TRENDS IN RESEARCH ON FOREST FIRE MAPPING AND MANAGEMENT: A BIBLIOMETRIC REVIEW

TRENDOVI U ISTRAŽIVANJU KARTIRANJA I UPRAVLJANJA ŠUMSKIM POŽARIMA: BIBLIOMETRIJSKI PREGLED

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SUMMARY

Forest fires are a significant environmental challenge, impacting ecosystems, biodiversity, and human communities. Over the past decade, research on forest fire mapping and management has surged, reflecting the urgent need for effective strategies to mitigate these risks. This review examines the relation between the mapping and management of forest fires from 2013 to 2023 using a bibliometric analysis based on the PRISMA framework. The Scopus database was selected for its extensive range of publications, ensuring comprehensive coverage of relevant research. An initial search identified 927 documents, which were refined to 240 publications through specific inclusion and exclusion criteria. The analysis reveals a notable increase in publications since 2019, highlighting the most productive journals, authors, institutions, and countries in this field. Key findings include the identification of leading research hubs and influential contributors, as well as emerging trends and prevalent keywords. The growing number of literature underscores the critical role of mapping and managing forest fires, particularly in the context of global climate change and its exacerbating effects on fire incidence and severity. This review provides valuable insights into the evolving landscape of forest fire research, emphasizing the importance of continued innovation and collaboration.

KEY WORDS: forest fires, environment, mapping, management, bibliometric analysis

INTRODUCTION
UVOD

Forest fires are considered to be one of the most destructive risks on the planet, ravaging millions of hectares worldwide each year (Bowman et al., 2009). These fires not only devastate vast areas of vegetation, leading to the loss of forests and biodiversity, but they also have severe consequences on human and animal populations (Cochrane, 2003) The smoke and emissions from forest fires contribute to air pollution, posing serious health risks to people living in affected areas (Johnston et al., 2012).

Furthermore, forest fires significantly impact global change. They release large amounts of carbon dioxide and other greenhouse gases into the atmosphere, exacerbating climate change (Richer et al., 2006).

Effective mapping and strategic management of forest fires are essential for controlling and preventing this risk. The use of advanced technologies, such as remote sensing and Geographic Information Systems (GIS), plays a crucial role in identifying high-risk zones and predicting forest fires (Soualah et al., 2024). Remote sensing allows for the continuous monitoring of large forested areas, enabling the detection of fire outbreaks in real time (Chuvieco et al., 2008). GIS helps in analyzing spatial data to identify patterns and areas that are susceptible to fires, aiding in the development of targeted prevention and mitigation strategies (Jaiswal et al., 2002). By integrating these technologies,

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authorities can enhance their response capabilities and reduce the overall impact of forest fires (Petropoulos et al., 2009).

Over the past decade, there has been a notable surge in research and publications related to forest fire mapping and management. This increase reflects the growing recognition of the importance of this field and the need for comprehensive strategies to address the challenges posed by forest fires. Given the expanding body of literature, a bibliometric analysis is essential to understand the research landscape, identify key trends, and highlight influential contributors and institutions (Juárez-Orozco et al., 2017). Such analyses can reveal the most frequently cited works, emerging areas of interest, and collaborative networks within the scientific community (Liu & Wimberly, 2015). By examining the bibliometric data, researchers and policymakers can better prioritize resources and efforts to enhance forest fire management practices (Pourghasemi et al., 2020).

The objectives of this bibliometric analysis are to explore the trends in research publications on forest fire mapping and management, identify the most prolific authors and institutions, and examine the collaborative networks and key journals in this field, by providing a comprehensive overview of the research activities and developments.

Furthermore, this study emphasizes the importance of several Sustainable Development Goals (SDGs), specifically Goals 11, 13, and 15:

Goal 11: Sustainable Cities and Communities

- Enhancing the resilience of communities to forest fires is critical for ensuring safe and sustainable human settlements.

Goal 13: Climate Action

- Effective prevention and management of forest fires are essential for reducing greenhouse gas emissions and mitigating the impacts of climate change.

Goal 15: Life on Land

- Proper management and prevention of forest fires are crucial for protecting terrestrial ecosystems, preserving biodiversity, and combating land degradation.

This is why we provided responses to these questions:

- What is the distribution of publications on the mapping and management of forest fires over the last 10 years?

- Which countries publish the most research on forest fires?

- What are the most relevant journals and authors in the field of mapping and management of forest fires?

- What are the key educational institutions involved in research on the mapping and management of forest fires?

MATERIAL AND METHODS
MATERIJAL I METODE

Research design – *Dizajn istraživanja*

This bibliometric analysis, based on the PRISMA framework (Moher et al., 2009), aims to investigate the mapping and management of forest fires. The review identifies the top countries, leading educational institutions, most relevant journals, and the most prolific authors in this research area. Additionally, it highlights key trends and keywords that have emerged in the field over the past decade.

We also utilized VOSviewer for enhanced data visualization and analysis. VOSviewer is a software tool for constructing and visualizing bibliometric networks. It is widely used in the field of bibliometrics to analyze scientific literature and visualize complex data. VOSviewer allows users to easily load bibliometric data, create visualizations, and customize maps.

The software can generate various types of bibliometric maps, including co-authorship maps, citation maps, and keyword co-occurrence maps. It also handles large datasets efficiently, making it suitable for analyzing extensive bibliometric data from sources like Scopus or Web of Science.

Researchers use VOSviewer to identify research trends, key authors, influential journals, and collaboration patterns within a specific field (van Eck & Waltman, 2014).

Identification – *Identifikacija*

Data base selection

This review took place on 1 June 2024. Scopus was selected as the main data base for this review due to its advanced analytical capabilities, extensive multidisciplinary coverage, and robust citation tracking features. This comprehensive database includes a wide range of articles, conference papers, and books, making it an invaluable resource for researchers. Its high-quality sources and detailed bibliometric tools facilitate thorough analysis, supporting a wide array of research fields (Baas et al., 2020).

Search strings

To ensure the retrieval of relevant studies, the researchers used specific keywords such as "mapping and management of forest fires," formulated as TITLE-ABS-KEY (mapping AND management AND forest AND fires). The search was limited to publications from the last ten years, specifically from 2013 to 2023 (PUBYEAR > 2012 AND PUBYEAR < 2024). Additionally, the subject area was restricted to environmental science (LIMIT-TO (SUBJAREA, "ENVI")). The document types were confined to articles and conference papers (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp")). Finally, only publications in the English language were included (LIMIT-TO (LANGUAGE, "English")).

Table 1. Inclusion and exclusion criteria
Tablica 1. Kriteriji uključivanja i isključivanja

Inclusion criteria *Kriteriji uključivanja*	Exclusion criteria *Kriteriji isključivanja*
Mapping and management of forest fires research area	
2013–2023	All publications before 2013 were excluded. Publications from 2024 were excluded. *Sve publikacije prije 2013. su isključene. Publikacije iz 2024. su isključene*
English language *Engleski jezik*	Any other languages were excluded. *Svi drugi jezici su isključeni.*
Article, conference papers *Članci, konferencijski radovi*	Theses, books, book chapter blogs were excluded. *Diplomski i doktorski radovi, knjige, poglavlja u knjigama i blogovi su isključeni.*
Journals *Časopisi*	
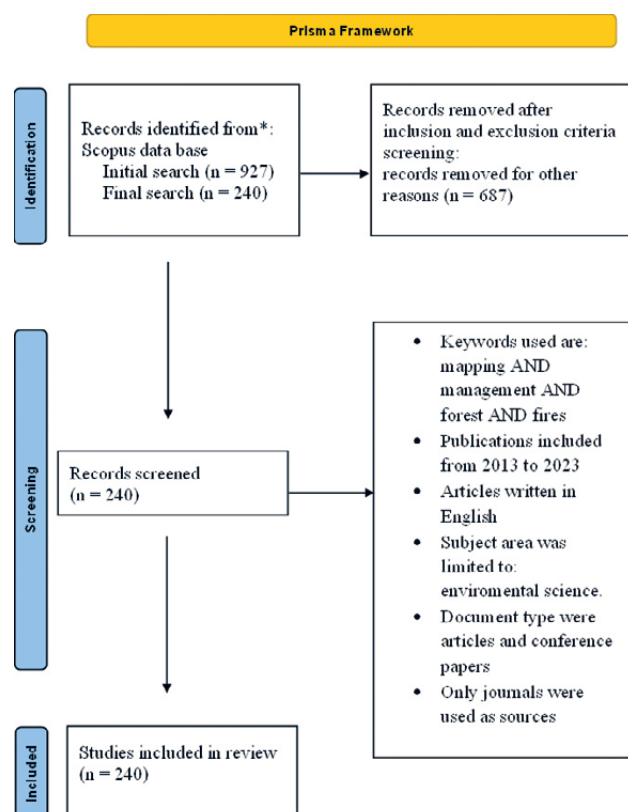
Figure 1. Prisma framework for this review
Slika 1. Prisma okvir za ovaj pregled

Screening and selections – *Probiranje i odabir*

The main keywords used were "mapping and management of forest fires," resulting in an initial search of 927 documents. After applying the inclusion and exclusion criteria outlined in Table 1, the final selection comprised 240 documents, with 687 publications excluded.

Inclusion and reporting – *Uključivanje i izvještavanje*

The findings of this bibliometric analysis have been reported based on the PRISMA framework (Moher et al., 2010), as illustrated in Figure 1. The following sections addresses the research questions in detail.

RESULTS
REZULTATI

In this section, we addressed the research questions based on the analysis of data retrieved from the Scopus database. A comprehensive search using the specified keywords and criteria resulted in a refined dataset of 240 relevant documents. The findings are organized as follows:

The distribution of mapping and management of forest fires publications – *Distribucija publikacija o kartiranju i upravljanju šumskim požarima*

In this section, we explored the temporal distribution of publications related to the mapping and management of forest fires over the past decade (2013-2023).

This section will answer the following question:

– What is the distribution of mapping and management forest fires' publications for the last 10 years?

Figure 2 illustrates the distribution of publications on the mapping and management of forest fires from 2013 to 2023. In 2013, there were only 8 publications. This number nearly doubled in 2014, with 15 publications. The trend continued to rise over the years, reaching a peak in 2022 with 37 publications. In 2023, there were 34 publications, showing a slight decline but still maintaining high research activity in the field.
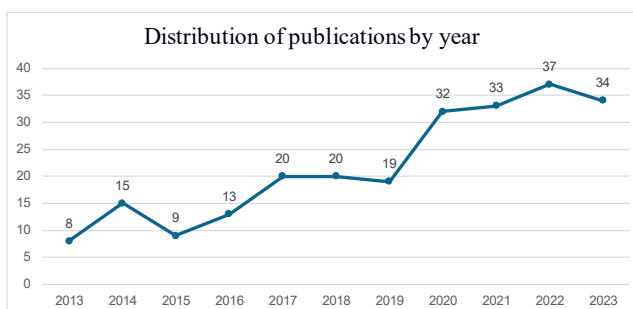
Figure 2. Distribution by years
Slika 2. Distribucija po godinama

Top 10 countries that publish the most about forest fires and their most significant academic institutions *– Prvih deset zemalja koje najviše objavljuju o šumskim požarima i njihove najznačajnije akademske institucije*

The analysis is based on the number of publications attributed to researchers from each country in the last ten years. This section will answer the following questions:

Which countries publish the most about forest fires?

Which are the most significant academic institutions in these countries?

Over the past ten years, the United States has published 76 articles on forest fire mapping and management. This substantial volume of research is driven by the frequent and severe wildfires, particularly in states like California. Other countries have also made significant contributions to this field, though to a lesser extent. Italy has published 22 articles, followed by Indonesia with 18, Australia with 17, China with 16, and both India and Iran with 14 publications each. Canada and Spain have each contributed 13 articles, while the United Kingdom has published 11 articles.

This section also identifies the top 10 countries with the highest number of publications in the field of mapping and management of forest fires and highlights the most productive countries and their leading academic institutions contributing to this research area. By examining these institutions, we can gain insight into the regions driving advancements in forest fire research.

The map illustrates the top 10 countries in terms of publications on the mapping and management of forest fires. The color intensity represents the number of publications, with darker shades indicating a higher number of publications.

Table 2 lists the top 10 institutions publishing on the mapping and management of forest fires. Leading the list is Moulay Ismail University, affiliated with the United States, with 76 publications, indicating significant research activity in
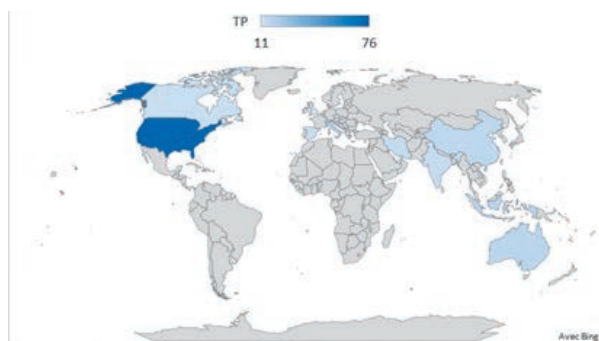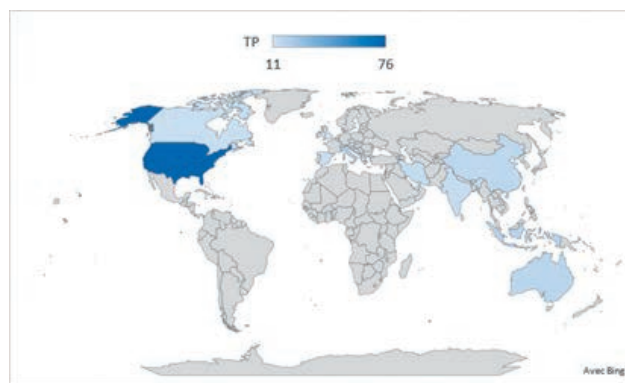

Figure 4: Top 10 countries in publishing about mapping and management of forest fires
Slika 4: Prvih 10 zemalja s najviše objavljenih radova o kartiranju i upravljanju šumskim požarima

Table 2. Top 10 countries in mapping and management of forest fires and their most significant academic institutions
Tablica 2. Prvih 10 zemalja s najviše objavljenih radova o kartiranju i upravljanju šumskim požarima i njihove najznačajnije akademske institucije

Rank *Rang*	Country *Država*	TP *UP*	Most significant academic institutions *Najznačajnije akademske institucije*
1	United states	76	Moulay Ismail University
2	Italy	22	University of Cassino and Southern Lazio
3	Indonesia	18	Universitas Muhammadiyah Yogyakarta
4	Australia	17	The Australian National University
5	China	16	Chinese Academy of Sciences
6	India	14	Thapar University
7	Iran	14	Shiraz University
8	Canada	13	Northern Forestry Centre
9	Spain	13	Instituto Pirenaico de Ecología
10	United Kingdom	11	University of Cassino and Southern Lazio

this region. The University of Cassino and Southern Lazio, affiliated with Italy, follows with 22 publications, showcasing a strong interest in forest fire research in Italy. Interestingly, the same institution, when affiliated with the United Kingdom, has 11 publications. The different publication outputs among these institutions reflect varying levels of interest and investment in forest fire research across different regions.

Most relevant journals – *Najrelevantniji časopisi*

This section identifies the most influential journals that publish research on forest fire mapping and management, highlighting their impact in the field. It also recognizes the leading authors who have significantly contributed to this area of study. By pinpointing these key sources and contributors, we can better understand the central hubs of knowledge and innovation in forest fire research.

The research question is:

What are the most relevant journals in mapping and management of forest fires research?

Figure 3: Top 10 countries that published the most about mapping and management of forest fires
Slika 3: Prvih 10 zemalja s najviše objavljenih radova o kartiranju i upravljanju šumskim požarima

Table 3: Top 10 journals covering forest fires in Scopus database in 2023
Tablica 3: Prvih deset časopisa o šumskim požarima u Scopus bazi podataka 2023.

Journal *Časopis*	TP *UP*	TC *UC*	Cite score *Citatni učinak*	Most cited article *Najcitiraniji članak*	Times cited *Broj citata*	Publisher *Izdavač*
Forest Ecology and Management	2956	22 767	7.5	Influence of nitrogen addition on the functional diversity and biomass of fine roots in warm-temperate and subtropical forests	30	Elsevier
Journal Of Environmental Management	8751	120 010	13.7	The role of digitalization on green economic growth: Does industrial structure optimization and green innovation matter?	268	Elsevier
Science of the Total Environment	30 644	540 202	17.6	Endorsing sustainable development in BRICS: The role of technological innovation, renewable energy consumption, and natural resources in limiting carbon emission	228	Elsevier
International Journal of Applied Earth Observation and Geoinformation	1495	17 951	12	Coherency and phase delay analyses between land cover and climate across Italy via the least-squares wavelet software	49	Elsevier
IOP Conference Series: Earth and Environmental Science	66 209	68 990	1	Investments in green business and corporate governance by Ukraine's cooperation with the European Union	24	
Fire Ecology	160	986	6.2	Forest fire and smoke detection using deep learning-based learning without forgetting	48	Association for Fire Ecology
Environmental Monitoring and Assessment	4086	19 023	4.7	The spatial pattern of Scirpus mariqueter expansion and the associated mechanism of self-organization using unmanned aerial vehicles and its significance for coastal wetland restoration	2	Springer Nature
Geocarto International	1229	7986	6.3	Modelling groundwater level fluctuations by ELM merged advanced metaheuristic algorithms using hydroclimatic data	23	Taylor & Francis
International Journal of Wildland Fire	338	1862	5.5	Nature-based solutions to wildfires in rural landscapes of Southern Europe: let's be fire-smart!	8	CSIRO
Sustainability (Switzerland)	55 991	381 353	6.8	Chatbots in Education and Research: A Critical Examination of Ethical Implications and Solutions	121	Multidisciplinary Digital Publishing Institute (MDPI)

Note: TC = Total citation   TP = Total publication
Napomena: UC = Ukupno citiranje   UP = Ukupno publikacija

As shown in Table 2, the most productive journals in the field of mapping and management of forest fires include "Science of the Total Environment," which boasts a CiteScore of 17.6, and the "Journal of Environmental Management," with a CiteScore of 13.7. In terms of total publications, "IOP Conference Series: Earth and Environmental Science" leads with 66,209 publications, followed by "Sustainability (Switzerland)" with 55,991 publications in this research area. Conversely, the journal "Fire Ecology" has the fewest number of publications, with only 160 articles.

In terms of total citations, "Science of the Total Environment" and "Sustainability (Switzerland)" have garnered 540,202 and 381,353 citations, respectively. In contrast, "Fire Ecology" has the fewest total citations. This discrepancy can be attributed to the interdisciplinary nature of the higher-cited journals, which cover a broader range of environmental topics. These journals attract a larger and more diverse group of researchers. On the other hand, "Fire Ecology" focuses specifically on the ecological aspects of fire, which limits its audience to a narrower research community.

Educational institutions – *Obrazovne institucije*

This section addresses the research question by identifying and analyzing the educational institutions that are leading in the field of mapping and managing forest fires. By highlighting the contributions of these institutions, we can better understand the sources of significant research and innovation in this critical area.

Research question: What are the leading educational institutions in the mapping and management of forest fires?

Table 4 highlights the most prolific educational institutions in the field of mapping and management of forest fires, with the United States emerging as a leader in this research area with 60 publications. This is evidenced by four prominent institutions: USDA Forest Service, USDA ARS Rocky Mountain Research Station, United States Geological Survey, and Oregon State University, which have published 31, 15, 8, and 6 articles, respectively.

Following the United States, Australia is notable for its contributions, with 18 publications. Three institutions, the

Table 4: Top 10 educational institutions in mapping and management of forest fires
Tablica 4: Prvih 10 obrazovnih institucija u kartiranju i upravljanju šumskim požarima

Institutions *Institucije*	TP *UP*	Countries *Države*
USDA Forest Service	31	United States
USDA ARS Rocky Mountain Research Station	15	United States
United States Geological Survey	8	United States
Natural Resources Canada	7	Canada
Canadian Forest Service	6	Canada
The Australian National University	6	Australia
Oregon State University	6	United States
University of Melbourne	6	Australia
Shiraz University	6	Iran
School of Ecosystem and Forest Science	6	Australia

Australian National University, University of Melbourne, and the School of Ecosystem and Forest Sciences, each contributed 6 publications.

In Canada, Natural Resources Canada and the Canadian Forest Service have published 7 and 6 articles, respectively.

Lastly, representing Iran, Shiraz University has published 6 articles.

This distribution underscores the global nature of forest fire research and highlights the significant contributions from institutions in the United States, Australia, Canada, and Iran.

Most prolific authors and their affiliations – *Najproduktivniji autori i njihove afilijacije*

In this section, we address the research question by identifying the most prolific authors who have made significant contributions to the field of mapping and management of forest fires. This analysis includes their publication counts and affiliations, highlighting the key individuals driving research and innovation in this area.

Research question: Who are the most prolific authors in the field of mapping and management of forest fires?

Table 5 highlights the top 10 prolific authors in the research area of mapping and management of forest fires. The most prolific author is Hamid Reza Pourghasemi from Shiraz University in Iran, who has authored 290 publications, with a total citation count of 21,769 and an H-index of 83. Following him is Andrew T. Hudak, affiliated with the USDA ARS Moscow Forestry Sciences Lab in the United States, who has 10,225 citations, 210 publications, and an H-index of 54.

From Italy, Marco Marchetti, affiliated with Università degli Studi del Molise, began publishing in 1995 and has since accumulated 7,378 citations across 217 publications, with an H-index of 44. Other notable authors from the United States include Alan A. Ager (H-index 47), Michelle A. Day (H-index 23), Gregory K. Dillon (H-index 7), Lisa M. Holsinger (H-index 24), and Robert E. Keane (H-index 27).

Additionally, Saeedeh Eskandari from Iran has a total of 525 citations and an H-index of 14, while Anna Barbati from Italy has 4,674 citations and an H-index of 28. These authors contribute significantly to the research on forest fire mapping and management, highlighting the global interest and collaborative efforts in this critical field.

Figure 5 presents the analytical results of the most productive countries in the field of mapping and management of forest fires. The analysis indicates that the United States leads in this research area, followed by Italy, Indonesia, Australia, China, India, Iran, Canada, Spain, and the United Kingdom. These countries are identified as the top ten contributors to this field.

Table 5: Top 10 authors in mapping and management of forest fires
Tablica 5: Prvih 10 autora u kartiranju i upravljanju šumskim požarima

| Author *Autor*	Year of first publication *Godina prve publikacije*	TP *UP*	H-index *H-indeks*	TC *UC*	Current affiliation *Trenutna afilijacija*	Country *Država*
Pourghasemi, Hamid Reza	2012	290	83	21,769	Shiraz University	Iran
Eskandari, Saeedeh	2010	37	14	552	Agricultural Research, Education & Extension Organization	Iran
Hudak, Andrew T	1996	210	54	10,225	USDA ARS Moscow Forestry Sciences Lab	United States
Ager, Alan A.	1995	132	47	5,485	SDA ARS Rocky Mountain Research	United States
Barbati, Anna	2006	66	28	4,674	Università degli Studi della Tuscia Viterbo	Italy
Day, Michelle A	2013	43	23	1,230	USDA ARS Rocky Mountain Research Station	United States
Dillon, Gregory K.	2005	11	7	998	USDA ARS Rocky Mountain Research Station	United States
Holsinger, Lisa M.	2006	44	24	1866	USDA ARS Rocky Mountain Research Station	United States
Keane, Robert E.	2007	82	27	3,044	USDA ARS Rocky Mountain Research Station	United States
Marchetti, Marco	1995	217	44	7,378	Università degli Studi del Molise	Italy
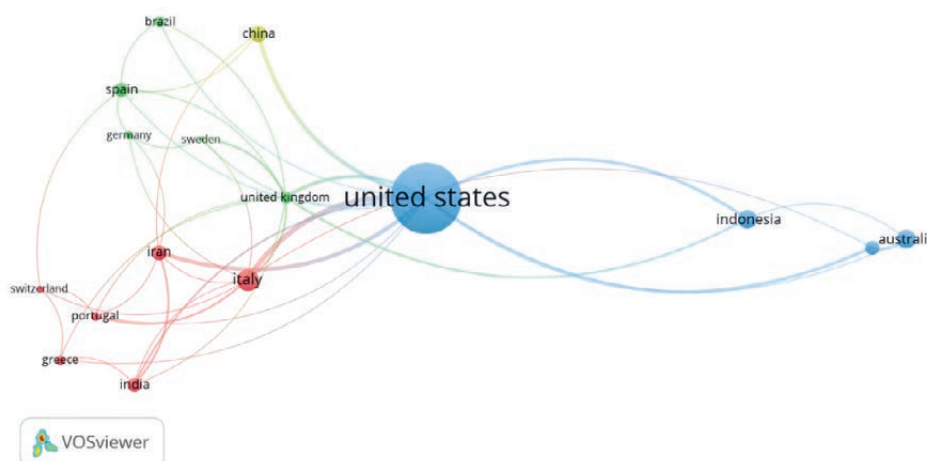
Figure 5: Analysis of the results of prolific countries in mapping and management of forest fires
Slika 5: Rezultati analize produktivnih zemalja u kartiranju i upravljanju šumskim požarima

Subject area – *Predmetno područje*

This section will explore the primary subject areas that the research on mapping and management of forest fires encompasses. By categorizing the research into various subject areas, we can better understand the multidisciplinary nature of forest fire studies and the diverse approaches used to address this complex issue. This analysis will also help in identifying gaps in the current research and potential areas for future investigation.

Research question: What are the main subject areas covered in the research on mapping and management of forest fires?

Figure 6 illustrates the distribution of research publications in the field of forest fire mapping and management across various scientific disciplines, with Environmental Science leading the contributions. Agricultural and Biological Sciences, along with Earth and Planetary Sciences, also play significant roles. Social Sciences, Energy, Engineering, and Computer Science contribute to a lesser extent but are still vital in providing comprehensive understanding and management strategies for forest fires. This distribution highlights the complexity of forest fire issues, requiring insights and collaboration across various scientific disciplines.
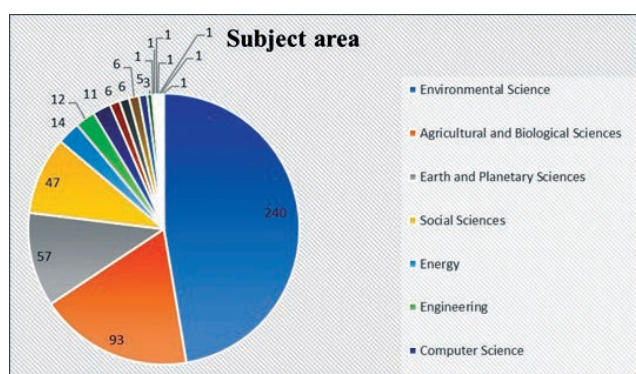
Figure 6: Subject area
Slika 6: Predmetno područje

The primary research keywords in the subject area – *Primarne ključne riječi u predmetnom području*

Figure 7 presents the analysis results of publications based on keyword co-occurrence. For this bibliometric analysis, "Co-occurrence" was selected as the analysis type, with "Author Keywords" marked as the unit of analysis. The visualization reveals a rich, interconnected research landscape in the field of forest fire mapping and management. Central themes include fire management, the integration of advanced technologies, the impact of climate change, and the ecological consequences of forest fires. These themes highlight the multi-dimensional nature of this research area. Additionally, the prominence of international collaborations and the diverse geographical focus underscore the global importance and collaborative efforts needed to advance knowledge and develop effective strategies for managing forest fires.

DISCUSSION
RASPRAVA

Within the rapidly evolving field of forest fire mapping and management, having precise and up-to-date maps created using advanced technology is crucial. These maps are essential for understanding the current situation, predicting the behavior of forest fires, and identifying high-risk areas. This information is invaluable for implementing effective strategies and management practices to control and prevent forest fires.

The findings of this review highlight the productivity of authors and institutions from various nations and organizations within this research field.

Patterns in publication and geographic distribution – *Obrasci u objavljivanju i geografskoj distribuciji*

This significant rise in publications on the mapping and management of forest fires from 2013 to 2023 can be attributed to several factors (Figure.2). One key reason is the

heightened awareness of the destructive impact of forest fires on ecosystems, the environment, and human communities, particularly from 2017 onward. Global changes have played a major role, with 2017 witnessing some of the largest and most destructive forest fires, according to FAO statistics. Similarly, 2021 saw unprecedented wildfire activity, prompting increased research into this critical issue. Furthermore, advancements in remote sensing technology and the widespread availability of satellite imagery have facilitated more extensive research and publication in this field.

The interest in publishing articles in this field is distributed across various countries worldwide, with particularly high contributions from the United States, Italy, and Indonesia, as demonstrated by this bibliometric analysis (Figure 3.).

Leading journals and academic institutions – *Vodeći časopisi i akademske institucije*

In this research, we highlighted the leading journals and academic institutions that are at the forefront of publishing in the field of mapping and management of forest fires (Table 2). By identifying these key contributors, our study provides valuable insight into the most influential sources of knowledge and innovation within this domain. The contrasting publication outputs suggest that research on forest fire mapping and management is more prominent in regions directly affected by forest fires. Institutions in countries like the U.S. and Italy are more likely to prioritize this field due to the immediate need for solutions to mitigate fire risks, while institutions in regions with lower fire risk may invest less in such research. This information is particularly useful for academics and authors who aspire to participate in and contribute to cutting-edge research in this field. The citation discrepancy highlights an important

principle in academic publishing: journals that cater to broad, interdisciplinary topics often garner more citations because they engage a wider, more diverse audience. Journals with a narrower focus, such as "Fire Ecology," while crucial for specialists, naturally receive fewer citations as their readership and contributing researchers come from a more limited field. Understanding which journals have the highest impact and which institutions are most prolific can help researchers target their submissions and collaborations more effectively, ultimately advancing the collective understanding and management of forest fires (Table 3).

Regarding educational institutions, a clear concentration of research in countries that experience severe forest fire challenges was observed, with the U.S., Australia, and Canada leading the way. Governmental institutions and universities play crucial roles in these regions, reflecting the pressing need for knowledge and solutions to manage and mitigate wildfire impacts. Iran's contributions reflect an emerging research focus, suggesting that the global relevance of forest fire management is gaining traction even outside of traditional wildfire-prone areas (Table 4).

Productive authors and keywords – *Produktivni autori i ključne riječi*

The presence of authors from multiple countries indicates that managing forest fires is a global priority, with cross-disciplinary and cross-border collaboration. These researchers are likely to address both the scientific and management aspects of forest fires, including the use of Geographic Information Systems (GIS), remote sensing, and ecological analysis (Table 5).

The keywords provided in this research can help authors easily identify relevant subjects and offer valuable insights into the field of mapping and management of forest fires (Figure 7). Including keywords such as "climate change" and "disaster management" is particularly relevant to this area and can significantly influence researchers. These keywords help authors focus their studies on pertinent topics, ensuring their work aligns with current trends and critical issues in forest fire research.

Research area and its impact – *Područje istraživanja i njegov utjecaj*

This research encompasses a wide range of subject areas, underscoring the multidisciplinary nature of forest fire studies. Key disciplines include environmental science, which addresses the ecological and atmospheric effects of fires, agricultural and biological sciences, which focus on the impact of fires on flora, fauna, and agricultural practices, and earth and planetary sciences, which examine the geological and climatic factors influencing fire behavior (Figure 6). By integrating these diverse fields, the research provides a comprehensive understanding of forest fires, from their imme-

Figure 7: Analysis results of publications by keywords
Slika 7: Rezultati analize publikacija prema ključnim riječima

diate environmental effects to their broader ecological and geological implications.

In summary, the discussions highlight the dynamic and multidisciplinary nature of forest fire research, the leading contributors in terms of authors, institutions, and countries, and the importance of advanced technologies and international collaborations in advancing the field.

Summary of the findings – *Sažetak rezultata*

This section provides a comprehensive overview of the key aspects discussed throughout this review, highlighting the findings, their implications, current trends, and future aspects in the field of forest fire mapping and management research.

CONCLUSION
ZAKLJUČAK

The bibliometric analysis of research on the mapping and management of forest fires reveals significant trends and insights crucial for advancing knowledge and practice in this field. The notable increase in publications from 2013 to 2023 underscores the growing recognition of the importance of this research area. The United States, Italy, and Indonesia emerge as leading contributors, with key institutions such as the USDA Forest Service and Shiraz University playing pivotal roles.

The analysis also highlights the central themes in forest fire research, including fire management, the integration of advanced technologies like remote sensing and GIS, the impact of climate change, and ecological consequences. These themes reflect the multi-dimensional nature of forest fire research and the necessity for a comprehensive approach that includes technological, environmental, and social perspectives.

Furthermore, the identification of influential journals and prolific authors provides valuable insights into the sources and contributors driving research advancements. Journals like "Science of the Total Environment" and "Sustainability (Switzerland)" are identified as leading platforms for disseminating research, while authors such as Hamid Reza Pourghasemi and Andrew T. Hudak are recognized for their significant contributions.

The keyword analysis emphasizes the interconnectedness of various research areas and the importance of collaboration and interdisciplinary approaches. This is essential for developing effective strategies to manage and mitigate the impacts of forest fires.

Overall, this bibliometric analysis offers a comprehensive overview of the research landscape in forest fire mapping and management. It provides researchers, policymakers, and practitioners with valuable information to guide future research, enhance collaboration, and implement more effective fire management strategies. Continued efforts and international cooperation are necessary to address the escalating challenges posed by forest fires and to protect ecosystems, human health, and global climate.

By understanding the trends, key contributors, and central themes in forest fire research, stakeholders can better prepare for and respond to the increasing threat of forest fires, ensuring a more resilient and sustainable future.

Table 6: A comprehensive overview of the key aspects
Tablica 6: Sveobuhvatan pregled ključnih aspekata

Aspect *Aspekt*	Findings *Rezultati*	Implications *Implikacije*	Trends *Trendovi*	Future aspect *Budući aspekti*
Publications *Publikacije*	Significant increase in publications from 2017	Reflects growing interest and urgency in addressing forest fires	Continued growth in research output	Likely continued increase due to the ongoing and escalating impact of forest fires
Journals *Časopisi*	Leading journals include "Science of the Total Environment" and "Sustainability (Switzerland)"	High-impact journals drive research dissemination and influence	Preference for publishing in high-impact, interdisciplinary journals	Increased recognition and submission to journals focusing on environmental and sustainability issues
Countries *Države*	Top contributing countries: USA, Italy, Indonesia, Australia, China, India, Iran, Canada, Spain, UK	Indicates global collaboration and recognition of forest fire challenges across diverse regions	Dominance of contributions from countries frequently affected by forest fires	More international collaborations and contributions from emerging research hubs
Educational institutions *Obrazovne institucije*	Key institutions: USDA Forest Service, USDA ARS Rocky Mountain Research Station, Shiraz University	Institutions with strong research programs lead advancements in the field	Concentration of research in institutions with established environmental and forestry programs	Increased funding and resources directed to leading institutions, potentially more partnerships
Authors *Autori*	Prolific authors include Hamid Reza Pourghasemi and Andrew T. Hudak	Recognizes key contributors and their influence on the research landscape	High citation and publication rates for leading authors	Continued contributions from established authors, potential rise of new influential researchers
Keywords *Ključne riječi*	Central themes: fire management, climate change, remote sensing, GIS	Keywords reflect core research areas and help guide new studies	Emphasis on technological integration and environmental impact studies	Evolving keywords with new technologies and emerging environmental challenges

REFERENCES
LITERATURA

- Baas, J., Schotten, M., Plume, A., Côté, G., & Karimi, R. (2020). Scopus as a curated, high-quality bibliometric data source for academic research in quantitative science studies. *Quantitative Science Studies*, *1*(1), 377–386. https://doi.org/10.1162/qss_a_00019

- Bowman, D., Balch, J., Artaxo, P., Bond, W., Carlson, J., Cochrane, M., D'Antonio, C., Defries, R., Doyle, J., Harrison, S., Johnston, F., Keeley, J., Krawchuk, M., Kull, C., Marston, J., Moritz, M., Prentice, I., Roos, C., Scott, A., & Pyne, S. (2009). Fire in the Earth System. *Science (New York, N.Y.)*, *324*, 481–484. https://doi.org/10.1126/science.1163886

- Chuvieco, E., Giglio, L., & Justice, C. (2008). Global characterization of fire activity: Toward defining fire regimes from Earth observation data. *Global Change Biology*, *14*(7), 1488–1502. https://doi.org/10.1111/j.1365-2486.2008.01585.x

- Cochrane, M. A. (2003). Fire science for rainforests. *Nature*, *421*(6926), 913–919. https://doi.org/10.1038/nature01437

- Jaiswal, R. K., Mukherjee, S., Raju, K. D., & Saxena, R. (2002). Forest fire risk zone mapping from satellite imagery and GIS. *International Journal of Applied Earth Observation and Geoinformation*, *4*(1), 1–10. https://doi.org/10.1016/S0303-2434(02)00006-5

- Johnston, F. H., Henderson, S. B., Chen, Y., Randerson, J. T., Marlier, M., DeFries, R. S., Kinney, P., Bowman, D. M. J. S., & Brauer, M. (2012). Estimated global mortality attributable to smoke from landscape fires. *Environmental Health Perspectives*, *120*(5), 695–701. https://doi.org/10.1289/ehp.1104422

- Juárez-Orozco, S. M., Siebe, C., & Fernández y Fernández, D. (2017). Causes and Effects of Forest Fires in Tropical Rainforests: A Bibliometric Approach. *Tropical Conservation Science*, *10*. https://doi.org/10.1177/1940082917737207

- Liu, Z., & Wimberly, M. C. (2015). Climatic and Landscape Influences on Fire Regimes from 1984 to 2010 in the Western United States. *PLoS ONE*, *10*. https://api.semanticscholar.org/CorpusID:16721994

- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Antes, G., Atkins, D., Barbour, V., Barrowman, N., Berlin, J. A., Clark, J., Clarke, M., Cook, D., D'Amico, R., Deeks, J. J., Devereaux, P. J., Dickersin, K., Egger, M., Ernst, E., Gøtzsche, P. C., … Tugwell, P. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. In *PLoS Medicine* (Vol. 6, Issue 7). Public Library of Science. https://doi.org/10.1371/journal.pmed.1000097

- Petropoulos, G., Carlson, T. N., Wooster, M. J., & Islam, S. (2009). A review of Ts/VI remote sensing based methods for the retrieval of land surface energy fluxes and soil surface moisture. In *Progress in Physical Geography* (Vol. 33, Issue 2, pp. 224–250). SAGE Publications Ltd. https://doi.org/10.1177/0309133309338997

- Pourghasemi, H. R., Kariminejad, N., Amiri, M., Edalat, M., Zarafshar, M., Blaschke, T., & Cerda, A. (2020). Assessing and mapping multi-hazard risk susceptibility using a machine learning technique. *Scientific Reports*, *10*(1), 3203. https://doi.org/10.1038/s41598-020-60191-3

- Richer, H. B., Anderson, J., Brewer, J., Davis, S., Fahlman, G. G., Hansen, B. M. S., Hurley, J., Kalirai, J. S., King, I. R., Reitzel, D., Rich, R. M., Shara, M. M., & Stetson, P. B. (2006). Probing the faintest stars in a globular star cluster. *Science*, *313*(5789), 936–940. https://doi.org/10.1126/science.1130691

- Soualah, L., Bouzekri, A., & Chenchouni, H. (2024). Hoping the best, expecting the worst: Forecasting forest fire risk in Algeria using fuzzy logic and GIS. *Trees, Forests and People*, *17*, 100614. https://doi.org/https://doi.org/10.1016/j.tfp.2024.100614

- van Eck, N. J., & Waltman, L. (2014). *Visualizing Bibliometric Networks*. https://api.semanticscholar.org/CorpusID:46174142

SAŽETAK

Šumski požari predstavljaju značajan ekološki izazov koji utječe na ekosustave, biološku raznolikost i ljudske zajednice. Tijekom posljednjeg desetljeća, istraživanja u području kartiranja i upravljanja šumskim požarima značajno su porasla, odražavajući hitnu potrebu za učinkovitim strategijama za ublažavanje ovih rizika. Ovaj pregledni rad ispituje odnos između kartiranja i upravljanja šumskim požarima od 2013. do 2023. godine pomoću bibliometrijske analize temeljene na PRISMA okviru. Za analizu je odabrana baza podataka Scopus zbog njenog opsežnog raspona publikacija, kako bi se osigurala sveobuhvatnost relevantnih istraživanja. Početno pretraživanje identificiralo je 927 dokumenata, koji su pročišćeni na 240 publikacija putem specifičnih kriterija uključivanja i isključivanja. Analiza otkriva značajan porast objava od 2019. godine, ističući najproduktivnije časopise, autore, institucije i zemlje u ovom području. Ključna otkrića uključuju identifikaciju vodećih istraživačkih centara i utjecajnih suradnika, kao i pojavljivanje novih trendova i prevladavajućih ključnih riječi. Porast broja radova naglašava ključnu ulogu kartiranja i upravljanja šumskim požarima, posebno u kontekstu globalnih klimatskih promjena i njihovih pogoršavajućih učinaka na incidenciju i ozbiljnost požara. Ovaj pregled pruža vrijedne uvide u rastući opseg istraživanja šumskih požara, naglašavajući važnost kontinuirane inovacije i suradnje.

KLJUČNE RIJEČI: šumski požari, okoliš, kartiranje, upravljanje, bibliometrijska analiza