation factor (Tošić et al., 2019), the De Martonne index (Tošić et al., 2020), or developing a risk matrix (Marković et al., 2016).

Tabaković-Tošić et al. (2019) highlighted that fire occurrence is result of combined effect of natural and anthropogenic conditions, especially during spring season. In spring, amount of precipitation is low, burning material is scarce with humidity, therefore easily inflammable. Also, it's the season of agricultural burning of weeds and waste materials. High peak and frequency of fires during October and March Gajović & Todorović (2013) also connect with agricultural activity. Vranić and Mišić (2024) examined the spatial pattern of fire incidents at municipality level in Serbia, and showed that six out of eight high risk clusters are in Vojvodina region.

Using multiple criteria, the susceptibility to fire was assessed in Western Serbia (Gigović et al., 2019), on the Šar Mountains National Park (Durlević et al., 2025a), as well as in neighboring countries – Montenegro (Vujović et al., 2024) and Bosnia and Herzegovina (Gigović et al., 2018).

The aim of this study is spatio-temporal analysis of environmental and anthropogenic conditions which determined wildfire occurrence and intensity during the period 2012–2024 in Serbia. Novelty of this research is multiple:

1. Occurrence and intensity of the largest wildfires at the entire territory of Serbia is examined;
2. Besides natural and anthropogenic factors, FRP indicator is included in analysis;
3. Conditions are examined separately for each fire event.

2. MATERIAL AND METHODS

The Republic of Serbia covers an area of 88,361 km², with the largest urban centers being Belgrade (the capital), Novi Sad, Niš, and Pristina. According to the 2022 census, the population stands at 6.65 million, excluding data for the Autonomous Province of Kosovo and Metohija (Statistical Office of the Republic of Serbia, 2023). The country's geographical location has strongly shaped the diversity of its natural conditions.

Owing to the interplay of varied climatic, geomorphological, and hydrological characteristics, Serbia is distinguished by notable biodiversity and a wide range of protected natural areas. National parks such as Djerdap, Fruška Gora, Tara, Kopaonik, and Šar Planina, along with numerous nature reserves, are key zones for the conservation of plant and animal life (Durlević et al., 2024).

Figure 1. *Study area and inventory of large wildfires in Serbia*

Given the exceptionally rich biodiversity and the fertile agricultural land in Vojvodina, it is crucial to develop spatial models of wildfire susceptibility to ensure effective protective measures. The need for wildfire prediction in Serbia has become increasingly urgent due to the rising frequency and severity of such events

(Milanović et al., 2021). A notable example is the large-scale fire recorded on 7 July 2025, which caused severe ecological damage, posed risks to nearby settlements, and underscored the importance of wildfire risk analysis and preventive strategies (Sinko, 2025).

The VIIRS data from the NASA platform, FIRMS, which have a spatial resolution of 375 m, were used for the spatio-temporal analysis of wildfires in Serbia (FIRMS, 2025). For the period from 2012 to 2024, 32 large fires with an intensity exceeding 100 MW were identified. All spatial data were filtered and cartographically generated in the software package QGIS v3.28.10 (QGIS Development Team, 2023; Valjarević et al., 2025).

After the creation of the inventory of large wildfires, an overlap was made with natural and anthropogenic conditions in Serbia, within which the following were analyzed: elevation, slope, aspect, air temperature, precipitation, wind exposure, land use, distance from roads, distance from settlements, and distance from water surfaces. Elevation, slope, aspect, and wind exposure were derived from the analysis of the EU-DEM with a spatial resolution of 25 meters (European Environment Agency, 2016). The distance-from-roads dataset was generated by digitizing the content from OpenStreetMap, while land use, distance from settlements, and distance from water surfaces were obtained by downloading data from the ESRI (Environmental Systems Research Institute) Sentinel-2 Land Cover Explorer platform (Environmental Systems Research Institute, 2024; Humanitarian OpenStreetMap Team, 2025). Data for air temperature and precipitation were obtained from the geoportal of the Digital Climate Atlas of Serbia (Ministry for Environmental Protection, 2022). All spatial datasets were standardized to a pixel resolution of 25 meters.

3. RESULTS AND DISCUSSION

Based on the analysis of 32 large wildfires with natural and anthropogenic conditions, spatio-temporal patterns of the dynamics of fire occurrence were obtained. The table 1 presents data on fire intensity (FRP - Fire Radiative Power) from the FIRMS platform in combination with natural conditions such as elevation, terrain slope, aspect, mean annual air temperature, and annual precipitation.

The largest number of fires occurs during the summer and early autumn months, from July to October, which is expected because during this period, the vegetation is dry, temperatures are high, and precipitation is low. This creates conditions in which the fuel mass is most susceptible to ignition and intense fire spread. A significant number of fires are also recorded in April, which is most often the result of human activities in agriculture, such as burning stubble and clearing the land after winter, when the plant remains are dry and easily flammable.

Hypsometrically, most fires occur in lowland areas, with an altitude between 70 and 200 meters above sea level. In those locations, human influence is greater, therefore fires are more frequent. However, fires were also recorded at higher altitudes, over 1900 meters. This suggests that altitude alone is not the primary factor, but rather a combination of vegetation and climatic conditions. When examining the slope of the terrain, it is observed that most fires occur on gentle slopes with an angle of less than 5 degrees. There are also cases of fires on steep slopes

exceeding 20 degrees, but these are rare. Gentle slopes and plains are more suitable for fires, while steeper terrains can contribute to the faster spread of fire.

Relief exposure has a significant impact. It is noticeable that fires often occur on the southern, southeastern, and southwestern slopes. These are the sides that receive the most solar energy in the northern hemisphere, so they are hotter and drier, which increases the risk of fires. The northern and eastern exposures have slightly lower FRP values, which confirms that the southern sides are more vulnerable.

The average annual fire temperature within the investigated locations ranges between 8 and 12 degrees. Higher FRP does not occur exclusively at higher temperatures, indicating that temperature alone is not a decisive factor. However, fires were mostly recorded at higher temperatures for this region, which indicates that it is one of the factors that determine the occurrence of fires.

Table 1. *Spatio-temporal analysis of natural conditions*

Wildfire	FRP	Date	Elevation (m)	Slope (°)	Aspect	Air temperature (°C)	Precipitation (mm)
1	241.8	7/14/2022	77.1	0.5	S	11.4	640
2	227.0	10/25/2019	118.4	0.4	W	11.4	636
3	209.8	4/10/2020	699.8	4.7	NW	9.6	784
4	205.9	4/10/2020	700.7	5.7	NE	9.6	784
5	181.4	10/9/2018	76.0	0.4	SE	11.3	590
6	175.3	10/2/2017	79.6	0.6	W	11.4	574
7	170.3	8/18/2018	106.0	0.3	N	11.0	580
8	161.9	9/23/2020	77.1	0.7	SW	11.3	557
9	158.7	7/18/2015	79.2	0.2	N	11.4	562
10	158.0	8/27/2017	76.5	0.8	NW	11.1	539
11	155.5	7/18/2015	79.4	1.3	SW	11.4	562
12	155.1	9/1/2012	1934.0	21.6	E	3.3	1035
13	149.3	10/13/2018	131.9	1.7	SE	11.2	637
14	138.9	9/8/2024	120.2	1.6	NW	10.8	545
15	136.5	4/1/2019	511.9	5.8	SE	11.0	826
16	136.5	4/1/2019	477.8	6.5	SE	11.1	828
17	127.3	9/28/2024	98.8	0.2	E	11.4	629
18	124.8	4/2/2021	73.7	0.4	W	11.0	526
19	121.8	8/9/2013	75.1	0.6	NE	11.6	664
20	121.2	8/31/2012	972.2	14.8	E	8.1	764
21	118.2	10/17/2018	84.0	0.4	SE	11.5	650
22	117.6	8/8/2019	80.4	0.3	S	11.1	623
23	116.3	8/9/2013	75.7	1.2	E	11.6	664
24	113.4	10/27/2018	82.8	0.5	S	11.2	601
25	113.4	8/22/2024	58.8	4.5	NE	12.1	596
26	109.5	8/2/2017	463.0	23.2	SE	12.4	879
27	108.9	7/20/2012	583.9	3.5	S	10.4	697
28	108.5	4/1/2019	518.9	12.2	W	11.1	826
29	107.7	9/3/2012	1113.0	7.8	E	7.6	692
30	107.7	9/3/2012	1079.8	26.6	NE	7.6	681
31	107.5	8/12/2021	75.0	4.2	N	12.0	603
32	104.1	9/4/2024	72.8	0.3	SE	11.4	598

Rainfall shows an interesting pattern. The most intense fires were not registered in areas with the lowest or highest amounts of precipitation, but rather in areas with average values between 500 and 700 millimeters. In such areas, there is sufficient vegetation to provide fuel, and the natural conditions are conducive to

fires. In areas with very high rainfall, over 1000 mm, FRP values are lower, as moisture reduces the possibility of intensive combustion.

Based on the above, areas at lower and medium altitudes, with gentle slopes and southern exposure, in regions with moderate precipitation and typical summer temperatures, are at the greatest risk of wildfires. It is the combination of these factors that makes the terrain most susceptible to the occurrence and intensive development of fires.

Table 2. *Spatio-temporal analysis of natural and anthropogenic conditions*

Wildfire	Wind exposition	Land use	Distance from roads (m)	Distance from settlements (m)	Distance from water surfaces (m)	Municipality
1	Windward	Agricultural	975.0	3666.5	4656.8	Alibunar
2	Windward	Agricultural	353.6	4886.8	9251.8	Kovačica
3	Windward	Forest	348.2	442.3	10602.0	Srbica
4	Windward	Forest	255.0	230.5	10894.8	Srbica
5	Windward	Agricultural	675.0	715.9	3106.4	Sečanj
6	Windward	Agricultural	1278.9	1201.0	318.2	Zrenjanin
7	Leeward	Agricultural	1185.6	1106.8	5467.9	Mali Iđos
8	Leeward	Agricultural	2247.4	2590.0	546.0	Novi Bečej
9	Leeward	Agricultural	250.0	943.4	318.2	Zrenjanin
10	Windward	Agricultural	5145.7	4410.0	4038.9	Kikinda
11	Windward	Agricultural	355.3	1187.7	106.1	Zrenjanin
12	Windward	Rangeland	2954.8	617.5	12585.9	Peć
13	Leeward	Agricultural	1929.4	1765.1	1480.7	Irig
14	Leeward	Rangeland	1277.2	1280.6	2201.4	Subotica
15	Windward	Forest	355.3	637.4	4790.9	Istok
16	Leeward	Forest	901.7	989.0	4851.9	Istok
17	Windward	Agricultural	167.7	1950.0	5104.7	Inđija
18	Leeward	Agricultural	770.1	1118.0	2144.9	Čoka
19	Leeward	Agricultural	357.9	1456.5	5613.5	Pećinci
20	Windward	Forest	976.3	975.0	8399.0	Vučitrn
21	Leeward	Agricultural	965.7	1715.6	6919.9	Ruma
22	Windward	Agricultural	340.0	2390.9	1352.1	Odžaci
23	Leeward	Agricultural	570.1	1335.3	4927.5	Pećinci
24	Leeward	Agricultural	257.4	3193.9	313.2	Bačka Palanka
25	Leeward	Agricultural	176.8	50.0	477.6	Kladovo
26	Windward	Rangeland	614.9	602.1	391.3	Prizren
27	Windward	Agricultural	100.0	25.0	2840.9	Obilić
28	Windward	Forest	961.8	1089.2	5478.7	Istok
29	Windward	Rangeland	1934.7	1844.6	4128.7	Vitina
30	Windward	Forest	2128.7	2140.4	4242.6	Vitina
31	Windward	Rangeland	436.6	336.3	795.7	Kladovo
32	Leeward	Agricultural	430.1	353.6	419.1	Titel

Table 2 shows the occurrence of wildfires depending on wind exposure, land use type, distance from roads, settlements, and water bodies, as well as the municipalities where the fires were registered. The data enables the analysis of spatial susceptibility to fires in relation to human activities and natural factors.

Observing the wind exposure, fires were recorded on both the windward and leeward sides. The distribution between the two groups is approximately even, indicating that the wind exposure factor alone is insufficient to explain susceptibility.

Land use is an important indicator. Most fires occur on agricultural land, which indicates the importance of human activities, such as stubble burning. Meadows and pastures follow this, while a smaller number of fires were recorded in

forest areas. This suggests that anthropogenic factors and open spaces play a greater role in fire susceptibility than dense forest ecosystems (Durlević et al., 2025b; Durlević et al., 2025c).

The distance from roads indicates that many fires originated relatively close to roads, often within a few hundred meters. This highlights the association of fires with human presence, as roads provide access and increase the risk of careless or deliberate ignition. A similar pattern is observed in the distance from settlements: a significant number of fires occurred within 1500 m of settlements, which confirms that human activities are a key factor. However, there are also cases of remote locations, over 4000 meters, which means that natural factors also contribute to the occurrence.

When looking at the distance from water surfaces, a large variability is observed. Some fires were registered very close, at approximately 100 meters, while others were more than 10 km away. This shows that proximity to water does not have a direct protective effect in terms of fire prevention, but that fires can occur in different places, independent of hydrological conditions.

The spatial distribution by municipality reveals that fires were recorded throughout Serbia, from Vojvodina (Alibunar, Zrenjanin, Kikinda) to Kosovo and Metohija (Istok, Vitina, Prizren). This indicates that fire susceptibility is widespread across different ecological and social contexts, further confirming that a combination of local factors, rather than just one parameter, determines the likelihood of occurrence. There is an absence of large fires in western Serbia, which may be related to the large amount of precipitation and fewer agricultural plots, unlike those in Vojvodina. Also, in eastern Serbia (except in Kladovo), no large fires were recorded. This region has been exposed to depopulation and deagrarianization in recent years.

Based on these data, it can be concluded that agricultural lands near roads and settlements are particularly susceptible to fires, with wind exposure and distance from water bodies being of secondary importance. Human activity and terrain accessibility remain the main risk factors, while natural conditions determine the intensity and spread of fires once they occur.

4. CONCLUSION

In Serbia, from 2012 to 2024, 32 fires intensity higher then 100 MW were recorded. Analzysis of spatial pattern indicate that in northern (AP Vojvodina) and southern parts (AP Kosovo i Metohija) of Serbia are areas where the largest fire occured in previos twelwe years. In contrary to research of Tabaković-Tošić et al. (2019) where insuficient number of fires excluded Vojvodina from the analysis, this paper show that two most intense fire occured in Vojvodina Province. According to temporal pattern, two peaks can be singled out. First from July to October, and second in April.

In this study six environmental, and four anthropogenic conditions are considered for determing fire susceptibilty. The results indicate that combination of local conditions determines the susceptability of fire occurence. While enivironmental conditions influence the intensity and direction of spreading, human activity and terrain accessibility are the leading conditions for wildfire occurence.

Risk assessment for complex hazards such as wildfires is challenging, but inevitable for adequate prevention strategies and coordinated emergency actions.

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REFERENCES

Durlević, U., Srejić, T., Valjarević, A., Aleksova, B., Dedanski, V., Vujović, F., & Lukić, T. (2025a). GIS-Based Spatial Modeling of Soil Erosion and Wildfire Susceptibility Using VIIRS and Sentinel-2 Data: A Case Study of Šar Mountains National Park, Serbia. Forests 2025, 16, 484. https://doi.org/10.3390/f16030484

Durlević, U., Valjarević, A., Novković, I., Vujović, F., Josifov, N., Krušić, J., Komac, B., Djekić, T., Singh, S. K., Jović, G., Radojković, M., & Ivanović, M. (2024). Universal snow avalanche modeling index based on SAFI–Flow-R approach in poorly-gauged regions. ISPRS International Journal of Geo-Information, 13(9), 315. https://doi.org/10.3390/ijgi13090315

Durlević, U., Ilić, V., & Valjarević, A. (2025b). Wildfire Susceptibility Mapping Using Deep Learning and Machine Learning Models Based on Multi-Sensor Satellite Data Fusion: A Case Study of Serbia. *Fire*, *8*(10), 407. https://doi.org/10.3390/fire8100407

Durlević, U., Čegar, N., Ilić, V., & Kovjanić, A. (2025c). Machine learning and deep learning approaches for wildfire susceptibility prediction: A case study of the Djerdap Geopark, Serbia. *Earth Systems and Environment*. https://doi.org/10.1007/s41748-025-00945-z

European Environment Agency (EEA). (2016). European Digital Elevation Model (EU-DEM) (Version 1.1). https://www.eea.europa.eu/data-and-maps/data/eu-dem

Environmental Systems Research Institute (ESRI). (2024). Sentinel-2 Land Cover Explorer. https://livingatlas.arcgis.com/landcoverexplorer/#mapCenter=21.076%2C42.197%2C13&mode=step&timeExtent=2017%2C2023&year=2023

Fire Information for Resource Management System (FIRMS). (2025). Archive download. NASA. https://firms.modaps.eosdis.nasa.gov/download/

Gajović, V., & Todorović, B. (2013). Spatial and temporal analysis of fires in Serbia for period 2000-2013. Journal of the Geographical Institute „Jovan Cvijic“, SASA 2013 Volume 63, Issue 3 Conference Issue, Pages: 297-312 https://doi.org/10.2298/IJGI1303297G

Gigović, Lj., Jakovljević, G., Sekulović, D., & Regodić, M. (2018). GIS Multi-Criteria Analysis for Identifying and Mapping Forest Fire Hazard: Nevesinje, Bosnia and Herzegovina. Tehnički vjesnik, *25* (3), 891-897. https://doi.org/10.17559/TV-20151230211722

Gigović, Lj., Pamučar, D., Drobnjak, S., & Pourghasemi, H. R. (2019). Modeling the spatial variability of forest fire susceptibility using geographical information systems and the analytical hierarchy process. In Spatial modeling in GIS and R for earth and environmental sciences (pp. 337-369). Elsevier. https://doi.org/10.1016/B978-0-12-815226-3.00015-6

Humanitarian OpenStreetMap Team. (2025). *Serbia Roads (OpenStreetMap Export).* HDX – Humanitarian Data Exchange. https://data.humdata.org/dataset/hotosm_srb_roads

Republički zavod za statistiku. (2025). Početna. Republički zavod za statistiku Republike Srbije. Preuzeto 2. oktobra 2025. https://www.stat.gov.rshttps://www.stat.gov.rs (on Serbian)

Marković, V., Nagy, I., Sik, A., Perge, K., Laszlo, P., Papathoma-Köhle, M., Promper, C. & Glade, T. (2016). Assessing drought and drought-related wildfire risk in Kanjiza, Serbia: the SEERISK methodology. Nat Hazards **80**, 709–726, https://doi.org/10.1007/s11069-015-1991-4

Milanović, S., Marković, N., Pamučar, D., Gigović, L., Kostić, P., & Milanović, S. D. (2021). Forest fire probability mapping in Eastern Serbia: Logistic regression versus random forest method. Forests, *12* (1), 5. https://doi.org/10.3390/f12010005

Ministry for Environmental Protection. (2022). *Digital Climate Atlas of Serbia (Project "Advancing Medium and Long-Term Adaptation Planning in the Republic of Serbia").* https://atlas-klime.eko.gov.rs

Pishahang, M., Jovcic, S., Hashemkhani Zolfani, S., Simic, V., & Görçün, Ö. F. (2023). MCDM-Based Wildfire Risk Assessment: A Case Study on the State of Arizona. *Fire*, *6*(12), 449. https://doi.org/10.3390/fire6120449

QGIS Development Team. (2023). QGIS geographic information system (Version 3.28.10) with GRASS. Open Source Geospatial Foundation Project. http://qgis.osgeo.org

Ratknic, T., Ratknic, M., Cirkovic-Mitrovic, T., & Brasanac-Bosanac, L. (2018). The impact of climate factors on the wildfire occurrence in Serbia. Fresenius Environmental Bulletin, Germany, 27(6), 4014-4022.

Sekulić, G., Dimović, D., Kalmar Krnajski Jović, Z., & Todorović, N. (2012). Climate Vulnerability Assessment-Serbia.WWF (World Wide Fund for Nature); Environmental Improvement Centre. http://awsassets.panda.org/downloads/cva_srbija_english.pdf

Sinko, V. (2025). 620 wildfires in Serbia over 12 hours; Two firefighters and four civilians injured. Blic. https://www.blic.rs/vesti/drustvo/pozari-sirom-srbije-620-zabelezenih-incidenata-u-jednom-danu-povredjeni-vatrogasci/9lf3djl

Statistical Office of the Republic of Serbia. (2023). Final results of the census of population, households and dwellings, 2022. Statistical Office of the Republic of Serbia. https://popis2022.stat.gov.rs/en-US/0-popisi

Statistical Office of the Republic of Serbia. (2025). Damages to forests, 2024. Statistical Office of the Republic of Serbia. https://www.stat.gov.rs/en-us/vesti/20250606-stete-u-sumama-2024/

Tabaković-Tošić, M., Milosavljević, M., & Vasiljević, A. (2019). Wildfires in Republic of Serbia in the period 2009-2017. Silva Balcanica, 20(1).

Tošić, I., Mladjan, D., Gavrilov, M., Živanović, S., Radaković, M., Putniković, S., Petrović, P., Mistridželović, I. & Marković, S. (2019). Potential influence of meteorological variables

on forest fire risk in Serbia during the period 2000-2017. Open Geosciences, 11(1), 414-425. https://doi.org/10.1515/geo-2019-0033

Tošić, I., Živanović, S., & Tošić, M. (2020). Influence of extreme climate conditions on the forest fire risk in Timočka Krajina region (Northeastern Serbia). Idojaras, 124(3), 331-347. DOI:10.28974/idojaras.2020.3.2

Valjarević, A., Morar, C., Brasanac-Bosanac, L., Cirkovic-Mitrovic, T., Djekic, T., Mihajlović, M., Milevski, I., Culafic, G., Luković, M., Niemets, L., Sehida, K., & Kaplan, G. (2025). Sustainable land use in Moldova: GIS & remote sensing of forests and crops. *Land Use Policy, 152*, 107515. https://doi.org/10.1016/j.landusepol.2025.107515

Vranić, P., & Mišić, N. (2024). Spatial Distribution Patterns of Wild-Fires Incidents in Serbia Based on VIIRS 375 m Data for the Period 2013-2023. Facta Universitatis, Series: Working and Living Environmental Protection, 21(2),87 – 96 https://doi.org/10.22190/FUWLEP240605008V

Vujović, F., Valjarević, A., Vila-Subirós, J., Šiljeg, A. & Lukić, T. (2024). Geospatial modeling of wildfire susceptibility on a national scale in Montenegro: A comparative evaluation of F-AHP and FR methodologies. Open Geosciences, 16(1), 20220694. https://doi.org/10.1515/geo-2022-0694

Živanović, S., & Gocić, M. (2022). Forest fires in Serbia—Influence of humidity conditions. Journal of the Geographical Institute „Jovan Cvijić", SASA, 72(2), 221–228. https://doi.org/10.2298/IJGI2202221Z

SPATIO-TEMPORAL ANALYSIS OF LARGE WILDFIRES IN SERBIA BASED ON GIS AND VIIRS REMOTE SENSING DATA

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Summary

The paper presents the results of spatiotemporal patterns of large wildfires in Serbia from 2012 to 2024, utilizing GIS and VIIRS data from the FIRMS platform. Thirty-two large fires (FRP > 100 MW) were identified, most often occurring during July–October due to high temperatures and drought, while in April, fires are mostly caused by agricultural burning. Fires are most prevalent in Vojvodina and Kosovo and Metohija, while they are almost non-existent in western and most of eastern Serbia. The riskiest areas are characterized by low to medium altitudes, gentle slopes, southern exposures, and moderate annual precipitation, with proximity to agricultural areas, roads, and settlements. The analysis shows that human activities have a decisive influence on the occurrence of fires, while natural factors shape their intensity and spread. The integration of GIS and satellite data provides valuable insight for risk assessment and improvement of fire protection strategies in Serbia.

PROSTORNO-VREMENSKA ANALIZA VELIKIH POŽARA U SRBIJI ZASNOVANA NA GIS I VIIRS PODACIMA DALJINSKE DETEKCIJE

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Rezime

U radu su analizirani prostorno-vremenski obrasci velikih požara u Srbiji u periodu 2012–2024, koristeći GIS i VIIRS podatke sa FIRMS platforme. Identifikovana su 32 velika požara (FRP >100 MW), najčešće tokom jula–oktobra zbog visokih temperatura i suše, dok u aprilu požari uglavnom nastaju usled poljoprivrednog spaljivanja. Požari su najzastupljeniji u Vojvodini i na Kosovu i Metohiji, dok ih gotovo nema u zapadnoj i većem delu istočne Srbije. Najrizičnija područja odlikuju se malim do srednjim nadmorskim visinama, blagim nagibima, južnim ekspozicijama i umerenim padavinama, uz blizinu poljoprivrednih površina, puteva i naselja. Analiza pokazuje da ljudske aktivnosti imaju presudan uticaj na pojavu požara, dok prirodni faktori oblikuju njihov intenzitet i širenje. Integracija GIS i satelitskih podataka pruža dragocen uvid za procenu rizika i unapređenje strategija zaštite od požara u Srbiji.