FEs2025

4th International Congress on
Fire in the Earth System: Humans and Nature
Algés, Portugal
June 2-5, 2025

Department of Agriculture, Hellenic Mediterranean University
Universitat de València, Departament de Geografia
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fEs2025

4th International Congress on Fire in the Earth System: Humans and Nature

Algés, Portugal, June 2-5, 2025

Editors

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The Mission of fEs2025

Fire has long been a vital component of the Earth System, historically used by humans as hunters and farmers. In the 21st century, fire takes center stage in environmental management, highlighting the urgent need to define its role in shaping sustainable landscapes. Success in this effort depends on collaboration and networking among scientists, citizens, and practitioners. To facilitate these connections, fEs organizes a hybrid conference that brings together diverse stakeholders to share knowledge, ideas, and strategies for utilizing fire as a tool for sustainability.

Participants from various backgrounds are invited, including fire dynamics, fire risk management, the effects of fire on vegetation, fauna, soil, and water, as well as socio-economic, historical, geographical, political, and land management perspectives. This initiative connects scientific communities from different regions of the world with practitioners and citizens, enabling the exchange of experiences and the development of innovative approaches to fire research.

fEs2025 fosters synergistic collaborations among researchers, citizens, and stakeholders. By integrating biological, biochemical, and physical research with socio-economic, historical, geographical, sociological, and policy considerations, fEs synthesizes existing knowledge to create fire-resilient landscapes.

In addressing the intensification and geographic spread of wildfires driven by climate and land-use changes, fEs equips society, practitioners, and scientists with the tools and knowledge needed to adapt. With global change and fire serving as critical factors shaping the future of humanity, fEs provides a platform for meaningful discussion and action.

The president of the fEs2025 Organizing Committee,

Artemi Cerdà

Professor
University of Valencia

Scientific Committee

1. Akli Benali, University of Lisbon
2. Ana Bastos, University of Leipzig
3. Andrew C Scott, Royal Holloway University of London
4. Carlos da Camara, University of Lisbon
5. Célia Gouveia, University of Lisbon
6. Elia Mario, University of Bari
7. Eric B Kennedy, York University
8. Fabio Silva, Fire Analysis and Use Group, Portugal
9. Hannes van Zyl, Nelson Mandela University
10. Heather D Alexander, Auburn University
11. Ine Vandecasteele, European Environment Agency
12. Ioannis Daliakopoulos, Hellenic Mediterranean University
13. Iryna Skulska, Centre for Applied Ecology, Univ. of Lisbon
14. Javier Rodríguez, Universidad de Santiago de Compostela
15. Jesús Barrena, Universidad de Extremadura
16. Jiafu Mao, Oak Ridge National Laboratory
17. Jose Cardoso Pereira, University of Lisbon
18. Manuel Pulido, Universidad de Extremadura
19. Marco Turco, University of Murcia
20. Navashni Govender, South African National Parks
21. Rita Durão, Instituto Português do Mar e Atmosfera
22. Rosa Mosquera, Universidad de Santiago de Compostela
23. Sandy P Harrison, Leverhulme Centre for Wildfires
24. Saskia Deborah Keesstra, Climate Kic
25. Simone Morais, Polytechnic Institute of Porto
26. Stefan Doerr, University of Swansea
27. Tiaan Pool, Nelson Mandela University
28. José Múñoz-Rojas. University of Évora
29. Eva Barrocas. University of Évora
30. João Raposeira. Tapada de Coelheiros
31. Isabel Ferraz de Oliveira. University of Évora
32. André Oliveira. University of Évora
33. João Ribeiro. University of Évora

Organizing Committee

1. CÉLIA GOUVEIA, Earth Observation Unit, Instituto Português do Mar e Atmosfera Instituto Dom Luiz, Faculdade de Ciências Universidade de Lisboa
2. ARTEMI CERDÀ, Professor in Physical Geography, Soil Erosion and Degradation Research Group (SEDER), University of Valencia
3. IOANNIS DALIAKOPOULOS, Assistant Professor, Hellenic Mediterranean University, Greece

Keynote speakers

Fábio Silva

National coordinator, Fire Analysis and Use Group, Portugal

Fábio Miguel Martins da Silva joined the fire service in 1998 and in 2005 became a member of Portugal's Civil Protection Special Force, where he contributed to creating the Fire Analysis and Use Group (GAUF) in 2011. He served as the national coordinator of GAUF from 2013 to February 2024 and assumed a position as the National Operations Assistant of the Civil Protection Special Force in 2014. In February 2024, he began an extended leave to pursue a Ph.D. in wildfire analysis. He holds a degree in Sociology, a postgraduate specialization in wildfires, and is an accredited technician in Fire Suppression and Prescribed Burns. Fábio is a member of the Pau Costa Foundation and currently serves on its Executive Committee.

Ine Vandecasteele

Climate Risk and Resilience Unit, European Environment Agency

Ine Vandecasteele is an expert in the Climate Risk and Resilience Unit of the European Environment Agency (EEA). Ine currently works on subnational adaptation to climate change and the implementation of nature-based solutions for climate resilience. She coordinated the publication of the EEA's urban adaptation report 2024 and contributed towards the first European Climate Risk Assessment. Most recently she has been working on nature-based solutions to address forest disturbances under climate change, looking in particular at fire and pests. Ine has an academic background in both environmental and political sciences, a PhD in hydraulic engineering (from the University of Brussels, Belgium), and previously worked at the European Commission's Joint Research Centre on topics related to water, energy and land resources.

Carlos Dacamara

Department of Geographic Engineering, Geophysics and Energy, University of Lisbon

Carlos C. DaCamara, BSc in Physics (1979) and License in Geophysics (1981) by the University of Lisbon (Portugal), and PhD in Atmospheric Science (1991) by the University of Missouri-Columbia (USA). He is an Associate Professor at the Department of Geographic Engineering, Geophysics and Energy at the University of Lisbon where he has been lecturing a wide range of subjects in the fields of Meteorology, Climatology, Physics and Remote Sensing. His research encompasses a variety of fields that include active fire monitoring and burned area mapping by satellite, the retrieval of land surface temperature and emissivity using information from satellite, the short and medium range assessment of meteorological fire risk, the recovery of vegetation after large wild fires, the meteorological conditions associated to extreme events (e.g. droughts, heat waves) and the activity of planetary waves in the atmosphere and its impact on climate variability. He has authored/co-authored over one hundred publications in ISI journals and has supervised 20 PhD theses and a large number of MSc dissertations. He is a member of Instituto Dom Luiz (IDL) and was vice-president of the Portuguese Institute of Meteorology (2003-2005).

José Miguel Cardoso Pereira

Forest Research Centre, School of Agriculture, University of Lisbon

José Miguel Oliveira Cardoso Pereira. Completed the Título de Agregado in Engenharia Florestal e dos Recursos Naturais in 2005/05 by Universidade de Lisboa Instituto Superior de Agronomia, Licenciatura in Silvicultura in 1983/09/16 by Universidade de Lisboa Instituto Superior de Agronomia, Doctor of Philosophy in Renewable Natural Resources Studies in 1989 by The University of Arizona and Master Universitario in Landscape Architecture in 1986/12/16 by The University of Arizona School of Natural Resources and the Environment. Is Full Professor in Universidade de Lisboa Instituto Superior de Agronomia. Published 139 articles in journals. Has 1 book(s). Supervised 18 PhD thesis(es) e co-supervised 8. Has received 10 awards and/or honors. Participates and/or participated as Co-Principal Investigator (Co-PI) in 2 project(s), Principal investigator in 3 project(s) and Researcher in 8 project(s). Works in the area(s) of Agrarian Sciences with emphasis on Agriculture, Forestry and Fisheries with emphasis on Forestry and Natural sciences with emphasis on Earth and Environmental Sciences with emphasis on Environmental Sciences.

Christiaan F. Pool

Head of Forestry Department, Nelson Mandela University

Christiaan F. Pool is the head of the Forestry Department in the Science Faculty of Nelson Mandela University. He holds a Diploma in Tertiary Education from the University of South Africa, a B-Tech Degree in Forestry, and a Master's degree in Technology (Fire Management) from the Nelson Mandela University (NMU). Before Joining the NMU as an academic, he was a professional forester for 10 years and managed a training centre for a leading forestry company for three years. He is co-author and editor of the South African edition of the Fire Managers Handbook on Veld and Forest Fires and has written more than 30 articles for technical magazines on the topic of Fire Management. He also wrote a training manual on Integrated Fire Management for Commercial Forestry in Tanzania and was part of the team rewriting Wildfire bylaws for villages in Tanzania. He further designed and registered a Higher Certificate in Veldfire Management at the NMU and is the facilitator of the Fire Management symposium series in South Africa. His services as a fire management expert are often called upon in Wildfire litigation cases. He is actively involved in co-supervising postgraduate students within the forestry Department.

Ana Bastos

Professor for Land-Atmosphere Interactions, Leipzig University

Ana Bastos obtained her PhD in Geophysical and Geoinformation Science from the University of Lisbon in 2015 and is since 2024 a Professor for land-atmosphere interactions at Leipzig University. In her career, she has conducted research and teaching in Portugal, the USA (Fulbright fellowship), France (LSCE), and Germany (LMU, MPI-BGC). In 2022, she received the Early Career Scientist Award by the Biogeosciences Division of the European Geosciences Union and was granted an ERC Starting Grant to advance understanding about forest vulnerability to compound extremes under climate change. Beyond Earth System Science research and teaching, Prof. Bastos is engaged in promoting diversity and inclusion and supporting work/private life balance and mental health in academia.

Izak Smit

Senior Scientist, South African National Parks

Izak Smit completed a BSc (Ecology) and BSc (Hons) (Environmental Analysis and Management) at the University of Pretoria, South Africa, followed by a MSc (Environmental Protection and Management) and MPhil (GIS and Remote Sensing) at Edinburgh and Cambridge Universities respectively. In 2010 he received his PhD (Geography) form the University of Cambridge (UK). He is currently a Senior Scientist with South African National Parks (SANParks) where he works in the field of applied ecology and conservation sciences, with an increasing focus on social-ecological dimensions of conservation. Izak has applied GIS and remote sensing tools (optical and LiDAR) in a range of studies related to fire spatio-temporal patterns and exploring the effects of fire on vegetation structure across various national parks within South Africa. He works at the science-management interface, translating science into management implications and management questions/concerns into research questions. In addition to his appointment with SANParks, Izak is a Research Associate at the Nelson Mandela University (Sustainability Research Centre) and an Extraordinary Professor at the University of Pretoria (Department of Zoology and Entomology). He enjoys collaboration and has published with colleagues hailing from more than 30 countries and serves as Associate Editor of the Journal of Applied Ecology.

Andrew C. Scott

Distinguished Research Professor in Ancient and Modern Fire Systems, Royal Holloway University of London

Andrew C. Scott is Distinguished Research Professor the Department of Earth Sciences, Royal Holloway, University of London. He holds a B.Sc in Geology, a PhD in Palaeobotany and a D.Sc. In ancient terrestrial ecosystems from the University of London. His taught at Chelsea College, University of London before joining to form the new Geology Department at Royal Holloway. He became Professor of Applied Palaeobotany in 1996. He held a visiting Professorship at Yale University in 2006-7. In 2007 he was given the Gilbert Cady award by the Geological Society of America. His research has deals with aspects of palaeobotany, palynology, and the geological history of wildfire and the role of fire on Earth. His work on charcoal in deep time had led to an understanding of the role of fire in the Earth System. He has published more than 260 scholarly articles and written or edited 12 books. He is the lead author of the text-book "Fire on Earth: An Introduction" published by Wiley. He co-edited the Royal Society volume on 'The interaction of wildfire and mankind', published in 2016, his book "Burning Planet" was Published by Oxford University Press in 2018 and 'Fire- A very short introduction', by Oxford University Press was published in 2020.

Akli Benali

Researcher, Forest Research Centre, School of Agriculture, University of Lisbon

Akli Benali holds a PhD in Sustainable Forests and Products in 2018 by the Universidade de Lisboa Instituto Superior de Agronomia, where he is currently a Researcher. He has worked mostly on remote sensing and fire behavior modelling, focusing his work on practical applications. He has pursued the implementation of scientific knowledge and products with the aim of improving decision-making in the prevention, suppression and recovery of wildfires in Portugal. Since 2019, he actively collaborates with the National Decision Support Unit for Wildfire Analysis, integrating scientific knowledge and tools in operational contexts contributing to improved decision-making. He currently leads two applied science projects in the areas of prevention, pre-supression and suppression, leveraging his experience in fire behavior modelling to improve risk analysis and better decision-making. Finally, he is currently the vice-chair of the european Network on Extreme fiRe behaviOr (NERO) Cost action.

Conference Program

FINAL AGENDA

fEs 2025
FIRE IN THE EARTH SYSTEM
HUMANS AND NATURE

Algés, Portugal, May 30th – June 8th, 2025
Célia Gouveia, Yannis Daliakopoulos and Artemi Cerdà
Av. Alfredo Magalhães Ramalho, 6 1495-165 Algés

Organisers:
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Instituto Dom Luiz, Faculdade de Ciências Universidade de Lisboa.
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Soil Erosion and Degradation Research Group. University of Valencia.
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www.firecongress.eu

Field Excursions
fEs2025
IV FIRE IN THE EARTH SYSTEM INTERNATIONAL CONGRESS

Conference Tour.

Célia Gouveia, Instituto Português do Mar e Atmosfera
Ana Miranda, Universidade de Aveiro
Antonio Ribeiro, Autoridade Nacional de Proteção Civil – Aveiro
gouveia@ipma.pt

Pre- and Post-conference Tours. **Artemi Cerdà**

Soil Erosion and Degradation Research Group. University of Valencia
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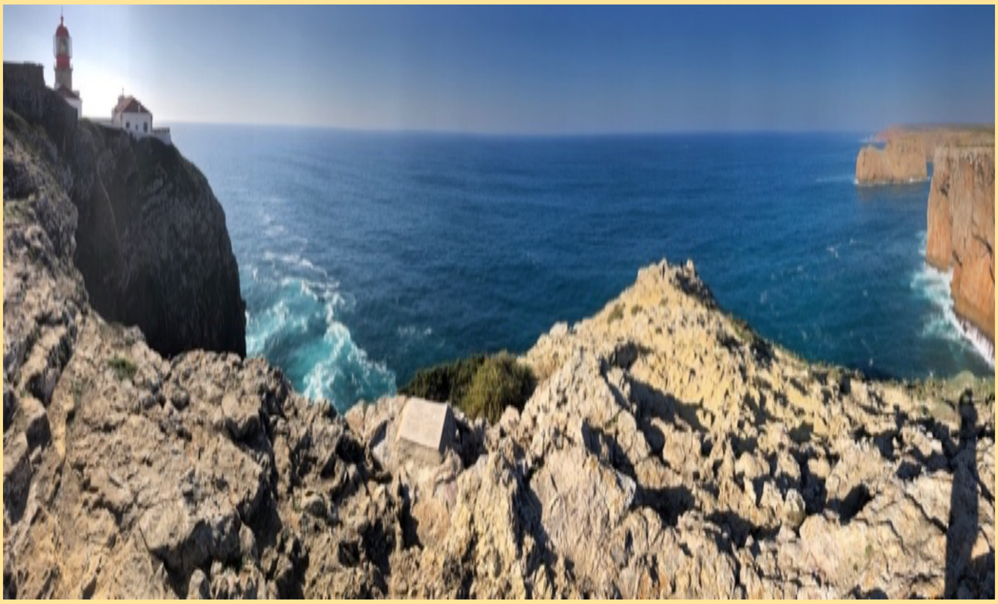
www.firecongress.eu

Pre-conference excursions

Date	Topic
29/05/2025	**29/05/2025. Travel day to Albufeira. Accommodation** 22:00 departure from Lisbon Airport to Albufeira (accommodation hotel). Accommodation at Hotel Da Aldeia. Dr. Francisco As Carneiro APT 511 nº 1 8200-280. Algarve. Arrive to the hotel on your own. From Lisbon, you can reach the hotel of Albufeira (257 Km: 2:27 by car) or by bus (bus Station Lisboa Sete Rios to Terminal Rodoviária in Albufeira, 2:34 h) or by Train from Lisbon to Terminal Rodoviária in Albufeira, 3h), or to fly to Faro (1 h from Lisbon) and bus. The organizers will have private cars and will help to pick you up. Contact Artemi Cerdà via WhatsApp at +34 696320315 to help. The organization covers one meal, accommodation, and breakfast.
30/05/2025	**30/05/2025. Ria Formosa Natural Park. Artemi Cerdà** The sedimentary coast of the south of Portugal Visit the coastal land of the Natural Park of Ria Formosa with a walk along the Ludo trail. Visit to the city of Faro. The fate of the sedimentary coast in Portugal. The environmental impact of tourism growth in Portugal. Transport and accommodation by the organization. Accommodation at Hotel Da Aldeia. Dr. Francisco As Carneiro APT 511 nº 1 8200-280. Algarve.  
31/05/2025	**Seven hanging valleys and the coast of Albufeira. Artemi Cerdà** The cliffs of the south of Portugal. Visit the coastal land of Albufeira and walk along the Seven Hanging Valleys Route to connect with nature and marvel at the magnificence of the Algarve coastline. The impact of urbanization on the coastal land. Protection and Restoration of urban and rural landscapes. Transport and accommodation by the organization. Accommodation at Hotel Da Aldeia. Dr. Francisco As Carneiro APT 511 nº 1 8200-280. Algarve.

	
01/06/2025	**1/06/2025. Road trip from Faro to Lisbon. San Vicente Cape. Artemi Cerdà** The Saint Vincent Cape is iconic. The road from Albufeira to Cabo de São Vicente and Lisbon will show us the taste of the coastal land of Portugal. Environmental concerns in a millennia-old landscape today are affected by land abandonment, urbanization, infrastructure development, and farming. Transport and accommodation by the organization. Return to Lisbon at 20:00 Accommodation at Hotel Da Aldeia. Dr. Francisco As Carneiro APT 511 nº 1 8200-280. Algarve 

Conference

Monday, June 2nd 2025	
10:00 **13:00**	**City walks in Lisbon. A city for the world. Old Town Lisbon Walking Tour.** Guide: Rogério Bento Date: 2nd June 2025 (around 2 hours, depending on the walking speed), starting at 9:30 at Praça do Comércio, close to King D. José statue (38.7077,-9.1364). Reminders: Bring water, a hat, and sunscreen. Praça do Comércio – Catedral Sé de Lisboa (outside) – Miradouro Portas do Sol – Alfama – Castelo de São Jorge (outside). **Join us in whatsapp (send a message at +34 696320315 to follow all the activities in real time)**
14.00 **15.00**	**Registration Instituto Português do Mar e da Atmosfera.** **Av. Alfredo Magalhaes Ramalho 6, 1495-165. Algés**
15:00 **15:10**	**Opening** **Célia Gouveia.** **Instituto Português do Mar e da Atmosfera. Faculdade de Ciências. Universidade de Lisboa.**
15:10 **15:30**	**Opening Conference.** **Christiaan F. Pool. Head of Forestry Department. Nelson Mandela university.** **Education and training in Fire Management**
15:30 **17:30**	**Scientific session. Soil erosion and forest fires. The fate of sediments, water, nutrients, and soils in landscapes affected by fires** **Chairperson: Ioannis Daliakopoulos and Artemi Cerdà**

Guangyuan	Wang	China's Forest Fire Prevention and Management System and Practices
Munesh	Kumar	Impact of fire on soil nutrients and understorey vegetation in Chir pine dominated forest in Garhwal Himalaya, India
Halil Ibrahim	Yildiz	Hydrological Impact of Wildfire: Bohemian Switzerland National Park
Yan	Yu	Small fires dominate the recent increase in dust emissions from burned landscapes
Henrique	Mira Godinho	Practical example of opportunities in the management of marginal mountain lands in northern portugal - the case of LIFE Maronesa
Miriam	Marzen	Experimental study of post-fire wind-drift and dust emission of ash, pyrogenic carbon and unburnt litter in European broadleaf and coniferous forest environments
Xu	Ziyang	Effects of Fire Severity on the Coupling Relationship Between Fine Root Functional Traits and Soil Physicochemical Properties in Pinus tabuliformis forest
Israel	do Nascimento Santos	Evaluating Soil Conditioners for Erosion Control Over Three Years After Prescribed Fire in Mediterranean Shrublands, NE Portugal
Parmis	siami	Prescribed Burning in Global Research: A Systematic Review and Bibliometric Analysis
Bahre	Rastipishe	A Review of Soil Erosion on Agricultural Lands in Iran
João	Horta Marques	Can conventional forest management affect soil C stocks of burnt cork oak under semi-arid conditions?

17:30 **18:00**	**Coffee-tea Break.**
18:00 **18:30**	**Conference Keynote.** **Izak Smit (San Parks, South Africa): Fanning the Flame or Educating the Public? Media narratives on fire and the scientist's role**
18:30 **19:00**	**Conference Keynote.** **Ine Vandecasteele.** **Climate Risk and Resilience Unit. European Environment Agency.** **Boosting climate resilience across Europe: Nature-based solutions for fire-resilient European forests**?
19:00 **19:30**	**Conference Keynote.** **Andrew C. Scott. Distinguished Research Professor in Ancient and Modern Fire System. Royal Holloway, University of London** **Burning planet. The story of fire through time.**

Tuesday June 3rd 2025	
8:30 9:00	**Registration**
	Parallel Session. Room 2
9:30 13:30	**Room Luiz Saldanha room. Workshop.** **Debora Gun, María Rosa Mosquera-Losada, Ana Belén Robles, María Eugenia Ramos, Rosa María Canals-Tresserras, Diego Vázquez Miramontes.** **Vegetation fuel management for fire prevention and rural population retention. Pyric herbivory: prescribed burning and targeted grazing.**
	Parallel Session. Room 1
9.00 9:30	**Main Room. Conference Keynote.** **Ana Bastos.** **Institute for Earth System Science and Remote Sensing. Leipzig University.** **Simulating fire in a terrestrial biosphere model with coupled carbon, nitrogen and phosphorus cycles.**
9:30 11:50	Matthew Forrest — Integrating Human Dimensions into Fire Models: Insights from Empirical Studies and Modelling Approaches Seppe Lampe — BuRNN: Modelling global burned area with deep learning Simon Bowring — Dancers in the dark: Global process-based modelling of boreal fires and their extremes Xiao Zhang — Analyses of driving factors and their spatiotemporal heterogenetic influence on forest fire occurrence at different temporal scales Luciano Telesca — Investigation of the time dynamics of forest fire sequences in Basilicata region (southern Italy) Tristan O'Mara — Improving Canopy Fuel Estimates for Fire behaviour Modeling in Arizona Using Google Earth Engine and Random Forest Regression Dimitra Tarasi — Simulating peat ignition probability: New insights from experimental data Johanna San Pedro — Modelling Future Wildfire Risks in South America with FLAM Candice Charlton — Predicting Summer Wildfire Potential in Jamaica: Models and Projections James King — Fire Impacts of Large-Scale Forest Expansion in a Changing Climate Zosia Staniaszek — Climate and atmospheric composition impacts of boreal biomass burning emissions changes Othusitse Lekoko — Role of fire regimes in Botswana's Miombo woodlands: opportunities for enhanced carbon sequestration and ecosystem co-benefits Diogo Lopes — High-resolution VERA decision-support tool for cross-border wildfire smoke management
11:50 12:10	**Coffee/tea break**
12:10 13:40	**Scientific session. Climate and Wildfires: Modeling, Indicators, and Future Projections** **Chairpesons: Célia Gouveia, Marco Turco, Miguel Ángel Torres Vázquez & Gabriele Vissio** Kim Feuerbacher — Low-cost, Low-latency Wilfire Monitoring with Smallsats Yan Yu — Convective potential and fuel availability complement near-surface weather in regulating global wildfire activity Liming Lou — Understanding the ignition mechanism of lightning-induced forest fires: from smoldering ignition to flaming transition Tiago Ermitão — Fire Recovery Analysis of Recurrently Burned Vegetation across Mediterranean Regions Worldwide Eric Stoch — Shrinking window: the Impact of changing weather patterns on firebreak preparation in grassland ecosystems Andreia Ribeiro — Increasing overlap of Australia – North America fire weather seasons Yan Boulanger — Harvest-induced changes in forest landscapes does not fully compensate for climate-induced increase in landscape flammability in eastern Canada

	Olivia	Haas	Preparing for future wildfires: The role of global models in understanding local fire trajectories
	Marco	Turco	Lessons Learned from the ONFIRE Project: Advancing Understanding and Prediction of Climate-Driven Wildfires
13:40 15:15	**Lunch break**		
15:15 15:45	**Conference Keynote.** **José Miguel Cardoso Pereira. Forest Research Centre. School of Agriculture. University of Lisbon.** **Thirty years of fire cartography in Portugal**		
15:45 17:00	**Room Luiz Saldanha room. Workshop.** **Marco Turco.** **Using R to Analyze Fire and Climate Data**		
15:45 17:00	**Scientific session. Wildfire Educating and training: Addressing the elephant in the room – who/what did we forget?.** **Chairpersons: Tiaan Pool & Hannes van Zyl**		
	Eric	Stoch	Igniting resilience: Youth, Women, and People with Disabilities at the Forefront of Fire-Affected Rangeland Restoration in the North West Province, South Africa
	Eric	Stoch	Reversing desert encroachment in the North Wesr provine of South Africa.
	Eric	Stoch	From the Ashes of Tradition: Reclaiming South African Fire Management Techniques for Modern Application
	Eric	Stoch	Seasonal Burning Wisdom: Lessons from South African Traditional Communities for Contemporary Wildfire Prevention
	Izak	Smit	Fire: friend or foe? The role of scientists in balancing media coverage of fires in national parks
	Hannes	van Zyl	Transforming Wildfire Management Education: A Problem-Based Learning Approach
	Bryan	Yockers	Restoring Balance Through Fire: Bridging Indigenous Burning Practices and Current Fire Management
17:00 17:20	**Coffee-tea break**		
17:20 17:50	**Conference Key-note.** **Carlos DaCamara. Department of Geographic Engineering, Geophysics and Energy. University of Lisbon.** **An improved early warning system of meteorological fire danger over Europe: rationale and analysis of results.**		
17:50 19:00	**Room Luiz Saldanha room. Workshop.** **Marco Turco.** **Calculating the Fire Weather Index and Trend Analysis in R**		
17:50	**Poster Session.** **Chairperson. Saskia Keesstra and Célia Gouveia** **Cocktail reception by the Universidade de Lisboa**		
	Miguel Ángel	Torres Vázquez	Rising Exposure Amid Declining Flames: Urban Expansion and Wildfire Risk in Catalonia (1992–2021)
	Shamsollah	Ayoubi	Post-Fire Recovery Time Effects on Soil Redistribution in Steep Rangelands: A ^{137}Cs-Based Assessment
	Monika	Moreu Vicente	Exploring Future Fire Regimes in Serranía de Cuenca, Spain through an Integrated Fire Management Lens
	Nusrat	Mehnaz	Defining and assessing bushfire risks at the Wildland-Urban Interface in Australia
	Outi	Kinnunen	Peatland wildfires in Finland
	Luis	Lopes	From Fire to Forest: Recovery of Soil Quality under Post-Fire Management in Portuguese Pyrenean Oak woodlands

Anna	Klamerus - Iwan	Post fire Chronosequence of Water Retention Properties in Pine Forest Arenosols
Dener	Silveira da Silva	The Wildland-Urban Interface Index (WUIX) Applied to Rural Settlements: The Interface Exposure in Three Villages of the Montesinho Natural Park
Laura	Eifler	The role of protected areas on Burned Area in Portuguese forests
Miguel Ángel	Torres-Vázquez	Harmonization of burned area data: Improving global comparability and accuracy with FireCCI
Gian Luca	Spadoni	FIRE-BOX: innovative tools for science-based fire risk management
Cheng-Ying	Yang	New Relations between Fire Severity and Linear Fire Rate of Spread in Global Extreme Wildfires
Rita	Durão	Extracting space-time PM10 patterns during fire seasons in Portugal from CAMS reanalysis data
Cinzia	Passamani	Interaction between wildfire, dieback and avalanches in transboundary forests between Italy and France: Implications for forest ecosystem services protection, production and biodiversity
Dimitra	Tarasi	Exploring the Influence of Wildfires on Hydrological Cycle Using ISIMIP Fire-Enabled Land Surface Models
Artemi	Cerdà	A literature review of the impact of forest fires effects on watershed water resources
Saskia	Keesstra	Advancing Climate Adaptation Through Forest-Based Nature-Based Solutions: A European Database Approach
Artemi	Cerdà	Who is who about forest fires in Iran
Artemi	Cerdà	Burning versus chipped pruned branches in olive plantations in Eastern Iberian Peninsula
Jing	Teng	Study on the Thermodynamic Characteristics of Wood Pyrolysis Gas Combustion Based on OpenFOAM Simulation
Yacin	benhalima	Evaluating Soil Carbon Stock Variability Across Fire Histories Using Field Data and Remote Sensing
Timur	Koshovskii	Long-term post-fire soil and vegetation changes in the Southern Baikal region, Baikalsky State Nature Reserve
Tamires	Bertocco	Recurrent Fires and Burn Severity Variability in Headwater Catchments: A Case Study from Montesinho Natural Park
Henintsoa	Andrianarivony	Machine learning and deep learning approaches for wildfire spread prediction
Rafik	Ghali	Deep Learning Approach for Smoke Detection
Halil	Selçuk Biricik	Let animals breathe easier in forest fires
Antonio	Giménez Morera	The impact of fire and chipped pruned branches on soil erosion in almond plantations. The REACT4MED Project contribution.
Ana	Pérez Albarracín	The impact of fire and chipped pruned branches on soil erosion in vineyards. The REACT4MED Project contribution.

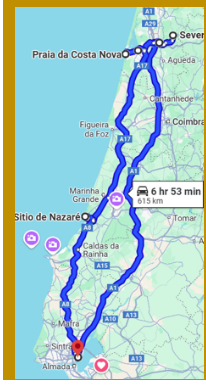
Wednesday June 4th 2025			
8:00 8:30	**Registration**		
8:30 9:40	**Scientific session: Challenges and Solutions in the Wildland-Urban Interface: A Growing Threat of Wildfires. Chairpersons: Mario Elia, Sandra Oliveira and Avi Bar-Massada**		
	Onofrio	Cappelluti	Pyro-Socio-Ecological Zones: An Integrated Approach for Fire Risk Management in Wildland-Urban Interface Ar
	Avi	Bar-Massada	Mapping the Wildland-Urban Interface: concepts, approaches, and implications for wildfire risk assessment
	Jonathan	Boucher	Mitigating Wildland Fire Risk Through A Fuel Break Placement Optimization Model
	Eric	Stoch	Fostering a Sound Cross-Border Strategy for Wildfire Prevention and Suppression: A Regional Imperative Involving the Northern Cape and North West Province (South Africa) and Botswana, with Special Reference to the Erstwhile Bophuthatswana and Tribal Authorities.
	Bruno	Barbosa	Semi-Automated Multi-Criteria Filtering of Building Footprints for Enhanced Wildland-Urban Interface Mapping in Portugal
	Ana	Gonçalves	The Influence of Lanscape Management Alternatives on Wildfire Exposure: The Case of Alvaiázere, Central Portugal
	Eva	Stegmeijer	Mapping wildfire risk for museums and built monuments in the Netherlands
9:40 10:50	**Scientific session: Shifting vegetation structure and composition and implications for future flammability Chairperson: Heather D. Alexander**		
	Samukelisiwe	Msweli	Flammability of native and invasive alien plants common to the Cape Floristic Region and beyond: Fire risk in the wildland–urban interface
	Izak	Smit	The Role of High-Intensity Fires in Managing Woody Encroachment in African Savannas: Short- and Medium-Term Outcomes
	Tamara	Milton	Burn history and ecoregional gradients alter leaf litter flammability trait values and variability
	Heather	Alexander	Shifting forest structure and composition following decades of fire exclusion in the eastern U.S.: Implications for prescribed fire restoration and wildfires
	Elisabetta	Belli	Effect of fire in soil microbial composition in thermo and meso-mediterranean forest areas in Sicily
	Ascoli	Davide	Pyro-sylviculture in mountain dry conifers to mitigate crown fire potential
	Rayo	Pinto Prieto	Burned understory legacies as indicators of canopy and ground fire severity
10:50 11:10	**Cofree-Tea Break**		
11.10 12:20	**Scientific session: Forest and Wildfire Risk Governance: Obstacles and Opportunities Chairperson: I. Skulska, P. Gomes, CM. Colaço and F. Rego.**		
	Eric	Stoch	Brindging the enforcement gap: low enforcemet peace officer (LEPO) training as a catalyst for environmental compliance in South Africa.
	Tristan	OMara	Beyond Places and Assets: Reframing Valuation in Quantitative Wildfire Risk Assessments to Capture Stakeholder Perceptions and Value
	Gian Luca	Spadoni	Devegetation is a pervasive fire driver in the Brazilian Cerrado
	Iryna	Skulska	COMMON-BASES: Strengthening Collaborative Governance of Community Lands to Prevent Wildfires and Foster Sustainable Rural Development
	Pedro	Gomes	Prescribed Fire, a Bridge Between Forestry and Grazing in Communal Lands
	Maria	Colaço	Current trends in the management of Portuguese Baldio\'s area
	Okan	Ürker	A comparative case study from Pacific Northwest of US and Türkiye to create the holistic management for the large fires

12.20 **13:30**	**Scientific session: Mobilizing Data, Knowledge, and Wisdom in Fire Decision-making** **Chairperson: Eric B. Kennedy** Eric — Stoch — Cultural Fire Stewardship: Bridging Indigenous Knowledge and Modern Fire Management Systems in South Africa Eric — Stoch — Industrial theatre as a tool for enhancing fire management awareness in disadvantaged communities. Focus on Disabled Youth and Populations with an Educational Backlog Chiara — Aquino — Towards Tier 3 Monitoring of Greenhouse Gas Emissions from Forest Fires: An Earth Observation-Based Framework in support of the UN Climate Goals Pengle — Cheng — From smoke to fire: A forest fire early warning and risk assessment model fusing multimodal data Jaša — Saražin — Slovenian case study on the access speed of response vehicles on fire roads in fire-prone forests Ana — Carvalho — Fier history-severity relationship: A spatio-temporal análisis of Eucalypt fores in Southwestern Australia. Carmen — Steinmann — Quantifying global socio-economic wildfire impacts and risks
13:30 **14:30**	**Lunch break**
14:30 **15:00**	**Key-note conference. Fabio Miguel Martins da Silva. Researcher at INESC TEC and Faculty of Engineering of the University of Porto (FEUP)** **GAPs between Science and Practices.**
15:00 **18:00**	**Scientific session. Miscelaneous** **Uncovering the Unseen: Wildfires effects on Aquatic Ecosystems** **Yesterday and Today - Chronosequential Changes After Fires in the Environment** **Nature-Based Solutions in fire management** **On the Front Lines: The Human Health Impacts of Forest Fires and the Risks to Firefighters** **Pyric herbivorism: a forest fire prevention management tool** **Comunity-led wildfire solutions: From innovation to action** **Enhancing Wildfire Resilience with Machine Learning and Earth System Models** **Chairpersons: Simone Morais, Jiafu Mao, Nelson Abrantes, María Rosa Mosquera and Brigitte Botequim** Brigite — Botequim — Bridging policy and people: Collaborative wildfire risk governance in the Rural–Urban Interface of Lousã Maria — Colaço — Fire-explorer: a Fire Education Platform Cátia — Santos — From Perception to Prevention: What Rural Communities Know About Fire? — A Mental Models Approach to Inform Risk Communication Diogo — Santos — Effects of Wildfire Ash from Native and Exotic Forests on growth and Recovery of Xenopus laevis Tadpoles Yacin — benhalima — Post-Fire Soil Dynamics Over Two Decades in Mediterranean Cork Oak Ecosystems Miralalaina Lovafitia — Ratovoarimanana — Environmental factors regulating the fire effects on soil organic carbon across Malagasy ecosystems Filipa — Ferraz — Biodiversity and carbon credits as means to encourage forest management and wildfire prevention Alexandra — Díez Méndez — From ashes to life: microbial insights into post-fire soil recovery in Ávila´s Mediterranean forest ecosystem. Mark — Grosvenor — Estimating health impacts from recurrent fire seasons in SE Asia Eric — Stoch — Fighting fire wirth fier. The Stoch Kalahari formation in practice: A collaboration between the North West Umbrella Fire Protection Association and Stenden University (South Africa)

	Eric	Stoch	From ancestral practice to modern solution: NWUFPA's Pyric Herbivorism Safeguarding North West's Livestock, Game and Eco-tourism
	Martin	Aguirrebengoa	Microbial rhythms in Mediterranean shrublands: the impact of fire and grazing on plant-soil interactions
	Eric	Stoch	Indigenous kowledge systems: Mapping Traditional Fire Management Practices of South African First Nations
	Diogo	Pinto	Community perspoectives on wildfire risk: Insight to rethink local resilience strategies
	Venkata Suresh Babu	Kukkala	Literature Review on Machine Learning Approaches for Wildfire Prediction and Risk Assessment
	Raúl	Casado-Barbero	Advancing vegetation analysis in Mediterranean shrublands through remote sensing integration
	Sandra	Oliveira	Using machine-learning to assess the current and future wildfire exposure of villages in Portugal
	María Eugenia	Ramos Font	Cortijo Clavero, an ongoing living lab to study pyric herbivory effects on Mediterranean shrublands in SE Spain (Dalías, Almería).
	Halil	Selçuk Biricik	Let animals breathe easier in forest fires
18:00 18:30	**Coffee-Tea break**		
18.30 19:00	**Closure conference. Akli Benali. Centro Estudos Forestais. Institugo Superior de Agronomia. Universidade de Lisboa. Modelling fire behavior at the landscape-level for prevention and suppression applications.**		
19:00 19:30	**fEs2026. Fire in the Earth system 2026. Tiaan Pool. South Africa. The Kruger Park fire management. November 2026 Proposals for future Fire in the Earth System Congresses (fEs2026, fEs2027, fEs2028)**		
19:30 19:40	**Closure. Célia Gouveia**		

Conference excursion, Thursday, June 5th 2025

Thursday, June 5th 2025. Conference field trip. The forest fires of Portugal. Célia Gouveia.



Itinerary: Departure 8:00 Return 21:00

Lisboa (Avenida Almirante Reis) to Albergaria-a- Velha and Sever do Vouga (2,5 hours trip and 1,5 h field observation): visit to the burned area of last year. ANEPC (national Civil Protection) and/or ICNF (Forestry Institute) will show us the region. **Albergaria a Velha to Praia da Costa Nova** (30 min trip * visit and lunch (2 horas)): beach area with traditional houses built by fishermen. **Praia da Costa Nova to Aveiro City center** (15 min trip + 45 min – see the river area and traditional boats and tasting egg pastry): **Aveiro to farol da Nazaré** : (1,5h trip and view of the famous big waves of Nazaré and maybe a cold drink/beer (30 min)). (We willcross over a region that burned in 2017). **Nazaré to Lisboa** (1,5h)

Post-conference excursions

Date	Topic
6/06/2025	**Friday, June 6th, 2025. Olive production. A diverse landscape with contrasted production systems. Montado in Monfurado (guided by Isabel Ferraz and André Oliveira).** **José Muñoz-Rojas, Isabel Ferraz de Oliveira and André Oliveira. University of Évora.** Under the guidance of José Múñoz-Rojas from the University of Évora we will learn about the diverse landscape of the Alentejo Region. Different agricultural production systems will be shown to understand the management and richness of those landscapes. We will visit to a farm in Montado/Dehesa with Isabel Ferraz de Oliveira and André Oliveira to see the work of the Scrubnet project on-site. The farm is located in the Natura 2000 area of the Serra de Monfurado (Montemor-o-Novo - about 40 km west of Évora), which is emblematic of this type of extensive landscape. And visit to a vineyard and winery with certified organic practices in the vineyard and winery and affiliated with the Alentejo Wine Sustainability Program, located about 24 km north of Évora. Transport by the organization. Departure with cars (by the organization) from Lisbon to Évora. Transport and accommodation by the organization. 
7/06/2025	**Saturday, June 7th 2025. The Montado agro-silvo-pastoral system. A unique landscape.** **Ana Barrocas and José Muñoz-Rojas. University of Évora** The montado agro-silvo-pastoral ecosystem is found as a key heritage for sustainable management and use of the land. Under the guidance José Muñoz Rojas (Assistant Professor (Rural Geography & Landscape Ecology) -Departamento de Paisagem, Ambiente e Ordenamento (DPAO) Senior Researcher (Landscape Dynamics and Management)-MED / Mediterranean Institute for Agriculture, Environment & Development), we will discover the management and the impact of a diverse ecosystem in arid lands. Visit an organic olive grove (also with Montado/Dehesa) near Ferreira do Alentejo (80 km south of Évora) and observe the radical change in the surrounding landscape as a result of rapid intensification. The owner and producer of this olive grove, Eva Barrocas, where we are promoting olive oil certification linked to biodiversity conservation practices. Accommodation Ibis Hotel (Rua de Viana 18 7005-410 Évora, Portugal). Transport and accommodation by the organization.

	 
8/06/2025	**Sunday, June 8th 2025. *Sustained management of the Mediterranean forest* Sustainability. Mauro Raposo. University of Évora.** Mauro Raposo will guide us to understand the complex management of the Mediterranean forest and their sustainability to supply goods and services and also to fight against Desertification and forest fires. Accommodation Ibis Hotel (Rua de Viana 18 7005-410 Évora, Portugal). Transport and accommodation by the organization.  
9/06/2025	**Monday, June 9th 2025.** Transport to the airports by the participants (contact the organizers). Lisbon is at 1:20 h by train or bus. If you are travelling to other airports (Madrid, Faro….) ask the organizers how to reach the airports. Contact Artemi Cerdà +34 696320315 via WhatsApp if you have any doubts.

Conference Pictures

Pre-Conference excursions

The southern coast of Portugal. A land prone to forest fire due to the land abandonment and the urbanization as a consequence of tourism

Day 1. May 30th 2025


The components (23) of the pre-conference excursion at the Ludo trail in Ria Formosa shows us the beautiful landscapes of marshes and lagoons.

Day 2. May 31st 2025


The attractive landscapes of the southern coast of Portugal contributed to a sudden shift into a tourism-based economy that resulted in agriculture abandonment and urbanization with a high risk of forest fire in the urban-rural areas. The seven hanging bridges trail shown us how beautiful are the clift coastal landscapes.

Day 3. June 1st 2025

San Vicent Cape. The coastal land of limestones of the last known land for Greeks and Romans. An example of deforestation based on fire management. The 6 Km walk on the limestones shows the changes induced by a millennia old management by fire.

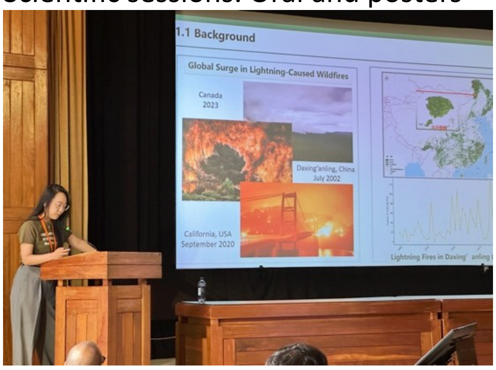
Conference in Algés, Portugal

Picture of the entrance of the venue with the participants. Instituto Portugués do Mar e da Atmosfera. Algés, Portugal.

Day 4. June 2nd 2025
Opening Conference

To the left. Célia Gouveia open the fEs2025 conference in Algés. To the right, view of the participants at the fEs2025

Day 5. June 3rd 2025
Scientific sessions. Oral and posters



To the left. Talks at the fEs2025 conference in Algés. To the right, poster session at the fEs2025

Day 6. June 4th 2025

Scientific talks and workshops. Closing ceremony

To the left closing conference day. Instituto Portugués do Mar e da Atmosfera (IMPA). Algés, Portugal. To the right, Professor Tiaan Pool announce the Fire in the Earth System Conference in Kruger Park, South Africa, November 2nd to November 14th 2026.

Conference excursion
The impact of forest fires in the region of Aveiro. Afforestation, plantations, and forest fires.

Day 7. June 5th 2025

View of the participants and landscapes along the fEs2025 conference excursion

Post-conference excursions
The agriculture land of Portugal. A fire-prone land managed by farmers.

Day 8. June 6th 2025


View of the participants at the Montado landscapes of Alentejo.

Day 9. June 7th 2025


Visit to olive plantations in Alentejo region

Day 10. June 8th 2025


View of the fEs2025 participants on the afforested land in the Alentejo region.

Conference Abstracts

On the Front Lines: The Human Health Impacts of Forest Fires and the Risks to Firefighters

Morais, Simone

Polytechnic Institute of Porto, Portugal

Forest fires pose several threats to both human health and those on the front lines of wildfire combat. Among the general population, especially the elderly, pregnant women and children are among the most vulnerable to the health effects of toxic smoke exposure from wildfires. The occupational activity as a firefighter has been classified as carcinogenic to humans. This session aims to shed light on the urgent need to prioritize human health in forest fire management and to foster a deeper understanding of the critical role that public health and firefighter safety play in addressing the growing challenges of forest fires. This session includes a broad discussion of the consequences related to exposure to toxic smoke, extreme heat, and the physical demands of battling unpredictable and intense fires, physical health, mental well-being, and community exposure and pressure on public health systems. The discussion of indirect effects of forest fires, such as the displacement of populations, and the implications for public health preparedness and the importance of protecting both civilians and firefighters by implementing strategies to mitigate these risks are welcomed.

Fire in the Earth System Abstracts
Vol. 4 FES-386-In-person Oral
Algés, Portugal, 2–5 June, 2025

China's Forest Fire Prevention and Management System and Practices

SONG, Xinchun

Ministry of Emergency Management China

Abstract

China's firefighting system incorporates both fire prevention and suppression programs with a strong support system. Six key projects underpin these programs. (1) Construction of an early warning and monitoring system: Currently, China operates 3,245 wildfire monitoring stations, 746 fuel accumulation monitoring stations, 9,312 observation towers, and 3,998 video surveillance systems. (2) Construction of a fire prevention communication and suppression information command system: The communication network primarily relies on Very Small Aperture Terminal and Beidou satellites, facilitating real-time information transmission between ground firefighters and national and provincial command centers. (3) Expansion and training of professional firefighter teams: An additional 150 teams equipped with mechanized forest firefighting equipment, such as fire engines and aircraft, have been established. (4) Development of forest aviation firefighting capacity: Increasing the number of aircraft available for firefighting, and 25 new forestry airports are currently under construction. (5) Construction of fuel barriers: Currently, there are 364,000 kilometers of natural fire barriers, and engineered fuel barriers spanning 337,000 hectares. (6) Construction of emergency roads for fire prevention and suppression: At present, China has 473,000 kilometers of forest roads with an average road density of 1.8 meters per hectare in state-owned forest areas. Since 1988, the initiation of the national fire prevention and suppression system has led to a significant decrease of 94% and 89% in both fire occurrences and burned areas, respectively.

Keywords: China, Forest Fire Prevention, System and Practice

Fire in the Earth System Abstracts
Vol. 4 FES-449-In-person Oral
Algés, Portugal, 2–5 June, 2025

Estimating Health Impacts From Recurrent Fire Seasons in Se Asia

Grosvenor, Mark[1], Wainwright, Toby[1], Wooster, Martin[1], Ardiyani, Vissia[2], Phompila, Chittana[3], Tanpipat, Veerachai[4], Nguyen, Quang[5] and Roberts, Gareth[6]

[1]*King's College London, UK*
[2]*Health Polytechnic of Palangkaraya, Indonesia*
[3]*National University of Laos*
[4]*Hydro-Informatics Institute, Thailand*
[5]*Vietnam Meteorological and Hydrological Administration, Vietnam*
[6]*University of Southampton, UK*

Abstract

Global models, such as those produced by the Copernicus Atmospheric Monitoring Service (CAMS), provide standardised estimates of air quality worldwide which can be used as inputs to health-impacts assessments. Analysis of these data have identified specific regions where near-annual fire seasons are the primary cause of hazardous air quality and the potential health impacts (Roberts & Wooster, 2021). However, it is important to understand how well these large-scale estimates represent real-world exposures as how significantly smoke can impact a population will depend on a range of factors including the fuel source, cause of the fire, and the context of the wider landscape. Understanding regions where these estimates are less reliable is essential when using them to inform health impact assessments. One such region where fire-derived $PM_{2.5}$ causes extreme air quality degradation is Southeast Asia, where we present two case studies; Indonesia and the Upper ASEAN region. In Indonesia, fires within degraded tropical peatlands are difficult to extinguish and can smoulder for extended periods, releasing large quantities of $PM_{2.5}$ per unit area. Our research using ground validation measurements shows that satellite-based $PM_{2.5}$ estimates from CAMS perform reasonably well in capturing emissions from these landscapes (Grosvenor *et al.*, 2024). Using these gridded estimates, we apply a range of health impact functions to quantify the resulting population-level health risks. The upper ASEAN region is another area where models indicate that fire-emitted $PM_{2.5}$ contributes to widespread annual air quality degradation. However, ground-based validation in parts of this region is limited, making it difficult to assess the accuracy of model outputs. Since 2023, a network of low-cost $PM_{2.5}$ sensors (PurpleAir) has been deployed across Laos, northern Thailand, and Vietnam. Initial comparisons between sensor data and large-scale model outputs reveal notable discrepancies in $PM_{2.5}$ concentrations, which limit the models' utility for health impact estimation. We present preliminary health impact estimates for the upper ASEAN region based on data from the sensor network and discuss the limitations and key considerations when using different $PM_{2.5}$ datasets in health impact assessments.

Keywords: air quality, pm2.5, health impacts, in-situ sensors

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Mobilizing Data, Knowledge, and Wisdom in Fire Decision-making

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Mobilizing Data, Knowledge, and Wisdom in Fire Decision-making

Fire in the Earth System Abstracts
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Towards Tier 3 Monitoring of Greenhouse Gas Emissions From Forest Fires: an Earth Observation-Based Framework in Support of the Un Climate Goals

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Abstract

Wildfires are a critical component of the Earth's carbon cycle, influencing terrestrial ecosystems and climate patterns (Harrison et al., 2021; Bowman et al., 2009). Fires release greenhouse gases (GHGs), aerosols, and other trace gases, impacting atmospheric composition and contributing to climate change (Liu et al., 2014). Despite a decline in global burned area (Andela et al., 2017), an increase in severe forest fires threatens to turn carbon sinks into sources, exacerbating climate feedback loops (Zheng et al., 2021). Accurate estimation of fire emissions is crucial for tracking progress towards the Paris Agreement and Sustainable Development Goal 13, which emphasises the need for precise GHG quantification. Under the United Nations Framework Convention on Climate Change (UNFCCC), National Inventory Reports (NIRs) provide bottom-up emission estimates for the forestry sector. However, discrepancies in methodologies across countries and the lack of spatial granularity limit their application in harmonising fire monitoring and mitigation strategies (Chiriacò et al., 2013).
This study presents FIRE-TRACE, a satellite-based model designed for Tier 3-level GHG emission estimation from forest fires. FIRE-TRACE applies Copernicus Earth observation data and national in-situ inventories to dynamically compute combustion completeness and fuel load distribution, dramatically enhancing the spatial and temporal resolution of emissions estimates. The combustion efficiency model, based on field-calibrated relationships between differenced Normalized Burn Ratio (dNBR) and observed biomass consumption, yielded statistically significant correlations ($R = 0.89$ for conifers, $R = 0.72$ for broadleaved forests).
For the test period (2018–2023), FIRE-TRACE provided insights into fire dynamics at both ecological and administrative level. Total wildfire GHG emissions in Italy reached 6,578 Gg CO_2eq, with an annual average of 1,096 Gg CO2eq yr^{-1}. Emissions peaked in 2021, accounting for 45% (2,892 Gg CO2eq) of the total, primarily driven by large wildfires (>50 ha), which, despite comprising only 7% of recorded fires, contributed 67% of emissions. Silver fir/Norway spruce forests exhibited the highest per-hectare emissions (0.26 Gg CO2eq/ha), whereas Mediterranean pine forests had the highest total emissions (1,529 Gg CO_2eq). The Southern regions of Sicilia and Calabria were the most affected regions, contributing 70.9% of national emissions. A comparison with global satellite-

based datasets (GFASv1.2, GFED4s, FINNv2.5), the process-based FOFEM model, and the national NIR revealed consistent trends, with the strongest correlation observed for FOFEM. The modular, open, and scalable nature of the FIRE-TRACE framework enables adaptation to different EU regions, providing critical insights into fire dynamics and accelerating efforts towards emission monitoring and reduction.

Keywords: Wildfire Emissions, Greenhouse gases (GHGs), Earth Observation, Climate mitigation, Combustion completeness

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Fire in the Earth System Abstracts
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From Smoke to Fire: a Forest Fire Early Warning and Risk Assessment Model Fusing Multimodal Data

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Abstract

Experienced forest firefighters can integrate knowledge of smoke patterns and risk factors to assess fire risk and anticipate potential fire spread and outbreaks in complex, variable environments. This study simulates the previously mentioned monitoring process and presents the Multimodal Smoke Risk Estimation Network (MM-SRENet), an innovative multimodal fusion model. This model uniquely integrates the Multi-Scale Dilation Block and Repulsion Loss into a lightweight and efficient target detection system to accurately identify smoke's presence. Furthermore, an advanced backbone based on star operation extracts the scene characteristics associated with smoke and merges them with various fire risk factors. The objective is to simulate fire risk assessments in smoke scenarios and to reduce the misallocation of fire resources resulting from false alarms and missed alerts. The proposed model was trained and validated on a multimodal dataset comprising multiple backgrounds. It successfully identified smoke features and fire potential risks in different scenarios, achieving a prediction accuracy of 93.68%. Fusing smoke images with fire risk data resulted in an 17% improvement in recognition accuracy compared to the single modal model. This work bridges the gap between multimodal data fusion and forest fire risk monitoring, providing a new direction for future intelligent forest fire prevention and control practices.

Keywords: Multimodal smoke risk estimation network, Deep learning, Forest fire monitoring, Multimodal data fusion, Smoke detection

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Fire in the Earth System Abstracts
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Slovenian Case Study on the Access Speed of Response Vehicles on Fire Roads in Fire-Prone Forests

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Abstract

In Slovenia fire roads are a special type of forest roads modified for the local fire suppression needs, where the economic benefit of forests are not ensuring establishment of a regular forest road. In the sub-Mediterranean part of Slovenia, their network is more than 800 km long. Their main purpose is to ensure quick access of various types of response vehicles to the wildfire event (Saražin, 2023). Their technical characteristics vary greatly an range from rough surface, 2 m wide trails, to macadam 4 m wide roads. Due to the relatively high density of response units and the public road network in rural areas, the term “quick access” was not sufficiently questioned up to date. However, some grey spots with access times way over 30 min were found. Access length on fire roads can in some cases exceed 5 km, what makes big difference in access time if technical characteristics of fire roads differ. The aim of our study was to conduct a case study on driving speed on different types of fire roads. We drove 50 km of fire roads with small 4x4 vehicle, which is comparable to the smallest firefighting response vehicles with 200 l water tank (Saražin, 2022). The driving speed was measured with a precise GPS tracking device and the average speed was calculated for each of the 42 sections.
It turned out that rough natural surface of the fire roads is the main limiting factor that lowers the average speed down to 10 km/h. However, a well-smoothed surface and a road width of more than 3 m were the most important factors for achieving average speeds of over 30 km/h. The results of the study highlight the importance of investing in the maintenance of fire roads and provide following recommendations: (1) categorisation of fire roads according to road width and smoothness allowing calculations of access times, (2) maximum permissible length of narrow and rough surface fire roads.

Keywords: Access speed, Fire roads, Slovenia, Firefighters, Wildfires

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Fire in the Earth System Abstracts
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Cultural Fire Stewardship: Bridging Indigenous Knowledge and Modern Fire Management Systems in South Africa

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Abstract

This presentation examines the rich fire management heritage of the amaNdebele of King Mabhoko III in Mpumalanga and Gauteng, alongside traditional practices from Eastern Cape communities around Port Alfred, Port Elizabeth, and George. We explore how these practices can inform contemporary wildfire management strategies, particularly through collaborative models exemplified by the North West Umbrella Fire Protection Association (NWUFPA).
The amaNdebele, under King Mabhoko III's leadership, maintained complex seasonal burning regimes tied to agricultural cycles and grassland management. Their practice of "isivande" (protective burning) created strategic firebreaks around settlements and agricultural fields, while "ukuvuselelwa" (renewal burning) was conducted during specific lunar phases to promote healthy grazing land regeneration. These techniques were governed through intricate community structures that ensured knowledge transmission and coordinated implementation.
In the Eastern Cape, coastal communities from Port Alfred to George developed distinct approaches responding to the region's unique fynbos ecosystems. Their "mosaic burning" techniques maintained biodiversity through carefully timed, small-scale burns that created habitat diversity. Elders recall specific indicators for burn timing, including the flowering of certain protea species and the arrival of particular migratory birds, demonstrating sophisticated ecological knowledge.
The NWUFPA in North West Province represents a successful modern integration model, combining traditional knowledge with contemporary fire science. By establishing community fire committees that include traditional leaders alongside technical experts, NWUFPA has created a knowledge-sharing platform that validates indigenous expertise while enhancing wildfire prevention efficacy. Their documentation program has preserved burning techniques from multiple communities, creating a regional knowledge repository that informs prescribed burning schedules.
We propose expanding this model nationally, creating regional fire knowledge networks that centre indigenous practitioners while providing scientific monitoring frameworks.

This approach offers a path toward more resilient landscapes by acknowledging that effective fire management requires both technical expertise and the generational wisdom embedded in South Africa's indigenous communities. By rekindling these forgotten practices within modern frameworks, we can better address the mounting challenges of climate-driven mega-fires while simultaneously supporting cultural revitalisation.

Keywords: Fire stewardship, traditional practices, firebreak, biodiversity, traditional leaders

Fire in the Earth System Abstracts
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Industrial Theatre as a Tool For Enhancing Fire Management Awareness in Disadvantaged Communities: Focus on Disabled Youth and Populations With an Educational Backlog

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Abstract

This paper examines the efficacy of Industrial Theatre as an innovative communication medium for fire management awareness in disadvantaged communities, with particular emphasis on disabled youth and individuals with educational backlogs. Traditional fire safety education often relies on written materials, formal presentations, and digital resources, which may present accessibility barriers for these vulnerable populations. Industrial Theatre, with its roots in labor education and social activism, offers an engaging alternative that transcends literacy requirements and cultural barriers.

Our mixed-methods study conducted across three disadvantaged communities demonstrates that theatrical performances incorporating local narratives, multilingual delivery, and participatory elements significantly improved fire risk comprehension and emergency response knowledge among participants. The research indicates a 68% increase in fire safety knowledge retention compared to conventional educational methods, with the highest gains observed among youth with hearing and cognitive disabilities.

The theatrical interventions were specifically designed to address the diverse needs of the target audience through several adaptations: visual storytelling techniques for those with hearing impairments; simplified yet dignified messaging for individuals with cognitive disabilities; tactile demonstrations for visually impaired participants; and culturally resonant narratives that acknowledge the socioeconomic realities of informal settlements. By employing community members as performers and co-creators, the productions fostered authenticity and community ownership of safety protocols.

Significantly, the study reveals that Industrial Theatre creates a democratized learning environment where educational disparities are mitigated through shared experiential learning. Post-performance focus groups indicated that participants with limited formal education felt empowered by the accessible format, while disabled youth reported enhanced social inclusion through the communal viewing experience.

The research concludes that Industrial Theatre represents a viable and effective strategy for fire management education in contexts where conventional approaches fall short. However, sustainability challenges exist, including funding limitations, the need for ongoing performer training, and integration with broader safety infrastructure improvements. The paper proposes a framework for implementing Industrial Theatre programs in similar contexts, emphasising the importance of community co-creation, accessibility considerations, and measurable safety outcomes as key success factors for enhancing fire management awareness in vulnerable communities.

Keywords: Industrial Theatre, sub-standard education, socioeconomic, disabilities, environment, wildland fires.

Fire in the Earth System Abstracts
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New Relations Between Fire Severity and Linear Fire Rate of Spread in Global Extreme Wildfires

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Abstract

While wildfires have been extensively studied in terms of fire risk and post-fire severity, how the fire actually spreads in real-time remains unclear. This study extends the scope of the FireRuns algorithm, a recently developed tool that identifies the fastest fire path connecting adjacent fire progression perimeters, to investigate the relationship between maximum linear fire speed and fire severity. We used fire progression maps from Spain, Australia, the United States, and Chile to better understand general patterns of fire behaviour. We fitted a mixed effect linear model including fire speed and terrain characteristics of the path of the run to predict fire severity, with the fire as a random factor. Severity maps were generated (using three indices - differenced Normalized Burn Ratio (dNBR), Relative Burn Ratio (RBR), and relativized differenced Normalized Burn Ratio (RdNBR)) with Sentinel-2 and Landsat-7 datasets utilizing Google Earth Engine (GEE). We compared different time compositing methods for pre-fire and post-fire image collections, using pixel-wise mean values across timeframes and mosaicking pixels closest to the burning time after cloud filtering. On the other hand, the linear fire runs were generated according to two different methods depending on whether the fire followed the wind direction or not. Results indicated that all severity indices showed higher values along fire run paths when fire speed increased. Conversely, lower standard errors of severity indices tended to occur with higher fire run speeds. This contrast from negative correlation of standard errors suggests that low fire speed may induce more spatial variability of severity. In addition, our provisional results suggest that the terrain variables, such as mean slope and aspect of fire run path, didn’t impacted fire severity significantly. However, the mixed-effect model combing terrain variables and fire run speed provided fair prediction of fire severity (conditional R^2 = 0.56), whereas the random effect from each fire event accounted for up to 56% of the total variance. This indicates that fire-to-fire variability in baseline burn severity is almost as large as the within-fire residual variability. Results also showed that for fast runs in runs without considering prevailing winds, the model predicted the highest severity accuracy (RMSE = 33.1%), suggesting that extreme fires governed by pyroconvection processes have a high impact on severity patterns. This study provides first time evidence of the positive impact of linear fire rate of spread on fire severity using a set of global extreme wildfire events.

Keywords: fire rate of spread, fire progression, severity mapping, remote sensing, extreme wildfires

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Fire in the Earth System Abstracts
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Fire History–Severity Relationship: a Spatio-Temporal Analysis of Eucalypt Forests in Southwestern Australia

CARVALHO, Ana, Horwitz, Pierre., van Etten, Eddie and Blake, David

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Abstract

Fire regimes vary significantly across forest types, yet most research has focused on a narrow range of ecosystems, often with limited spatial and temporal scope (Barker & Price, 2018; Sayedi et al., 2024). In Mediterranean-type climate regions, fire management practices such as prescribed burning dominate, but these strategies are frequently informed by studies conducted in ecologically dissimilar areas, raising concerns about their long-term effectiveness (Campbell et al., 2022; Canadell et al., 2021; Lindenmayer et al., 2024). This study investigates fire regime relationships by identifying which fire history variables are most influential on the severity of fires. We analysed 340 fire events from 1990 to 2021 in a drinking water catchment dominated by eucalypt forests, specifically northern jarrah forest ecosystems, in Southwestern Australia. Fire perimeters and dates, retrieved from a fire history database (Landgate, Western Australia) were validated, and fire severity was derived using a semi-automated approach combining spectral indices from Landsat and MODIS imagery. A machine learning workflow was used to generate a refined dataset containing key fire history metrics: severity of previous fires, time since fire, number of fires, and fire season. The study area was divided into a grid of 900 m^2 cells (n = 1,644,536), enabling detailed spatial and temporal analysis of overlapping fire events at the cell level. Chi-square tests, Cramér's V, and Spearman correlation assessed associations between fire history and severity (Boer et al., 2009; Collins et al., 2020). Spatio-temporal generalized linear mixed models (GLMMs) (Barker & Price, 2018; Lindenmayer et al., 2021; Steel et al., 2015), implemented with the sdmTMB R package (Anderson et al., 2024), quantified the relative importance of each fire history variable and examined how fire severity aligns with the categories of each variable. Data processing was performed using Python and JavaScript in Google Earth Engine, with spatial operations in ArcGIS Pro. Fire severity was found to respond in a non-linear way to fire history. Preliminary trends indicate that time since fire had the strongest influence, with severity declining postfire until 4-6 years, then increasing to 10–24 years and declining after 25 years. Prior high-severity burns appear to be linked to increased severity in subsequent events. These results underscore the need to evaluate fire severity through the effects of interacting fire regime variables. A more integrated approach is essential for understanding long-term fire severity dynamics and leveraging the ecological and risk-reduction potential of long-unburned forests.

Keywords: Fire regimes, Fire severity, Mediterranean-type forests, Geo-statistics

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Quantifying Global Socio-Economic Wildfire Impacts and Risks

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Abstract

Wildfires are an emerging peril in traditional global natural hazard risk assessment. Remote sensing data comprises the most comprehensive data source for their assessment. However, scientists and practitioners in Disaster Risk Reduction are faced with several fire products from different satellite missions, whose differences, advantages and limitations can be difficult to access and understand, especially for users outside the remote sensing domain. This complicates the process of identifying the most appropriate dataset, making it a challenging and time-consuming endeavor, and in some cases can result in suboptimal or even erroneous results. We address this issue by offering a concise overview of remote sensing fire products and clarifying terms that are interpreted differently across scientific communities, with a focus on their application in risk assessment. Moreover, we provide risk estimates based on different historic wildfire hazard sets. These are derived from MODIS satellite products for the years 2001–2024, leveraging burned area and fire radiative power. We join these hazard sets with exposure datasets (representing physical assets and population) and damage records to calibrate socio-economic vulnerabilities to wildfires. These form the basis for estimating direct socio-economic wildfire impacts and risks, while quantifying uncertainties related to the chosen hazard representation. Such risk analyses find application in prioritising adaptation options and in designing insurance products.

Keywords: socio-economic impacts, risk assessment, disaster risk reduction, interdisciplinary research

Agroforestry: Reducing fires risk and Restoring forest fires while enhancing value chains

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Agroforestry: Reducing fires risk and Restoring forest fires while enhancing value chains

Fire in the Earth System Abstracts
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Let Animals Breathe Easier in Forest Fires

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Abstract

Sivil Düşün is an European Union programme supporting active citizens and civil society organisations throughout Türkiye. It offers unique mechanism that easily and quickly enables civic actors to secure support for specific needs and desired outcomes. This study titled as “Let Animals Breathe Easier in Fire” was supported by this programme.

In recent years, especially as a result of the forest fires, many small and large animal barns were burned and animals such as tortoises, dogs, cats, cows and sheep perished in Türkiye. Fire Brigade teams make the first response in forest and house fires. Like other disasters, firefighters give priority to human rescue activities in case of fires, and animal rescue activities are overlooked. High temperatures, toxic effects of smoke, and oxygen depletion can therefore cause mortality or impairment of animals. Firefighters often face difficulties during these rescue operations. If Oxygen masks spesific to animals is used during fires, all the oxygen is going into animals’ lungs and make a positive contribution to animal welfare as first aid.

The target group of this study was firefighters working in the cities of Aegean region in Türkiye. Awareness activities, seminars and experimental events to increase animal rescue capacities of first responders were performed. The main activity was to encourage firefighters to use Oxygen masks for animals, unconscious due to smoke or have breathing difficulties during forest or house fires. These masks should be available in all Fire Brigades. With the widespread use of Oxygen masks in fires, it will make a positive contribution to animal welfare at the national level. Current study will also contribute to animal rescue strategies in case of fires and other emergencies.

Keywords: Animal rescue, forest fire, Oxygen mask

Shifting vegetation structure and composition and implications for future flammability

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Shifting vegetation structure and composition and implications for future flammability

Fire in the Earth System Abstracts
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Flammability of Native and Invasive Alien Plants Common to the Cape Floristic Region and Beyond: Fire Risk in the Wildland–Urban Interface

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Abstract

In Mediterranean-type ecosystems, shifting vegetation structure and composition due to biological invasions, climate change, and land-use transitions reshape fire regimes and thus having potential to alter future flammability dynamics. This study examines how species-specific flammability traits influence fire risk by analysing excised branches from 30 native and invasive woody species in the Cape Fynbos biome, South Africa. Through controlled combustion experiments conducted under varying weather conditions in 2018, we assessed combustibility, consumability, ignitability, and an integrated flammability index to determine how vegetation shifts may impact fire behaviour in the wildland-urban interface (WUI). Our findings highlight significant variability in flammability among species, with native thicket species—characterized by higher moisture content, thicker leaves, and greater proportions of coarse plant material—exhibiting lower combustibility than native fynbos and invasive alien plants (IAPs). In contrast, highly flammable IAPs such as Acacia saligna demonstrated traits that enhance fire spread potential, suggesting that vegetation transitions driven by invasions may escalate future fire hazards. Principal Component Analysis (PCA) revealed key plant traits driving these patterns, underscoring the role of species in shaping fire-prone landscapes. These results are particularly valuable for the WUI management, where strategic vegetation planning can reduce fuel loads and mitigate fire risks. By integrating flammability assessments into land-use planning, fire-prone communities can prioritize the use of lower-flammability species for defensible space design, buffer zones, and fuel breaks. As climate change intensifies droughts and extreme fire weather, applying species-specific fire risk assessments will be essential for developing resilient landscapes that balance ecological integrity with fire safety.

Keywords: Fire risk, wildfire mitigation, Wildland-urban interface (WUI)

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Fire in the Earth System Abstracts
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The Role of High-Intensity Fires in Managing Woody Encroachment in African Savannas: Lessons Learned

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Abstract

Woody encroachment threatens the ecological integrity of savannas worldwide, prompting the need for effective management strategies. High-intensity fires have been proposed as a potential tool to reverse this process. In 2010 and 2013, a series of controlled fire treatments of varying intensities were conducted in the Kruger National Park, South Africa, to evaluate the short- and medium-term effects on woody vegetation structure. Initial findings indicated that repeated high-intensity fires significantly reduced woody cover in the short term, with greater declines observed when two consecutive high-intensity fires were applied. However, this approach also led to notable losses of large trees, raising concerns about its long-term sustainability. A decade later, a follow-up study reassessed these sites using ground surveys and airborne LiDAR. Despite the initial reductions in woody cover, results showed that a decade later, shrub density increased across all fire treatments, with no significant differences between high-, medium-, and low-intensity fires. Large trees continued to decline due to ongoing mortality, likely influenced by fire and herbivory (presumably elephants). These findings highlight that while one or two high-intensity fires can temporarily reduce woody cover, their effectiveness in reversing encroachment of fire-adapted savanna woody species is limited over the medium term. The study highlights the importance of long-term monitoring and adaptive fire management strategies, and alternative approaches to reduce woody encroachment in future may include wet-season burns when the woody vegetation is still phenologically active. The study also highlights the logistical costs of conducting high intensity fires and the importance of proactive communication to the broader public.

Keywords: Bush encroachment, Fire management strategies, High intensity fires, Vegetation structure, Woody densification

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Fire in the Earth System Abstracts
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Burn History and Ecoregional Gradients Alter Leaf Litter Flammability Trait Values and Variability

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Abstract

Following a century of fire exclusion across the eastern U.S., historically fire-maintained open forests (savannas and woodlands) with a high-flammability herbaceous understory are transitioning to closed-canopy forests with a dense midstory of encroaching fire-sensitive species. Prescribed fire is used to restore open forest structure and composition, but its successful implementation requires flammable leaf litter fuels which may depend on a variety of factors ranging from the presence of broad species groups (pines (*Pinus spp.*), upland oaks (*Quercus spp.*), non-oak hardwoods) to inter- and intraspecific trait variability associated with ecoregion and management history. Understanding this variability in leaf litter flammability can help predict the potential efficacy of prescribed fire for restoring degraded open forests. Our study asks how species, ecoregion, and burn history influence litter flammability trait values and variability. We hypothesized that trait values would be associated with higher flammability and less variable in oaks compared to non-oaks, less compared to more productive ecoregions, and regularly burned compared to unburned stands. To address these hypotheses, we collected leaf litter of 12 tree species from paired regularly-burned and fire-excluded stands at 11 sites across the southeastern U.S. and measured morphological traits previously shown to affect flammability, including surface area to volume ratio (SA:V), specific leaf area (SLA), and leaf thickness, curl, area, and dissection index. Among hardwoods, oaks had thicker, more dissected leaves with lower SLA and SA:V than non-oaks. Leaf area and curl varied more by ecoregion and burn history than functional group. Differences among oaks were driven by white oak (*Q. alba*) traits associated with lower flammability, while differences among non-oaks resulted from the lower flammability of red maple (*Acer rubrum*). Species differences among pines were due to higher curl and area of longleaf (*P. palustris*) compared to shortleaf (*P. echinata*), and high SA:V in loblolly (*P. taeda*). Burn history had no effect on average pine trait values. Hardwood trait variability responded most significantly to ecoregion, with low variability associated with less productive sites; however, three hardwood (*A. rubrum, Carya tomentosa, Q. falcata*) and one pine (*P. taeda*) species demonstrated decreased trait variability in burned areas. Overall, our results demonstrate trait differences among species and hardwood functional groups, and context-dependent responses of trait values

and variability to ecoregional gradients and burn history. Understanding factors affecting interrelationships between plant traits and flammability can help identify conditions where prescribed fire can be successfully applied to restore and maintain open forests.

Keywords: prescribed fire, morphological traits, open forest, leaf litter

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Fire in the Earth System Abstracts
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Shifting Forest Structure and Composition Following Decades of Fire Exclusion in the Eastern U.S.: Implications For Prescribed Fire Restoration and Wildfires

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Abstract

Following decades of intentional fire exclusion, fire-dependent, open pine (Pinus spp.) and oak (Quercus spp.) woodlands and savannas of the southeastern U.S. are transitioning into dense, closed-canopy forests dominated by shade-tolerant and fire-sensitive and/or opportunistic species (i.e., mesophytes). Historically, frequent, low-intensity surface fires exposed high-quality mineral soil seedbeds, reduced competition, and increased understory light availability, ensuring pine and oak regeneration, while the relatively open conditions and crowns of mature pines and oaks reinforced fire-prone conditions by promoting highly-flammable herbaceous undergrowth. Concerns about the loss of foundational pine and oak ecosystems and their provision of desired services, including timber and wildlife habitat, has led to the common application of prescribed fire, yet restoring fire may become increasingly difficult if encroachment decreases flammability. Over the last two decades, our research using experimental field burns and observations across fire gradients has demonstrated how mesophyte encroachment contributes to declining flammability through various interrelated mechanisms, including: 1) leaf litter traits that create moist, high bulk density fuel beds with reduced fuel loads, 2) crown and bark traits that increase relative humidity and decrease light, and 3) generalist traits of regeneration that allow persistence despite prescribed fire application. These findings suggest that mesophyte encroachment may hinder fire restoration attempts under controlled conditions. However, new data modelling wildfire occurrence and potential drivers indicate that drier weather combined with expansion of the wildland-urban interface may outweigh any dampening effects of mesophytes on flammability due to increased susceptibility of dense, small-diameter aboveground woody vegetation to accidental ignition and crown fires, thereby increasing the likelihood of wildfire events. Thus, shifting forest structure and composition may differentially influence flammability depending on fire ignition type and concurrent weather conditions.

Keywords: oak, pine, fuels, flammability, fire behavior, wildland urban

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Fire in the Earth System Abstracts
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Effect of Fire in Soil Microbial Composition in Thermo and Meso-Mediterranean Forest Areas in Sicily

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Abstract

Climate Change is a major problem affecting our planet, leading to an increase in the average global temperature, length of the arid season, and strongly increasing the probability and intensity of fire events. Mediterranean regions , such as Sicily, are particularly prone to this threat because they include many semi-arid areas under desertification risk. Fire events can influence soil microbial communities' composition both directly, destroying the community itself, and indirectly, modifying soils' chemical and physical features. In our study, we sampled 4 burnt areas of Sicily characterized by two different soil composition (calcareous and volcanic), two forest types (oak forests and pine afforestation), belonging to two different bioclimatic belts (thermo and meso-mediterranean) and we compared them with not impacted equivalents (i.e. not burnt areas). The samples were analyzed with meta-barcoding approach to characterize and compare the fungal and bacterial communities' composition. Our results show that fire affected the fungal component more than the bacterial one, which seemed to have a higher resilience and capacity for recovery after fire. The ectomycorrhizal genera Russula and Cortinarius, abundant in unburnt areas, have been replaced after fire mainly by airborne decomposers and generalist plant pathogens. In addition, our study shows that the site itself and the reforestation of the burnt areas can play a key role in determining the composition of microbial communities. In fact, the burnt and unburnt microbial communities in the same locality were closer to each other than burnt samples from different locations. Moreover, forest stands dominated by evergreen oaks were close to each other, in terms of microbial communities, even when growing in different soils and bioclimatic conditions. In conclusion, our data suggest that, in the studied

forest ecosystems, fire plays an important role in shaping the structure and composition of microbial communities, particularly the fungal component, which seems to be less resilient than the bacterial one and with longer recovery times after the disturbance event, with a more evident pattern in calcareous than in volcanic soils. At the same time, forest cover (native forest with oaks or afforestation with pines) played an important role in determining the diversity of the microbial community itself.

Keywords: Fire, Microbial communities, Reforrestation

Fire in the Earth System Abstracts
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Interaction Between Wildfire, Dieback and Avalanches in Transboundary Forests Between Italy and France: Implications For Forest Ecosystem Services Protection, Production and Biodiversity

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Abstract

Climate change is altering the regime of natural disturbances and their interactions in many ecosystems worldwide. In the Alpine mountain region, forests are experiencing a phenomenon of dieback and an increase in the frequency and severity of disturbances. Potential interactions between these processes could result in unprecedented impacts on the provision of multiple ecosystem services. In this context, the ALCOTRA project 'SylvAFoRes' (Adaptive Forestry for a Resilient Forest) promotes an innovative management approach aimed at understanding these processes and their effects to adopt new silvicultural solutions. The project focuses on a densely populated cross-border alpine area, covering the Durance Valley (France) and the Susa Valley (Italy). Our methodology began by identifying forest stands affected by dieback using the FORDEAD protocol, based on open-source Sentinel-2 satellite images, which was validated for mountain forests. These stands were included in the analysis of fire and avalanche hazard to assess the effect of dieback on these disturbances by comparing the pre- and post-dieback conditions. Fire hazard was defined as the combination of probability and intensity of burning, assessed through the software FlamMap. Avalanche hazard was estimated in terms of Potential Release Area (PRA), which also integrated information on fire hazard, to assess the potential combined effect of two interacting disturbances. Finally, we intersected dieback and wildfire hazard areas with layers representing the ecosystem services of protection, production and biodiversity to account for potential impacts. Our results show that both wildfire hazard and Potential Release Area (PRA) of avalanches increased in presence of dieback, by 0.55 % and 0.27 % of forested area respectively. When dieback is combined with wildfire events, PRA rises more significantly (2.79 %). Additionally, dieback and wildfires appear to reduce the provision of ecosystem services, with wildfires having a greater negative effect on protection and biodiversity, while dieback more strongly impacts production services. Our findings support the identification of forest stands most vulnerable to interacting disturbances, where management efforts should be concentrated. Adaptive and climate-smart silvicultural treatment should prioritize dieback-affected areas for both fire prevention and avalanche mitigation, to ensure the provision of ecosystem services to society.

Keywords: SylvaForRes, compound disturbances, Alps, Flammap

Fire in the Earth System Abstracts
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Pyro-Sylviculture in Mountain Dry Conifers to Mitigate Crown Fire Potential

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Abstract

Dry conifer forests in the European Alps are increasingly exposed to high-severity crown fires. These forests, often dominated by Scots pine and other flammable conifers, are subject to prolonged drought and foehn winds. When slope direction, wind, and continuous, even-aged canopy layers align, the probability of crown fire increases. Traditional management approaches, e.g. uniform thinning, are insufficient to mitigate crown fire potential on steep mountain slopes.
The study proposes a pyro-silvicultural treatment combining ecological principles and fire behaviour physics to structurally modify forests, reducing crown fire likelihood and promoting surface fire behaviour. Interventions create heterogeneous structures through variable retention harvests, selecting groups to retain and forming a network of elliptical gaps: larger gaps aligned with expected fire direction and smaller, transverse ones to disrupt fire spread. Selected stable tree in groups and fire-resistant isolated trees interrupt convective flows within gaps. The system enhances vertical and horizontal structural diversity, retains a basal area of 20–25 m^2/ha, limits trees to 400/ha, and opens at least 30% of the area to reduce fuel continuity, favouring less flammable species like larch and broadleaves. Activity fuels are treated with prescribed burning one to two years post-cutting.
Since 2022, this treatment has been implemented across a 40 ha shaded fuel break in a south-western inner Alpine valley. Supported by the Agritech project we used the Wildland Fire Dynamic Simulator (WFDS) to test for potential crown fire in control and treated areas. The treatments showed reductions in crown consumption, temperatures residence times above thresholds, and total energy release. Also untreated areas upslope of the fuel break benefited of the treatment displaying a reduced crown consumption. A martelloscope (Integrate training site) was also established for student and forestry technician education in pyro-silviculture for mountain conifer forests.
Unlike conventional methods, this approach actively manipulates fire spread dynamics by aligning biomass removal with wind and slope, enhancing upslope convective cooling and forcing hot air to rise vertically rather than fuelling lateral canopy spread. Although operational challenges remain, e.g. residue management and prescribed burning under favourable conditions, this method offers a proactive, scientifically sound framework for

improving the fire resilience of Alpine conifer forests.

Keywords: Closer-to-nature silviculture, WFDS, Scots pine, Alps

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Burned Understory Legacies as Indicators of Canopy and Ground Fire Severity

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Abstract

Fire severity indicates the degree of ecosystem alteration after a fire. Accurate estimation of fire severity, both in the vegetation and at the soil level, is essential for effective post-fire management. Remote sensing currently enables severity assessments over large areas; however, in areas where the canopy is only partially affected, its reliability in estimating soil severity may be reduced. Moreover, remote sensing estimates must be validated with field data to ensure accuracy for each specific fire event. Therefore, objective, simple, and rapid field methods are needed to evaluate fire severity across different ecosystem strata.

Traditionally, the minimum tip diameter of remaining branches of shrubs has been used as an indicator of fire severity in the understory. This study evaluates several understory metrics to determine their potential as indicators of fire severity in three ecosystems: Pinus pinaster and Pinus sylvestris forests, and Quercus pyrenaica woodlands.

Several metrics were calculated from the tip diameter, basal diameter and length of branches from Erica spp. shrubs in the understory. These were used as predictor variables for two canopy severity indicators (% foliage consumed and %f oliage scorched) and two soil severity indicators (%litter consumption and change in soil color—texture).

Results showed that the minimum tip diameter of remaining branches was significantly related to severity only in P. pinaster forests: % foliage consumed ($p= 0.003$; $R^2= 0.44$), % foliage scorched ($p= 0.003$; $R^2= 0.44$), and % soil change ($p= 0.007$; $R^2= 0.39$). In contrast, relative metrics such as the tip/basal diameter ratio showed significant relationships in both P. pinaster and Q. pyrenaica ecosystems for % foliage consumed ($p= 0.02$; $R^2= 0.33$ – P. pinaster; $p< 0.001$; $R^2= 0.84$ – Q. pyrenaica) and % foliage scorched ($p= 0.02$; $R^2= 0.33$ – P. pinaster; $p< 0.001$; $R^2= 0.60$ – Q. pyrenaica). For soil severity, significant differences were found in P. sylvestris forests for % litter consumption ($p= 0.01$; $R^2= 0.49$). The residual volume metric also showed strong correlations in P. sylvestris forests with % litter consumption ($p< 0.001$; $R^2= 0.85$) and change in soil color—texture ($p< 0.001$; $R^2= 0.74$).

In conclusion, while the minimum tip diameter of remaining branches is a useful severity indicator in P. pinaster forests, its effectiveness varies by ecosystem. Complementary metrics or a combination of burned legacy indicators may provide more robust field-based assessments of fire severity.

Keywords: fire severity, understory metrics, canopy severity, soil severity

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Enhancing Wildfire Resilience with Machine Learning and Earth System Models

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As wildfires become increasingly frequent and severe, there is an urgent need to strengthen our resilience against these destructive events. This session focuses on the integration of advanced machine learning (ML) techniques with Earth system models to improve the understanding, prediction, and management of wildfire risks. Attendees will explore how ML algorithms can be employed to analyze large datasets, uncovering critical factors that drive wildfire occurrences and behavior. The session will also highlight the integration of historical observations with Earth system model outputs to refine and constrain projections of future wildfire activities. This integrated approach enables the development of high-resolution regional wildfire risk maps, which are crucial for both immediate response strategies and long-term planning. Additionally, the session will present innovative efforts to create hybrid wildfire models that combine the strengths of ML with traditional process-based approaches in Earth system modeling. These hybrid models are designed to enhance the accuracy and reliability of wildfire predictions under various climate scenarios. By bringing together experts in ML, Earth system modeling, and wildfire risk management, this session aims to advance the field of wildfire resilience. Participants will gain valuable insights into cutting-edge methodologies that can inform and support policy and management decisions, ultimately mitigating wildfire risks.

Fire in the Earth System Abstracts
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Machine Learning and Deep Learning Approaches For Wildfire Spread Prediction

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Abstract

In recent years, wildfires have become a global hazard, occurring more frequently and with increased intensity. To help manage wildfires and understand the driving factors behind them, classical and traditional methods have been developed to predict the spread of wildfires. However, these methods, which are often based on empirical and mathematical approaches, have trouble capturing all the dynamics behind wildfire spread. With the advancement in computing, machine learning (ML) and deep learning (DL) methods have been adopted to predict the spread of wildfires with better accuracy. In this context, we reviewed ML and DL techniques used for wildfire spread prediction (Andrianarivony et al., 2024). In ML, approaches combining ML models and cellular automata (Zheng et al., 2017), or exclusive ML models (Rubí et al., 2023) are used to predict fire perimeters after a period of time. DL approaches leverage more complex models and achieve excellent performance by integrating multi-modal data. Convolutional neural networks (CNNs), such as those in (Jiang et al., 2023), are highly effective for processing spatial data. Convolutional recurrent networks (CRNs) (Masrur et al., 2024) are designed to effectively handle spatial and sequential data dependencies. Transformer-based models with attention mechanisms (Li et al., 2024) focus on important spatial regions when predicting wildfire spread. Reinforcement learning (Subramanian et al., 2018) and Graph Neural Network (Rösch et al., 2024) approaches are also explored to predict wildfire propagation. We also reviewed common datasets used with ML and DL techniques to predict wildfire spread. Tabular data such as fires from the Montesinho natural park (Cortez et al., 2007), which includes a diverse range of variables such as dates, coordinates, burned area, meteorological and vegetation variables, are used with ML models. Remote sensing multi-modal datasets, such as the Next Day Wildfire Spread dataset (Huot et al., 2022), which gathers remote-sensing fire entries with topography, vegetation, weather, drought index, and population density data across the United States, are used to train DL models. We further investigated potential areas of improvement with the use of ML and DL approaches to predict wildfire spread. The lack of explainability and interpretability of models limits their usefulness for authorities. Moreover, real-time models and generalised models should be explored further. As ML and DL models rely on the data they are trained on, developing high-quality datasets should be prioritised alongside developing reliable metrics to measure the performance of these models.

Keywords: Wildfire, wildfire spread prediction, machine learning, deep learning

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Literature Review on Machine Learning Approaches For Wildfire Prediction and Risk Assessment

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Abstract

In recent years, accurately predicting and assessing wildfire risk has become increasingly important for implementing effective prevention, mitigation, and management strategies. The field of wildfire science and modeling has advanced significantly through the application of machine learning (ML) and deep learning (DL) algorithms. This review presents a overview of various ML approaches employed in wildfire prediction and risk assessment, including a focus on DL as a specialized subset that employs artificial neural networks to automatically learn complex data patterns, often requiring minimal manual feature engineering. Logistic regression is frequently used for binary classification tasks, such as estimating the likelihood of wildfire occurrence. It incorporates variables like meteorological conditions, vegetation patterns, and socioeconomic factors to model wildfire risk across diverse regions. Decision trees and random forests constitute ensemble learning methods that excel at capturing non-linear patterns and identifying the significance of predictor variables. These methods have been effectively used for wildfire prediction in countries such as Portugal and Spain. Support Vector Machines (SVMs) are robust in handling complex, high-dimensional datasets, and have been applied to predict wildfire risks in regions like Lebanon. Meanwhile, artificial neural networks (ANNs) and deep learning architectures such as convolutional neural networks (CNNs) and long short-term memory (LSTMs) networks have demonstrated strong potential, especially when leveraging large heterogeneous datasets such as satellite imagery and atmospheric data. Ensemble methods, which merge various ML models, have been explored to improve predictive accuracy. Techniques such as bagging, boosting, and stacking have been utilized to integrate decision trees, random forests, and ANNs yielding improved wildfire risk predictions, particularly in the western United States. The integration of spatial and temporal dimensions within wildfire datasets has led to the development of sophisticated spatiotemporal models. Approaches employing LSTMs and similar techniques effectively capture the dynamic nature of wildfire occurrence and proliferation, particularly noted in regions like California. The potential of hybrid models combining numerous ML and DL algorithms, alongside diverse data sources such as satellite imagery, meteorological data, and geographic information, is also emphasized. These integrated frameworks have been instrumental in predicting wildfire risks in regions such as California and Spain. This review synthesizes a broad range of ML and DL techniques utilized in wildfire prediction and risk modeling,

illustrating their capabilities and highlighting the ongoing development. The findings underscore the transformative impact of these technologies in enabling more accurate and efficient wildfire management strategies.

Keywords: Wildfire prediction, Risk assessment, Machine learning, Deep learning, Ensemble methods

Acknowledgments: This research is funded by the ONISILOS programme, which has received funding from the European Union's Horizon 2020 Research and Innovation Programme under the Marie Skłodowska-Curie grant agreement No 1 10103440, and by the University of Cyprus.

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Deep Learning Approach For Smoke Detection

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Abstract

Wildfires cause severe damage to ecosystems, economies, human lives, and properties. For example, in 2023, Canada recorded the worst wildfire season, with over 17 million hectares burned (CIFFC, 2025). In 2022, forest fires burned more than 900,000 hectares of natural land in the Middle East, Europe and North Africa (EFFIS, 2025). As a result, various smoke detection systems have been proposed over the years to enable early wildfire detection, as smoke is often the first visible fire sign, and to help minimize damage. Recently, deep learning models have been employed in detecting and localizing smoke zones using ground and aerial images. These models show high performance better than classical machine learning methods. However, there are still numerous challenges related to smoke detection, including complex backgrounds, which include diverse terrain, vegetation and weather conditions, the presence of smoke-like objects such as clouds, and varying smoke size, intensity and shape, as well as the detection of small areas of smoke (Ghali and Akhloufi, 2023). To address these challenges, we employed YOLO models for detecting and localizing smoke, as they offer an excellent trade-off between speed and performance, enabling real-time detection (Gonçalves et al., 2024). Experimental results showed that YOLOv8 achieved a high performance with a mAP of 98.10% and a rapid processing speed (GFLOPS) of 28.40 compared to existing models. This demonstrates the potential of deep learning models for real-time smoke detection when integrated with monitoring systems, enabling rapid fire fighting and response, and improving fire management strategies.

Keywords: Smoke detection, Wildfire recognition, Deep learning, YOLO models

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Advancing Vegetation Analysis in Mediterranean Shrublands Through Remote Sensing Integration

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Abstract

Mediterranean shrublands, characterized by their exceptional plant diversity and high susceptibility to burning, present unique ecological challenges, management difficulties and research opportunities. Despite the global advancement of remote sensing technologies for vegetation analysis, their application in Mediterranean shrublands remains underexplored. This study aims to bridge this gap by showcasing a comprehensive methodology to accurately calculate vegetation cover, phytovolume, and biomass in these ecosystems using drone-based remote sensing. Field sampling provided foundational data on phytovolume and biomass within representative plots, essential for validating remote sensing outputs. Drone flights were conducted, employing RGB cameras, multispectral sensors (capturing red, green, blue, NIR, and red edge bands), and LiDAR technology to collect high-resolution spatial data, generate detailed point clouds, and calculate vegetation indices such as NDVI to assess plant productivity. A machine learning model was developed and trained to estimate vegetation cover, integrating remote sensing data and ground-truth validation. The workflow encompassed vegetation classification, phytovolume computation from LiDAR-derived point clouds, and biomass estimation through regression equations linking field-measured biomass with calculated phytovolume. This methodology has to date been applied in two Mediterranean living labs in southeastern Spain, where prescribed burns, grazing, and pyric herbivory were implemented to evaluate their effects on fuel load and plant diversity over time. By addressing the challenges of uneven terrain and leveraging high-resolution spatial coverage, this approach enables frequent, non-invasive vegetation monitoring, capturing phenological changes and disturbances with precision. The integration of drone technology reduces the costs and effort associated with traditional methods, while offering novel insights into Mediterranean shrubland dynamics. Here we provide a replicable workflow to enhance vegetation analysis and biomass estimation, contributing to improved ecosystem management and conservation strategies in fire-prone regions.

Keywords: drone, LiDAR technology, Mediterranean ecosystems, plant cover and biomass estimation, pyric herbivory

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The Wildland-Urban Interface Index (Wuix) Applied to Rural Settlements: the Interface Exposure in Three Villages of the Montesinho Natural Park

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Abstract

Rural wildfires pose a rising threat to natural and physical ecosystems worldwide. North America and Mediterranean Countries, including Portugal, Italy and Greece, have been particularly affected by this hazard. Using Montesinho Natural Park, Portugal, as a case study, this study evaluates the exposure of traditional villages to wildfire by testing and adapting the Wildland-Urban Interface Index (WUIX) methodology developed by Caballero (2019) to high-resolution aerial imagery from 2018 and 2021 obtained from the DGT repository. An exploratory survey of 18 out of 88 Park's villages was carried out in 2022, including a detailed visual inspection of the buildings' exterior. Based on this preliminary work, three villages (Aveleda, Montesinho, and Rio de Onor) were selected for further spatial analysis. The selection was informed by a combination of factors: the relative preservation of the buildings concerning their traditional built heritage characteristics, higher wildfire hazard classifications according to the ICNF map, and distinct urban-forest interface morphologies. Exposure is computed in the WUIX methodology by using a two-scale grid, composed of a fine resolution (Rf) nested within a coarse grid (Rg) (set in this study to 1 and 10 meters, respectively), and by quantifying vegetation continuity (Cg) and vegetation-structure overlap (Fg). The result of this calculation is the WUIX index, in m² per coarse cell. To adapt the data preprocessing, vegetation masks were generated automatically via Normalised Difference Vegetation Indices with GNDVI threshold masks applied to RGB-NIR orthophotos, replacing extensive manual work. The three villages are surrounded by// both forested areas and agricultural clearings, identified as continuity and low-continuity areas, respectively. Between 2018 and 2021, Fg values clustered around 10-20 cm per meter in each village, while the mean WUIX increased slightly but uniformly, potentially indicating aggravation of interface exposure over the three-year interval. Aveleda exhibited the highest absolute Fg and WUIX values, presumably driven by denser "intermix" (intra-village vegetation) along its borders. In contrast, Rio de Onor displayed the lowest exposure, likely due to compliance with fuel-break setbacks. When mapped, Aveleda's southeast quadrant revealed a higher average value for Fg due to overhanging tree crowns and abandoned properties. The automated WUIX workflow effectively highlights the critical interface hotspots and temporal trends in exposure, providing a quantitative basis for heritage protection and wildfire mitigation planning. Future work will focus on automating

building footprint detection and incorporating machine-learning-based vegetation segmentation to refine exposure assessments across Montesinho and other ecosystems.

Keywords: WUIX, Wildland-Urban Interface, Montesinho Natural Park, Traditional Buildings

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Acknowledgments: This work was supported by the national funds (PIDDAC) through FCT/MCTES [MTS/BRB/0086/2020 – "Sustainability-led approaches for the rehabilitation and revitalization of the cultural built heritage of Montesinho Natural Park"];. The authors acknowledges the financial support of the Foundation for Science and Technology (FCT) through the project UIDB/04625/2025 of the research unit CERIS.

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Using Machine-Learning to Assess the Current and Future Wildfire Exposure of Villages in Portugal

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Abstract

Large wildfires occurred recently have shown the need to increase the resilience of populated areas and improve the self-protection abilities of their inhabitants. In Portugal, this is particularly important considering the dispersed housing patterns of the most fire-prone areas, where small villages and isolated houses intermingle disorderly with wildland areas.
Furthermore, in many of these small human settlements, vulnerability is high since permanent residents are elderly people. Assessing wildfire exposure specifically for villages is critical to assist in decision-making at local level, but creating models on a suitable scale remains a challenge. In this context, we tested a model based on machine-learning, to obtain estimates of wildfire distribution and villages exposure for mainland Portugal at 1-km resolution. Adapted from ecological modelling studies, the model incorporates the cumulative
percentage of burned area between 1980 and 2022 as dependent variable, which was converted into binary data (presence/absence of wildfires) using the mean value for the Portuguese territory as threshold (57%). As potential response variables, we calculated the percentages of landcover categories such as shrubland, eucalyptus and pine forests, invasive species, agriculture and agroforestry, based on national cartographic data. Topographic data was included through mean elevation and mean slope per grid cell. To represent climatic conditions, we collected 17 bioclimatic variables from CHELSA-climate, among which mean annual temperature, precipitation seasonality and net primary productivity. For exposure
analysis, social variables were included, specifically the number of residents, number of buildings and the proportion of dispersed housing per grid cell. After testing for collinearity, we applied the maximum entropy method (MaxEnt) with 20 predictors to obtain a wildfire distribution model. Results show that the variables with higher contribution are related to climate and landcover, with annual precipitation amount and proportion of shrubland, agroforest and agricultural land being the top predictors. The evaluation of the model indicates an AUC (area under the curve) above 0.9. Estimates for the future are obtained using projected bioclimatic variables with a relevant contribution to the model. Other scenarios are tested by changing the proportion of specific landcover classes. The results of the model are spatially combined with the database of human settlements, to analyse the probability of wildfire occurrence in the villages and their surroundings, as well as potential changes in the future, contributing to define tailored mitigation and adaptation strategies at local level.

Keywords: wildfire distribution model, maximum entropy, local level

Uncovering the Unseen: Wildfires effects on Aquatic Ecosystems

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Wildfires have long been recognized as a natural evolutionary driver of forest ecosystems, playing a crucial role in maintaining and shaping ecosystem dynamics, while also promoting biodiversity and productivity. However, the current wildfire regime has been drastically altered by human land use changes and global climate shifts, leading to an increasingly severe and complex global challenge. The consequences of wildfires extend far beyond immediate socioeconomic impacts, such as the tragic loss of human lives, property damage, and the immense costs associated with fire suppression. They also pose significant threats to environmental health, including the destruction of wildlife habitats and vegetation, and the disruption of ecosystem services. Among the less visible but equally critical impacts of wildfires are those on atmospheric, terrestrial, and particularly aquatic ecosystems. Wildfires can release large quantities of potentially toxic elements (PTEs) into the environment, contaminating air, water, and soil, and posing serious risks to species and human health. Of special concern is the effect on aquatic ecosystems, where the increased runoff generated by wildfires leads to the transport of sediments, ashes, and PTEs into downstream water bodies. This not only degrades water quality but also disrupts aquatic habitats, potentially leading to long-term ecological damage. This session seeks to explore the broad spectrum of short- and long-term environmental impacts of wildfires on aquatic ecosystems. We invite contributions that address the complex interactions between wildfires and aquatic environments, including coastal and marine ecosystems, as well as the implications for human health. Additionally, discussions on restoration and mitigation strategies to alleviate wildfire impacts on aquatic systems are highly encouraged.

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Effects of Wildfire Ash From Native and Exotic Forests on Growth and Recovery of Xenopus Laevis Tadpoles

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Abstract

Portugal has recently experienced intense wildfire seasons, affecting landscapes dominated by both native and exotic forest species. Wildfires produce ash containing potentially hazardous substances, such as polycyclic aromatic hydrocarbons and trace metals, which may reach freshwater systems and pose risks to aquatic organisms. The chemical composition and ecotoxicological profile of wildfire ash can vary depending on the vegetation burned; however, its effects on amphibians remain poorly studied. This study specifically aimed to investigate the capacity for short-term recovery in Xenopus laevis tadpoles following an acute exposure to aqueous ash extracts (AAEs) from native Arbutus unedo and exotic Eucalyptus globulus forests.
An 8-day exposure assay was conducted in which tadpoles were exposed for four days to either FETAX medium (control) or AAEs derived from each forest type, followed by a four-day post-exposure period in clean FETAX medium to evaluate potential recovery. A subset of individuals was sampled daily for biometric analysis, including body weight and lengths (snout–vent, tail, and interorbital distance), and subsequently frozen for internal contaminant analysis. Mortality was monitored throughout the assay.
Exposure to both AAEs led to reduced growth rates and lower body weight compared to controls. Although mortality remained below 10% across all treatments, treatment-dependent differences were observed. Signs of recovery in biometric parameters were observed on days 7 and 8 in tadpoles previously exposed to both A. unedo and E. globulus ash. These results suggest that wildfire ash from both native and exotic forests can impair early amphibian development, though some effects may be reversible following short-term exposure. Ongoing contaminant body burden analysis will further elucidate exposure dynamics and the organisms' detoxification capacity.

Keywords: wildfire ash, amphibians, growth, recovery

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Impact of Wildfire Ash on the Fatty Acid and Sugar Profiles of a Freshwater (Corbicula Fluminea) and a Marine (Cerastoderma Edule) Bivalve Species

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Abstract

Wildfires can significantly affect both freshwater and marine ecosystems, through post-fire runoff. However, the impact of post-fire runoff on bivalve species, particularly those in marine environments, remains insufficiently explored. This study aimed to fill that research gap by examining how ash exposure alters the fatty acids (FA) and sugar profiles of two edible bivalve species: the freshwater clam Corbicula fluminea and the marine cockle Cerastoderma edule, and what are the potential implications for the bivalve’s nutritional value.
To simulate realistic environmental exposure, both species were subjected to aqueous extracts of Eucalyptus ash (AEAs) at concentrations that reflect post-wildfire conditions. The exposure lasted for 96 hours. Results demonstrated species-specific responses, with the marine species, C. edule, showing more substantial biochemical changes compared to the freshwater clam. Notably, C. edule exhibited a decrease in overall FA content, particularly for C17:0, and a visible reduction in unsaturated FA - components that are crucial for human health and nutrition. Interestingly, an increase in sugar content was observed in C. edule with rising AEA levels, although only statistically significant for galactose and xylose. In contrast, C. fluminea exhibited less pronounced changes as there was only a slight increase in FA levels and decrease in sugar content, with statistically significant effects being only observed for monounsaturated FA. These findings suggest that marine bivalves may be more sensitive to wildfire ash exposure than their freshwater

counterparts.
This research provides the first evidence that runoff from wildfires can alter the biochemical profile of commercially consumed bivalves. Such changes have important ecological and public health implications. Alterations in the nutritional content of these species could influence aquatic food webs and reduce the quality of seafood consumed by humans. As wildfires are expected to become more frequent and extensive due to climate change, understanding these impacts becomes increasingly urgent, underscoring the need for more comprehensive evaluations of wildfire-related pollutants and their broader ecological consequences.

Keywords: wildfires, post-fire runoff, toxicity, invasive clam, common cockle

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Modelling fire in the Earth System

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Models are a necessary tool for predicting future changes in the Earth System and are useful for understanding the causes of past changes. Modelling fire is particularly challenging because many factors can influence fire occurrence, including climate factors, vegetation properties, topography, and the direct and indirect effects of human activities including management. The importance of different factors changes with spatial scale and in different vegetation types. Further complexity is added because fires have different properties and fire seasons vary substantially across the world. Intentionally lit and managed fires may be influenced by different factors than wildfires. Many different approaches have been used to model both wildfires and managed fires, ranging from purely conceptual models, through empirical modelling or machine-learning methods to process-based models. None of these models incorporate the full complexity of the controls on fire and the interactions between them. In the face of increasing fire risk under future climate change, and with changes in the magnitude, intensity and timing of fires already being observed in many regions, there is an urgent need to improve our current modelling capacity. In this session, we will explore how we can learn from different types of fire models to improve the current state of fire modelling and our ability to predict what will happen in the future. We encourage submissions that apply models of any level of complexity and at any spatial scale under past, present and future states that can further this discussion.

Fire in the Earth System Abstracts
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Role of Fire Regimes in Botswana's Miombo Woodlands: Opportunities For Enhanced Carbon Sequestration and Ecosystem Co-Benefits

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Abstract

Fire is necessary for maintaining savanna ecosystems, however uncontrolled fires have negative consequences for people, infrastructure and biodiversity. In Botswana, an increase in uncontrolled bushfires poses a threat to the integrity of vegetation structure and related carbon sink capacity of the local savanna ecosystem. This study examines the impacts of fire regime on the dry Miombo ecosystem in Botswana's northern Chobe District. Covering 21,000km2, the Chobe District hosts the Chobe National Park, all six (6) of the country's forest reserves and the largest elephant population in the world ca. 131,000, serving "low intensity high value" wildlife-based tourism. The fire regime is dominated by relatively severe late dry season (LDS) fires which significantly alter the structural and floristic properties of the local Miombo system. This research investigates the effects of fire regime on vegetation over a 32year fire history coinciding with establishment of permanent biomass sampling plots and cessation of commercial timber harvesting in the region. We derive a fire frequency index (FFI) based on a combination of automated MODIS 250m and manually extracted Landsat 30m burnt area mapping from 1992 to 2023 and relate FFI to changes in above ground woody biomass and soil organic carbon (SOC) conditions from sampling at eighty-nine (89) permanent biomass sampling plots. The study highlights fire management opportunities with a view to develop methodologies for carbon sequestration in the above ground biomass (AGB) and in the soil organic matter (SOM) for the regional dry Miombo ecosystem. The results show a significant loss of vegetation cover in high fire frequency areas. Additionally, we found that moderate fire frequency areas had strong SOC sequestration capacity in upper and middle deep sandy soil layers, while soil profiles under low fire frequency demonstrated greater carbon storage potential in deeper soil strata. Collectively, these results have significant implications for local fire management approaches, opportunities for emissions abatement and participation in carbon markets, while achieving desired conservation outcomes.

Keywords: savanna, Baikiaea plurijuga, fire management, forest management, wildlife conservation, ecosystem co-benefits.

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Predicting Summer Wildfire Potential in Jamaica: Models and Projections

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Abstract

Wildfire prevalence in Jamaica and the Caribbean continues to increase, as anthropogenic climate change impacts the region, highlighting the need for enhanced early warning systems. This study examines the development of statistical models to project future fire potential for Jamaica in the summer (July-August). All-island Keetch-Byram drought Index (KBDI), Water Potential (Ψ_w), Vapour Pressure Deficit (VPD), maximum temperature, and rainfall were used in an initial predictor pool to hindcast July-August all-island fire incidence over 2001-2019 as characterized using MODIS. LASSO regression was applied to calibrate the model over 2001-2013 and validate it over 2014-2021. The hindcast skill was evaluated using LASSO, multiple linear regression (MLR), and Poisson regression models and their R^2 values. The Poisson model outperformed the LASSO regression and MLR models with an R^2 of 0.81 versus an R^2 of 0.63 respectively. Future July-August (JA) fire risk potential is projected using the developed Poisson regression model applied to PRECIS 25-km A1B scenario data for the 2030s to 2050s. Future fire frequency increases by 5 to 12% for the north and south coasts and southeastern parishes, with the central portion of the country maintaining near historical risk levels.

Keywords: Meteorological-based Indices, Bushfire risk, Jamaica, SIDs, Caribbean

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Fire in the Earth System Abstracts
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Investigation of the Time Dynamics of Forest Fire Sequences in Basilicata Region (Southern Italy)

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Abstract

The time dynamics of forest fires occurring from 2004 to 2023 in Basilicata (southern Italy) were investigated using various methodological approaches. A clustering of fire occurrences over time has been revealed by a significantly high coefficient of variation, suggesting that the fire sequence does not follow a Poisson distribution and instead exhibits a clustered structure, largely driven by the heightened frequency of events during the summer seasons. The analysis of monthly forest fire occurrences and total burned area indicates a correlation between the two. This correlation is reinforced by shared patterns, like the annual cycle that appears to be influenced by meteorological factors, aligning with the yearly fluctuations in the region's weather conditions typical of a Mediterranean climate. Furthermore, the relationship between Standardized Precipitation-Evapotranspiration Index (SPEI) and forest fires revealed that the accumulation period of SPEI corresponds to the cycle length of the fires: longer cycles in fire occurrences align with higher accumulation periods in SPEI data.

Keywords: Fires, SPEI, empirical mode decomposition, time-clustering

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Improving Canopy Fuel Estimations For Fire Behavior Modeling in Arizona Using Google Earth Engine and Random Forest Regression.

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Abstract

Meeting fuel reduction and ecological restoration goals is a challenge for land managers in the Mogollon Highlands ecoregion in Northern Arizona. Fire behavior modeling, risk assessment, and management planning require landscape-scale data layers of forest fuels and structures such as canopy base height, canopy bulk density, canopy height, and canopy cover. LANDFIRE is a standard method in the United States used to obtain these structural layers, yet it can offer limitations due to the resolution and vegetative classification accuracy in non-forested ecosystems. We utilized multispectral imagery and Google Earth Engine (GEE) to validate LANDFIRE by creating finer-scale metrics to similar input and output metrics from LANDFIRE. We collected plot data from approximately 2,207 plots in Northern and Central Arizona in our landscape of interest in the Mogollon Rim region. We used Forest Vegetation Simulator (FVS) to create detailed structural information including canopy height, canopy base height, canopy cover, and canopy bulk density for each plot location. We used a Random Forest regression in GEE to create wall-to-wall raster data layer predictions to estimate fuel loads, canopy cover, and forest structures. We compared our fuel predictions to LANDFIRE by differing our predictions on a pixel basis to create difference rasters. We also calculated fit statistics, including bias, percent bias, index of fit, and root mean squared error, to compare our model and LANDFIRE to observed plot values on our landscape. From our fit statistics, we established our model out-performed or was on-par with LANDFIRE predictions of forest canopy fuel metrics. Our model performed best in a mixed-conifer forest ecoregion than the Sonoran Desert or juniper forest ecoregion, encompassing a smaller percentage of our landscape. We found that LANDFIRE tends to significantly overpredict canopy bulk density, canopy cover, and canopy base height, as evident in the fit statistics and difference rasters. Our GEE model provides more accurate, finer resolution, and region-specific predictions to LANDFIRE's nationwide predictions. Our model provides actionable insights that land managers can use to prioritize areas for wildfire risk mitigation, particularly in landscapes at high fire risk. Our research highlights the importance of integrating more region-specific data to inform fire behavior modeling better and improve wildfire management efforts.

Keywords: Forest canopy fuels predictions, Google Earth Engine, LANDFIRE validation, fire behavior modeling inputs, Random Forest regression

Fire in the Earth System Abstracts
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Analysis of Driving Factors and Their Spatiotemporal Heterogenetic Influence on Forest Fire Occurrence at Different Temporal Scales

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Abstract

To grasp the spatiotemporal patterns of forest fire occurrence influenced by meteorological, vegetational, topographical, and socioeconomic driving factors, and to determine the dominant factors of forest fires at different temporal scales, this research investigates the drivers of forest fires based on spatiotemporal heterogeneity in Anhui Province of China as the study area. First, we employed the Geographically and Temporally Weighted Regression method to model forest fire occurrence at the inter-annual scale. This approach revealed the varying spatiotemporal relationship between forest fire and driving factors. Innovatively, we introduced nighttime lighting as a socioeconomic variable, finding it to be significantly associated with fire occurrence. Compared to the typical socioeconomic factor GDP used in previous studies, nighttime lighting, with its high spatial and temporal resolution, independence, and objectivity, improved model performance. Our findings indicate that socioeconomic factors, particularly nighttime lighting, were the primary drivers of the inter-annual forest fire occurrence, informing long-term fire management policies. Second, considering the seasonal characteristics of forest fire, we adapted the inter-annual model for the inter-monthly scale. We analyzed the correlated relationship between drivers and forest fires and determined the dominant factors based on correlation coefficients. By comparing the dominant factors during the fire season and non-fire season, we found that there were seasonal differences in the dominant factors. During the fire season, the relative importance of meteorological, socioeconomic, topographical, and vegetation factors were 44.54 %, 44.43 %, 8.56 %, and 2.47 % respectively; during the non-fire season, the relative importance of meteorological, socioeconomic, topographical, and vegetation factors were 29.69 %, 51.38 %, 17.06 %, and 1.87 % respectively. Additionally, maximum and minimum land surface temperature, relative humidity, and sunshine hours were relatively important meteorological factors, while nighttime lighting, road density, and railway density were relatively important socioeconomic factors. These results provide a reasonable explanation for the division of fire season and provide a working basis for the short-term fire risk zoning. By comparing the dominant factors at the inter-annual and inter-monthly scales, we found that meteorological factors were more sensitive to the temporal scale selection. At the inter-monthly scale, it played a leading role in the occurrence of forest fires, while at the inter-annual scale, its contribution was relatively low. Socioeconomic factors were not sensitive to the selection of temporal scale and played strong dominant roles in the occurrence of forest fires at both temporal

scales. This discovery provides new insights into multi-scale research.

Keywords: forest fire, driving factors, spatiotemporal heterogeneity, temporal scale

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Simulating Fire in a Terrestrial Biosphere Model With Coupled Carbon, Nitrogen and Phosphorus Cycles

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Abstract

Fire is a key Earth System process, controlling forest dynamics and structure, surface hydrology and energy partitioning, and biogeochemical exchanges at time scales from years to centuries. With increasing temperatures under climate change, fires are expected to become more intense and frequent – a trend that is already being observed in some regions of the globe. Since fires can release large amounts of carbon to the atmosphere immediately, and regrowing sinks take long time to compensate these losses, changes in fire regimes can contribute to destabilize the global carbon cycle, potentially amplifying global warming.

In addition to their impacts on carbon, fires influence nutrient allocation and nutrient cycling, which in turn can feedback to vegetation dynamics over longer time scales. For example, fires can contribute to nutrient mineralization, making it more readily available for plants, but also enhance surface runoff and soil erosion, which may result in nutrient loss. Understanding these interactions is crucial to project the coupled vegetation-fire dynamics under changing climate conditions, as they might result in non-linear feedbacks.

Here we will present first results of an implementation of the SPITFIRE model in the QUINCY (QUantifying Interactions between terrestrial Nutrient CYcles and the climate system) terrestrial biosphere model including fire-vegetation interactions and fully coupled carbon, nitrogen, and phosphorus cycles. We will show results of idealised simulations that allow us to quantify the influence of nutrient-fire interactions in modulating long-term trajectories in vegetation structure and biogeochemical cycling.

Keywords: Carbon-cycle, terrestrial biosphere models

Acknowledgments: This work was funded by the European Union (ERC StG, ForExD, grant agreement No. 101039567)

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Integrating Human Dimensions Into Fire Models: Insights From Empirical Studies and Modelling Approaches

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Abstract

Humans have been using fire in the landscape for hundreds of thousands of years and, in the present day, a plethora of human activities modify fire regimes (Bowman et al. 2020). These include activities which directly affect fire, such as setting fires (both deliberately and accidentally) and suppressing fires. In addition, there are indirect effects from modifications to the land surface, which can change flammability, fuel load and fuel continuity. These effects can pull in different directions and with regional differences. This challenging situation is further compounded by the affects of anthropogenic climate change and land use change. The prevailing global trends are decreasing burnt area (Andela et al. 2017), but an increase in extreme fires (Cunningham et al. 2024) and forest area loss due fires (Tyukavina et al., 2022). Disentangling the drivers of these trends - particularly the human component- is essential for modelling fire in the Earth system. This talk gives an overview of some key empirical studies that have shed light on the how humans affect fire regimes, and of modelling approaches that have sought to capture these effects. Studies from regional to global scope will be included, with a particular focus on recent results from the FirEUrisk project at the European scale (Forrest et al 2024.).

Keywords: anthropogenic effects, global modelling, regional modelling

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Fire in the Earth System Abstracts
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Dancers in the Dark: Global Process-Based Modelling of Boreal Fires and Their Extremes

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Abstract

Process-based fire models run at global scales are poor at reproducing observed seasonal and interannual variation in burned area, as well as fire in less frequently-burned parts of the world. The brightest blind spot for these deficiencies lies in the boreal biome, where year-on-year BA variability may reach or breach an order-of-magnitude at regional and continental scales. The global increase of temperatures associated with climate warming is amplified four-fold in the high latitudes by (snow/ice)-driven surface energy imbalances, which has caused, and will increase, the frequency of extreme fire events. Further, much of the boreal region is underlain by carbon(C)-rich permafrost soils (double contemporary atmospheric C stock), which is highly susceptible to combustion. Soil combustion emissions are estimated to comprise 70-90% of the total from boreal fires. It is therefore critical that for appropriate modelling of future carbon cycle and Earth system trajectories, fire models ‘get it right’ on predictive simulation of boreal fires, and their extremes in activity, which they currently fully fail at achieving.

Here, we present the theory, rationale and results of the –to our knowledge –first attempt at addressing this globally, through developments to a pre-existing land surface model (ORCHIDEE)-integrated fire model (SPITFIRE). The new extreme fire module (XPITFIRE) implements a large number of processes and variables engaged in a ‘dance’ of fire -inhibiting and -promoting effects whose relative strength depends on an interplay of climate and vegetation states. These ultimately result in a much broader spectrum of fire severity outcomes than previously possible with this model paradigm. Fire drivers include crown fire rate of spread, wind and slope and drought driven factors, and ‘fire-embracer’ tree traits. Model fire inhibition occurs mostly through landscape-related phenomena such as road, and lake fragmentation, vertical discontinuities, and seasonally-variant features such as river width and water table depth, in addition to fire traits of ‘fire tolerant’ tree species. Together, these broadly reproduce the observed relative severity and aggregate ‘quantity’ of fire between sub-regions in a given year, between large regions between years (e.g. boreal fires of 2022 vs. 2023), and their sub-annual space-time distributions. Importantly, they reproduce the extreme interannual variation in fire activity observed in these areas. This suggests that extreme fires can be appropriately simulated by land surface models given sufficient theoretical consideration of simple process representations, paving the way for improved understanding and simulation of their future carbon cycle impacts.

Keywords: Boreal, extreme fire, process-based modelling

Fire in the Earth System Abstracts
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Modeling Future Wildfire Risks in South America With Flam

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Abstract

This study presents the application of the WildFire Climate Impacts and Adaptation Model (FLAM) in South America to assess historical and future burned area patterns under changing climate conditions. FLAM is a process-based, spatially explicit disturbance model that integrates climate variables, fuel availability, and anthropogenic influences to simulate fire occurrence, spread, and burned area. Using two Earth System Models, MRI-ESM2-0 and GFDL-ESM4, we evaluated forest burned area projections under Shared Socioeconomic Pathways SSP1-2.6 and SSP5-8.5, including adaptation scenarios from 2020 to 2100. The model was calibrated with observed burned area data from the Global Fire Emissions Database (GFED5) for 2001–2014 and validated against historical patterns both spatially and temporally.

Calibration results showed strong model performance at the monthly temporal scale (Pearson's r > 0.75 for MRI-ESM2-0 and 0.84 for GFDL-ESM4) and high spatial correlation in fire-prone regions, where seasonal fire hotspots particularly across Brazil, Bolivia, and Paraguay were captured by the model. Under SSP5-8.5, forest burned area was projected to increase by 36 % by 2100 in MRI-ESM2-0 and by 339 % in GFDL-ESM4, highlighting a substantial difference in model sensitivity. Spatial patterns in the projection results revealed fire expansion into ecologically sensitive zones, especially the Amazon and Gran Chaco, with GFDL-ESM4 showing a broader and more intense spread. Adaptation scenarios simulating improved suppression efficiency—extinguishing fires within 1 or 3 days—reduced forest burned areas by over 70 %, particularly in central Brazil and eastern Bolivia.

Overall, this study demonstrates the utility of FLAM in capturing the interactions between climate, land use, and wildfire behavior across temporal and spatial scales. The integration of dynamic suppression, probabilistic ignition, and high-resolution input data provides a strong framework for projecting future fire regimes and evaluating the benefits of mitigation and adaptation strategies.

Keywords: Climate change, Wildfire, modelling, South America, adaptation

Fire in the Earth System Abstracts
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Climate and Atmospheric Composition Impacts of Boreal Biomass Burning Emissions Changes

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Abstract

Biomass burning emissions have caused strong recent trends in aerosols over boreal Asia and boreal North America. Results from the Regional Aerosol Model Intercomparison Project (RAMIP) have shown that the impacts of aerosols are regionally very heterogeneous, and dependent on the location of emissions. Changes in emissions in different regions can lead to both local and remote impacts via teleconnections. There are further region-specific impacts from biomass burning emissions in the Arctic and boreal regions, such as black carbon (BC) deposition on snow. RAMIP results have also highlighted an important feedback of aerosols on fire weather, which is strongly regionally dependent.
We investigate the climate and atmospheric impacts of several idealised biomass burning perturbations, focusing on aerosols. We first perturb aerosol and precursor emissions from biomass burning over the whole boreal region, and then individually in smaller regions of interest (boreal North America, East Siberia and West Siberia). The emitted species include: BC, SO4, organic carbon, SO2, DMS, and secondary organic aerosol precursors. These experiments use 2005-2014 as a baseline period, and use the sum of this period as the perturbation, giving an approximately x10 perturbation in the regions of interest, in both fixed SST (30 years) and coupled (200 years) simulations. The strength and location of the aerosol changes studied here (when comparing aerosol optical depth) are comparable to the recent trends in aerosols between 2015-2024 and 2005-2014.
We present initial results from CESM2 (as part of an ongoing multi-model study) showing the atmospheric composition response both globally and in the focus regions described above, including teleconnections to other regions. We also highlight the climate response to the biomass burning perturbations, including effective radiative forcing (ERF) and fully-coupled climate response estimates.

Keywords: aerosols, boreal, arctic, fire weather, feedbacks

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The Role of Protected Areas on Burned Area in Portuguese Forests

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Abstract

Forest fires are natural disturbances, but their frequency and intensity are rising, especially in Mediterranean regions like Portugal. While many initiatives focus on nature conservation, the impact of protected areas (PAs) on wildfire dynamics remains underexplored.

This study investigates how PA status influences burned area (BA) across Portugal, considering land cover (LC) types, fire weather, and geography. We applied three modeling approaches—Quantile Regression (QR), Generalized Additive Models (GAM), and Random Forest (RF)—with leave-one-out cross-validation to assess these relationships while accounting for spatial autocorrelation.

Our results reveal a diverging impact of PAs on BA. Statistical modeling shows mixed effects depending on forest type and fire size. Broadleaf and mixed forests inside PAs often experience larger BA, while needleleaf forests show reduced BA when protected. However, PA status alone is a weak predictor of BA, with low R^2 values across models. The Fire Weather Index (FWI) consistently emerged as the strongest driver, highlighting the critical role of fire weather conditions.

Among the modeling approaches, GAM proved most effective, capturing non-linear relationships and interactions between PA status and LC types. QR offered valuable differentiation by fire size but was limited by linear assumptions, while RF handled complex patterns but lacked interpretability.

These findings suggest that while PAs can influence wildfire behavior, their effect is context-dependent and often secondary to weather conditions. Improving PA management strategies and incorporating additional predictors—such as human activity, road proximity, and topography—could strengthen future analyses.

This work provides a framework for assessing the role of PAs in fire mitigation and emphasizes the need for integrated conservation and fire management planning.

Keywords: Wildfires, Protected areas, Burned Area, Fire Weather Index

Fire in the Earth System Abstracts
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Fire Impacts of Large-Scale Forest Expansion in a Changing Climate

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Abstract

Expansion of forest cover is increasingly being proposed as a 'nature-based solution' for climate change mitigation, with governments and the private sector investing in tree planting and forest restoration schemes to meet net zero emissions targets. However, while the carbon sequestration potential of forestation has been widely estimated, the broader unintended Earth system consequences of massively expanding tree cover remain less explored, particularly in relation to wildfire dynamics.

We use a global land model, CLM5, with an active fire module to investigate the fire impacts of a policy-plausible global forest expansion scenario involving the addition of ~ 750 Mha of forest cover by 2095, under a range of warming scenarios as well as evaluating the impact of population projections. We find that forest expansion interacts in complex ways with climate and human activity to affect future fire regimes. Expansion of tropical forests reduces local burned area and fire emissions, both due to the replacement of flammable savanna grasses with more fire-resistant tropical trees, and by eliminating the deforestation fire signal which dominates in these regions. By contrast, expansion of temperate forests increases burned area in regions such as the Mediterranean, due to increases in fuel load combined with projected decreases in rainfall in a warmer world.

Population growth and decline also have an important impact on future fire patterns, which is sometimes comparable in magnitude to the land use change signal. In a warmer world, strong population growth in sub-Saharan Africa decreases burned area due to increased fire suppression, whereas population decreases in parts of Europe are associated with reduced fire suppression and thus higher burned area. Across scenarios, we find that fire consistently reduces the size of the land carbon sink by ~ 60 PgC by the end of the 21st century compared to the same model experiment with no active fire module.

Our results highlight the importance of incorporating the complex interactions between fire, vegetation, climate, and humans in Earth system models to comprehensively evaluate the consequences of land-based climate change mitigation strategies. We argue that assessments of the terrestrial carbon sink in the context of climate change must account for fire feedbacks, and that forest expansion in fire-prone regions, such as southern Europe and central Asia, may undermine climate mitigation efforts.

Keywords: Nature-Based Solutions, Climate Change, Earth System Modelling

Fire in the Earth System Abstracts
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Simulating Peat Ignition Probability: New Insights From Experimental Data

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Abstract

Peatlands, although they cover only 3% of the Earth's terrestrial surface, are vital components of the global carbon cycle, storing approximately 25% of the world's soil carbon. However, ongoing climate change is increasing the vulnerability of these ecosystems to fire, with severe implications for the climate. As global temperatures continue to rise, peat fires, which are the largest and most persistent fires on Earth, are becoming more frequent and intense, transforming peatlands from carbon sinks into net sources of greenhouse gas emissions. Such a transition initiates a positive feedback mechanism, amplifying climate change through the release of large quantities of stored carbon into the atmosphere. Despite the crucial role of peat wildfires in climate change, most-current generation Earth system models (ESMs) lack dedicated mechanisms for simulating peat fires, hampering their ability to accurately predict future climate dynamics. Unveiling the smouldering behaviour of organic soils at the laboratory scale and scaling these processes to the global level are essential. The current state-of-the-art method for assessing peat combustibility was originally established by Frandsen (1997) and later integrated in recent peat fire modelling efforts (e.g., INFERNO-peat). In his seminal work, Frandsen conducted laboratory experiments on natural peat samples and developed an empirical model for smouldering ignition probability, grounded in three key peat properties: moisture content, inorganic content, and organic bulk density. However, certain limitations arise as the model was calibrated using only one peat type, limiting its global applicability, while it yields non-physical results when applied to peat with differing properties. In this study, we present an enhanced approach for calculating peat combustibility by optimising the coefficients in Frandsen's model. Experimental data from previous studies on peat smouldering, from seven distinct peat types, were combined with new insights from our own experiments on the ignition thresholds of natural peat samples to determine a new set of coefficients. Incorporating these optimised values into Frandsen's model resulted in better calibration and contributed to a more robust model, enabling more reliable predictions of ignition probability across a wider range of peat conditions. Notably, the prediction error was reduced from 62.1% to 10.7%, indicating a substantial improvement in the model's predictive performance. By improving the simulation of peat ignition probability using experimental data, this research aims to enhance the representation of peat fires within fire models and ESMs, thereby providing deeper insight into their impacts on future atmospheric composition

and climate.

Keywords: peat, fire, modelling, ignition probability, smouldering, experimental data, optimization, Frandsen

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High-Resolution Vera Decision-Support Tool For Cross-Border Wildfire Smoke Management

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Abstract

Wildfires are increasingly recognized as European cross-border natural risks, exacerbated by climate change, land-use practices, and seasonal droughts. Due to their transboundary nature, these events not only complicate effective response strategies but also pose serious threats to human health, particularly due to the severe air pollution caused by the large amounts of harmful emissions.
The main objective of this study was to improve the European cross-border risk management mechanisms through the development of the VERA (Vulnerable Elements and Risk Assessment) decision-support tool for wildfire hazards. To achieve this, a high-resolution smoke dispersion system was developed and tested in the Portuguese-Spanish cross-border region (i.e., Alto Tamega-Orense)[DL1] [GU2] to simulate the dispersion of particulate matter. This system consists of a wind field meteorological model (NUATMOS), a wildfire spread platform (IMFire), and a smoke dispersion model (DISPERFIRE). NUATMOS is a diagnostic wind model that produces a three-dimensional (3D) mass-consistent wind field for the region under analysis, considering orographic characteristics and real-time weather measurements (i.e., wind speed and direction). IMFire is an online wildfire simulation platform based on the Rothermel fire spread algorithm, using 3D wind fields obtained from the NUATMOS model, topography, and fuel models as its main input datasets. DISPERFIRE is a Lagrangian modelling approach developed to simulate the dispersion of pollutants in the atmosphere resulting from emissions during a wildfire. Its main input datasets include wind fields from NUATMOS, as well as fire progression, rate of spread, and fireline intensity provided by the IMFire platform. Additionally, information regarding fuel models, fuel load, and emission factors by fuel type is also required.
The VERA decision-support tool demonstrated the ability to simulate the particulate matter dispersion with high spatial and temporal (minute) resolutions, showing strong potential for near-real-time application in wildfire management across European border regions. Preliminary results indicate that the system effectively identifies vulnerable areas and at-risk populations, enabling more targeted evacuation plans and optimised allocation of emergency resources. This integrated approach marks a significant

advancement in transnational wildfire risk management, offering enhanced situational awareness, improved coordination across European Countries' borders, and better protection of the population. Future work will focus on operational deployment and scaling the platform to other high-risk European cross-border regions (e.g., Spain-France border).

Keywords: Diagnostic wind model, fire spread algorithm, Lagrangian dispersion model, Emergency response planning, cross-border risk management

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Burnn: Modelling Global Burned Area With Deep Learning

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Abstract

The temporal coverage from ~2000 to present of global burned area satellite observations limits many aspects of fire research. As a result, global fire models are often being used to investigate past and future fire behaviour. Unfortunately, high interannual variability and the limited temporal coverage of the observations also hinders the development and evaluation of these fire models. The current generation of process-based global fire models are capable of simulating some characteristics of regional fire behaviour, such as mean state and seasonality, well. However, the performance of these models differs greatly from region to region, and aspects such as extreme fire behaviour are not well represented yet.
Here, we propose a new, data-driven fire model that predicts burned area from the same input parameters that are passed to global fire models. We trained LSTMs (Long Short Term Memory networks) to model burned area from GFED5. We split our data according to the IPCC regions and perform a region-based cross-validation, that is, we train different LSTMs on different region-splits of the data. We then compose the predictions of these different models so that for each region the predictions are made by LSTMs that have never seen any data during training and validation from that region before. Our model outperforms the ISIMIP process-based fire models on a global scale and in most regions across a range of skill metrics. With our model, we can improve our understanding of past fire behaviour and simulate future fire trends.

Keywords: machine learning, modelling, patterns, trends

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Harmonization of Burned Area Data: Improving Global Comparability and Accuracy With Firecci

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Abstract

Earth Observation data is a highly valuable tool for burned area (BA) detection, as it provides global information systematically across various wavelengths, particularly in the infrared. The FireCCI project, under the European Space Agency (ESA) Climate Change Initiative (CCI), aims to develop and validate burned area algorithms that meet the standards of the Global Climate Observing System (GCOS) for Essential Climate Variables (ECV). These algorithms rely on multi-sensor data to generate consistent, stable, and well-characterized global satellite products, primarily designed for climate modelling.

Throughout the FireCCI project, several burned area data records have been generated, such as the FireCCI51 product, covering the period from 2001 to 2022. This product, based on MODIS surface reflectance and active fires, has served as the foundation for the newer and improved FireCCIS311 product, which uses data from Sentinel-3 (S3) and VIIRS. This new product has shown a greater capacity for detecting burned areas, finding 25.5% more BA than FireCCI51 in the training year (2019). These global datasets provide key information for dynamic vegetation and climate models, with a spatial resolution of 250 m (in the case of FireCCI51) and 300 m (in FireCCIS311), and a gridded product at 0.25°. However, due to differences in spatial resolution, sensors used, and methodologies applied over the years, burned area data generated by these two BA products are not directly comparable. This limits the precision of global estimates for long-term climate modelling, because the two datasets cannot be used together to obtain a time series covering the time span of both products. For this reason, harmonizing these data is crucial to create a coherent and reliable time series that allows consistent analysis of fires over time. Harmonization, using machine learning models that integrate climatic, vegetation, and fire data, corrects these inconsistencies and improves the usability of burned area estimates over a longer time series.

The harmonized dataset allows for the detection of ∼700,000 km^2 more burned area per year (representing ∼16% additional BA) compared to previous FireCCI51 data (2001-2022 period). This advance is key generating consistent and comparable global time series.

Keywords: FireCCI project, Satellite Remote Sensing, Burned Area, Harmonization

Challenges and Solutions in the Wildland-Urban Interface: A Growing Threat of Wildfires

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As urban expansion continues to encroach upon natural landscapes, the Wildland-Urban Interface (WUI) has emerged as a critical zone of vulnerability for wildfires. This session explores the unique challenges associated with WUI areas, where human development meets wildland vegetation, significantly increasing the exposure to wildfires. We will discuss the primary factors contributing to the rising frequency and severity of WUI fires, including climate change, land-use planning, and human activities. Key topics will include fire behavior in WUI zones, the role of community preparedness and education, and the need for integrated fire management strategies that involve local governments, urban planners, and environmental agencies. Case studies from recent wildfires will illustrate the urgent need for comprehensive policies and technologies to mitigate wildfire risks, protect lives, property, and ecosystems, and ensure sustainable development in fire-prone areas. Attendees will gain insights into best practices for improving fire resilience in WUI regions, including innovations in firefighting techniques, landscape management, and fire-adaptive building designs. This session is vital for policymakers, urban planners, emergency responders, and environmental professionals dedicated to addressing the increasing threat posed by wildfires at the WUI. This session encompasses the key issues surrounding the Wildland-Urban Interface and wildfires, appealing to a broad audience interested in disaster management, urban planning, and environmental sustainability.

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Pyro-Socio-Ecological Zones: an Integrated Approach For Fire Risk Management in Wildland-Urban Interface Areas

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Abstract

Wildland-Urban Interface areas (WUIs) represent a critical point of interaction between human settlements and natural ecosystems at risk of wildfire. This study proposes a new three-dimensional framework, called Pyro-Socio-Ecological Zones (PSEZ), which integrates ecological, socio-economic, and governance indicators to analyze and map fire risk dynamics in two Mediterranean regions: Southern California (USA) and Southern Italy. Through the use of publicly available data, we developed a spatially explicit approach that combines factors such as land cover, plant biomass, Human Development Index (HDI), and governance indicators. The results indicate that in California, PSEZ with high governance levels experience fewer wildfires, while in Italy, PSEZ with low governance show greater burned areas despite fewer fire occurrences. This study highlights the importance of considering regional socio-ecological and governance contexts when applying fire risk methodologies developed in one area—such as the United States—to regions with different characteristics. The PSEZ framework offers an innovative approach to fire risk management, promoting more effective conservation and governance strategies in peri-urban areas globally.

Keywords: Socio-ecological systems, Peri-urban areas, Land use change, Land cover change, Biomass, Governance, Socioeconomics

Acknowledgments: This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This manuscript reflects only the authors’ views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

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Mapping the Wildland-Urban Interface: Concepts, Approaches, and Implications For Wildfire Risk Assessment

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Abstract

The Wildland-Urban Interface (WUI), where human settlements are in or near patches of flammable vegetation, is the epicenter of wildfire exposure to human lives and property. According to recent estimates, the WUI covers 4.7% of the global land area, though its proportional area varies substantially across continents, countries, and localities. The considerable effort that has been devoted to identifying the WUI in the past two decades resulted in a proliferation of WUI mapping approaches, which differ conceptually and methodologically. This has led to some confusion among researchers and stakeholders alike regarding the correct interpretation of WUI data. Therefore, understanding the rationale and assumptions behind different WUI mapping approaches is essential if one wishes to use WUI data as a component in wildfire risk assessments. Here, I will present the current state-of-the-art in WUI mapping, discuss the rationale behind different mapping approaches, address limitations and caveats, and elaborate on the implications of different WUI characterizations on subsequent estimates of wildfire exposure and risk.

Keywords: exposure, wildland-urban interface, mapping, settlements

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Mapping Wildfire Risk For Museums and Built Monuments in the Netherlands

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Abstract

In this paper we study to what extent tangible cultural heritage (museums and built monuments) is under threat of wildfire in the Netherlands, now and in the future, due to climate change. We discuss the susceptibility of heritage sites to wildfire, or landscape fires, which we argue to be a more suitable term for the densely populated Netherlands. By using Geographic Information Systems, we developed maps that combines existing geodata on fire susceptibility of the landscape (based on vegetation, locational and climate factors) and the location of museums and nationally listed build monuments. By doing so, we indicate which heritage values could be at risk due to landscape fire: 27% of the 192 museums and 24% of the 22.873 built monuments included in the maps are currently located within 500 meters from a highly susceptible area. The number of heritage sites located in areas with high susceptibility will more than double between the present day and 2050. As the susceptibility data do not cover the entire Netherlands, the absolute numbers are higher when urban areas and the Wadden Sea Islands would be included. Even though awareness of the potential risk of landscape fires on cultural heritage is increasing globally, this paper is the first in mapping susceptibility of heritage sites in the Netherlands. It is also innovative in making integrated analysis of maps developed by climate scientists and cultural heritage researchers for this particular climate risk. We argue that in order to achieve a complete risk assessment, specific conditions and heritage values and vulnerabilities need to be assessed locally. In order to explore the value of the national maps for this purpose and define the next steps, we assessed areas in the Netherlands that are particularly vulnerable. Across these locations, we selected five cases that vary in terms of soil type, type of heritage site and present function, and assessed these through interviews, desk research and local fieldwork. The case-studies show some level of awareness of fire risks amongst heritage actors, yet these do not often translate to actual heritage-specific preventive measures. The local (safety) authorities generally do not yet have a clear view of the vulnerabilities of the heritage at stake. Thus, this paper offers an important starting point for raising awareness and promoting risk assessment and mitigation measures for heritage in areas increasingly vulnerable to landscape fire.

Keywords: Wildfire susceptibility, cultural heritage, GIS, the Netherlands

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Mitigating Wildland Fire Risk Through a Fuel Break Placement Optimization Model

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Abstract

With increased wildland fire season severity due to climate change, there is heighten threat to communities and residential areas, especially in regions with a high proportion of wildland-human interface (WHI). This study explores the application of Critical Node Detection (CND) to inform strategic landscape management plans aimed at limiting fire hazard (spread and intensity) and fire risk to structures while considering the restrictive costs associated with hard-to-access areas.
This is exemplified through a case study on a landscape with intensive military training, where ignitions are frequent. Our objective was to identify optimal fuel treatment locations to restrict wildfires from escaping the base and impacting neighbouring communities. We integrated CND with fire-growth modeling and structure loss rate modeling into a fuel break placement optimization model to comprehensively assess wildland fire risk. Our preliminary results suggest which strategies to adopt according to the desired objective of the mitigation, comparing their costs and relative efficacy.
Our approach encompasses the assessment of wildland fire risk (i.e., hazard and impacts), and mitigation strategies, offering valuable insights for proactive wildfire management in comparable settings. This interdisciplinary framework serves as a robust tool in support of safeguarding communities and bridging the realms of fire science, land management, and land use, thereby enhancing overall wildfire risk management effectiveness.

Keywords: Burn-P3, Bush fires, Fire Behaviour Prediction System, Fireguards, FireLossRate

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Fostering a Sound Cross-Border Strategy For Wildfire Prevention and Suppression: a Regional Imperative Involving the Northern Cape and North West Province (South Africa) and Botswana, With Special Reference to the Erstwhile Bophuthatswana and Tribal Authorities.

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Abstract

Wildfires pose a significant and persistent threat to the ecological integrity, biodiversity, and socio-economic well-being of a contiguous region encompassing the Northern Cape, the North West Province of South Africa, and Botswana. This abstract underscores the urgent need for a cohesive cross-border strategy to effectively prevent and suppress these destructive events across this interconnected landscape. The regional impact of wildfires is exacerbated by shared climatic conditions, prevailing wind patterns, and similar vegetation types that facilitate the rapid spread of fire, irrespective of political boundaries.

A critical dimension of this strategy is the central involvement of Tribal Authorities, particularly in the areas of the former Bophuthatswana within South Africa, and their counterparts in Botswana. Tswana tribes have a significant presence across all three geopolitical areas, highlighting deep cultural and social connections that transcend national borders. Recognising that fires do not recognise political borders, a collaborative approach that respects these traditional governance structures is essential.

Integral to building resilient fire management capacity is the proactive development of Fire Protection Association clusters that transcend national boundaries within the affected region. These will serve as platforms for collaborative fire risk assessment, the development of localised fire management plans that consider cross-border impacts, the sharing of resources and expertise, and the coordinated suppression of fires. Tribal Authorities will be central to the establishment and governance of these FPA clusters, ensuring that traditional land management practices and local ecological knowledge are effectively integrated into regional fire management strategies.

Overarching cross-border strategies necessitate the establishment of joint regional fire

management fora, actively including representatives from national and provincial disaster management centres, local municipalities, conservation agencies, agricultural organisations and Tribal Authorities from South Africa and Botswana. These fora will harmonise policies, protocols, and resource allocation across the region. Collaborative early warning systems, integrating technology and indigenous knowledge, alongside joint public awareness campaigns tailored to local cultural contexts across the region, are also crucial components. The strategy calls for the creation of joint funding mechanisms to support these integrated activities, including training initiatives, the operationalisation of Peace Officers (including FPA committee members), and strengthening of cross-border FPA clusters. By prioritising training, empowering local Peace Officers (with representation from FPA committees), and fostering strong, cross-border FPA clusters in partnership with Tribal Authorities across South Africa and Botswana, this strategy aims to significantly bolster the capacity for wildfire prevention and effective suppression in this vital and interconnected ecological and cultural landscape.

Keywords: Northern Cape, North West Province, Botswana, Tribal Authorities, fires, training, peace officers.

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Defining and Assessing Bushfire Risks at the Wildland-Urban Interface in Australia

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Abstract

The wildland-urban interface (WUI) are areas where human developments occur in or near wildland vegetation (Bar-Massada et al., 2013; Johnson, 2001; Radeloff et al., 2005; Stewart et al., 2007). These regions are a prime focus in bushfire management since they are populated area at risk of fire impact and a major site of ignition, mostly caused by human activities (Balch et al., 2017; Cardille et al., 2001; Carlson et al., 2022; Stewart et al., 2007). Fires in the WUI present a wide range of challenges to control and have the potential to cause economic, social and environmental damage. In Australia, increasing urban expansion and climate-driven fire risks have intensified the need for improved WUI characterization and risk assessment.

Previous studies in Australia on the WUI are mainly focused on local areas used for specific purposes. Australia still lacks a nationally consistent definition of WUI, which is specific to the distribution of fuel wildland and settlements of the continent. Several WUI mapping approaches have been adopted around the world to demarcate WUI regions. The most common mapping approach in the US and Europe uses housing and vegetation distribution to identify the WUI. Since the characteristics of bushfire events are largely governed by geographic location and prevailing climatic conditions, the parameters and threshold values of such an approach are unlikely to represent the WUI scenario in Australia.

This study introduces a nationally consistent definition of the Australian WUI (WUI-Aus) using census data, based on the proximity of developed areas to predominant vegetation type. Spatial mapping for 2016 and 2021 provides insights on the nationwide dynamic changes in WUI extent, with implications for future land-use planning and fire management. To evaluate fire risks on WUI communities, we used SPARK to simulate bushfire spread under varying meteorological conditions represented by Forest Fire Danger Index (FFDI). The findings demonstrate that an integrated approach combining refined WUI mapping and fire spread modelling can help in identifying the risk zones and design effective risk mitigation strategies, emergency planning, and community resilience building.

Keywords: wildland-urban interface, bushfire, GIS

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Semi-Automated Multi-Criteria Filtering of Building Footprints For Enhanced Wildland-Urban Interface Mapping in Portugal

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Abstract

Reliable and up-to-date spatial information is critical for identifying territorial patterns and supporting decision-making in disaster risk management and urban planning. In data-limited contexts such as Portugal, the absence of a comprehensive national building footprint database constrains the effective mapping of the Wildland-Urban Interface (WUI). This study proposes a semi-automated, multi-criteria filtering method to improve WUI mapping by leveraging open-source datasets (Microsoft's Global Building Footprints – MSB and the Overture Maps Foundation – OMF) and referencing Portugal's national Geographic Building Database (BGE), which provides the locations of residential structures. The methodology applies spatial metrics to exclude anomalies (e.g., industrial facilities and solar farms) and to prioritise the identification of residential buildings, thereby optimising resource allocation towards socially vulnerable areas. Implemented using Python and ArcGIS Pro, the approach supports scalability across different administrative levels (municipal, NUTS-2, national).

The method was applied at the NUTS-2 level, establishing dynamic thresholds for minimum polygon area (80 m^2), maximum area (95th percentile), and maximum distance between building centroids and the BGE reference (either 150 metres or the 95th percentile). Additional metrics were employed to identify overlaps and oversized structures.

Results demonstrate that the Overture Maps Foundation (OMF) dataset tends to capture smaller, denser constructions, while the Microsoft (MSB) dataset captures larger, more dispersed buildings, leading to significant variations in spatial analysis outcomes. The filtering framework effectively removed non-residential structures, such as solar farms and industrial facilities, highlighting the need for region-specific adjustments. The filtering process reduced the MSB dataset by 45.8% and the OMF dataset by 46.3%. At the NUTS-2 level, the number of remaining buildings in both datasets continued to exceed those recorded in the BGE database for the Centro and Oeste e Vale do Tejo regions. In the Alentejo region, the MSB dataset was reduced by 55%, while the OMF dataset saw a 49% reduction in the Centro region.

In conclusion, the proposed method mitigates biases in open geospatial datasets and offers a scalable and adaptable tool for enhancing wildfire resilience planning in data-limited regions.

Keywords: Geospatial Data Validation, Spatial Bias Correction, Geographic Information System, Wildfire Risk Management

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The Influence of Lanscape Management Alternatives on Wildfire Exposure: the Case of Alvaiázere, Central Portugal

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Abstract

Changes in land cover and land use significantly influence wildfire occurrence, affecting its frequency, intensity, and spatial distribution. In inland regions of Portugal these changes have been historically characterized by sociodemographic changes and the abandonment of agricultural activities, leading to the expansion of shrub and forest vegetation. These changes have contributed to an increase in wildfire hazard, particularly in wildland-urban interface (WUI) areas. This study aims to analyze how the alternative management options influence wildfire hazard and exposure in the WUI of inland Portugal.The study area is composed by the villages of the municipality of Alvaiázere, Central region, focusing on the hazard within the surrounding 100 meters around them (distance defined by law). Hazard levels were estimated by combining two fire components: burn probability and flame length (to represent Susceptibility), both obtained with FlamMap, a fire behavior simulator operating at a landscape scale. Four land use scenarios were developed to represent different management alternatives: (i) Business-as-Usual (BAU), which maintains current trends; (ii) Natural Change, which extends the historical land cover transitions without active management (transition from agriculture to shrubland or forest observed between 1995 and 2018); (iii) Exposure Reduction, which changes land use to reduce human exposure to fire in high-exposed areas, replacing forest and shrubland with low-flammable agriculture uses; and iv) Support landowner concerns, increasing agricultural areas and expanding eucalypt and cork oak forests. Exposed Assets was calculated based on population density at the human settlement level, using a cartographic representation of built-up areas from 2018. Both components (Hazard and Exposed Assets) were normalized, classified into quintiles and crossed in a matrix, resulting in a variable that defines the exposure of highly populated areas to fire. Preliminary results indicate that under the BAU scenario a considerable number of villages are surrounded by high fire hazard areas. The Natural Change and Support landowner concerns scenarios show an increase in hazard. In contrast, the Exposure Reduction scenario leads to a notable reduction in the extent of critical areas. This study highlights the value of scenario-based modelling for supporting territorial planning and wildfire risk management in WUI zones. While fuel management remains essential, it is equally important to understand the influence of spatial and social predisposing factors to design more targeted and effective mitigation strategies, tailored to the specific characteristics of each village.

Keywords: Land Use, Hazard, Exposure, Wildfire

Forest and Wildfire Risk Governance: Obstacles and Opportunities

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This section aims to analyse the main challenges and opportunities in forest governance and wildfire risk management, focusing on models that involve collaboration between multiple stakeholders. The governance of forest, even if it is on State property, private or communal land, requires effective coordination between local communities, national, and regional authorities, state forest services, NGOs, academia, and the private sector. While the decentralisation of forest management is a growing trend in several countries, its implementation faces significant obstacles, such as bureaucracy and inconsistent State support. Throughout the section, we will examine various governance models adopted in different countries, highlighting the strategies used to address wildfire risk. We will analyse models such as Baldios Clusters, ZIF, AIGP in the context of Portugal and similar ones in other European countries. In this way, we intend to discuss the successes and challenges all these models have faced in their implementation, evaluating their contribution – or lack thereof – to reducing wildfire risk and promoting sustainable forest management. Additionally, we will consider the economic and social factors that directly impact the effectiveness of these models. We aim to identify barriers and synergies in legislation and practice and propose ways to improve coordination among the different actors involved. This critical analysis is essential for developing more effective public policies to increase forests' resilience and ensure their sustainability in the face of the growing wildfire threat. Furthermore, we hope the insights gained from this session will serve as a foundation for future international collaboration. KEYNOTES

1. Collaborative Forest Governance Models for Wildfire Risk Mitigation. Explore how different collaboration models between various stakeholders can contribute to wildfire risk mitigation.
2. Decentralisation in Forest Management: Opportunities and Challenges. Analise the decentralization of forest management in various countries, highlighting the challenges such as bureaucracy, overlapping regulations, and lack of State support, as well as the opportunities to enhance forest resilience through more effective governance.

3. Best Practices in Reducing Wildfire Risk: Lessons from European Forest Governance Models. Compare different forest governance models adopted in European countries, in different kind of state property, private or communal land, to reduce wildfire risk, highlighting the lessons learned and the successful strategies in terms of sustainability and resilience.
4. The Role of Economic and Social Factors in Sustainable Forest Management. Discuss the impact of economic and social factors on the effectiveness of forest governance models, with a focus on the implementation of public policies that promote sustainability and enhance resilient against wildfires

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Bridging the Enforcement Gap: Law Enforcement Peace Officer (Lepo) Training as a Catalyst For Environmental Compliance in South Africa

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Abstract

This paper proposes the strategic implementation of Law Enforcement Peace Officer (LEPO) training as a primary mechanism for enhancing the enforcement of environmental legislation across South Africa, with specific attention to the National Veldfire Act, No. 101 of 1998. Effective enforcement of this Act is crucial for mitigating the devastating impacts of veldfires on ecosystems, infrastructure, and livelihoods. While the Act places responsibilities on landowners and promotes Fire Protection Associations (FPAs), consistent and comprehensive enforcement remains a significant challenge. LEPO training provides individuals with the necessary legal knowledge and authority to act as peace officers, enabling them to ensure compliance with environmental laws. This approach can empower a broader range of stakeholders, beyond traditional law enforcement agencies and the often-inactive state entities, to actively participate in environmental protection. This additional module will focus on the full environmental legislative suite, thus empowering Peace Officers with the comprehensive knowledge required to effectively and efficiently apply various pieces of legislation relevant to environmental protection. By equipping personnel within FPAs, with this enhanced LEPO accreditation, a more localized and proactive enforcement strategy can be realized, particularly in addressing the current enforcement vacuum by state entities. The North West Umbrella Fire Protection Association (NWUFPA) model, recognized for its innovative integration of diverse communities, including tribal authorities, in fire management, presents an ideal platform for piloting the widespread adoption of this enhanced LEPO training. These trained officers, potentially including members of traditional leadership structures as empowered by the amended Act, can play a pivotal role in monitoring firebreak maintenance, ensuring adherence to fire prevention measures, and directly addressing violations of the Fire Act, even on state-owned land where current enforcement is lacking. Furthermore, to proactively prevent instances of landowners claiming ignorance of their responsibilities under the Act, NWUFPA has reportedly initiated a mechanism, such as a Notice of Compliance, which can be formally issued to non-compliant entities and landowners, including government bodies. This step aims to ensure that all stakeholders are clearly informed of their legal obligations regarding veldfire prevention and can be held accountable. This localized enforcement capacity, coupled with the collaborative framework of NWUFPA, the enhanced training through Nelson Mandela University, and such proactive communication initiatives, can lead to improved compliance, reduced veldfire incidents, and enhanced environmental stewardship within the North West Province. This serves as a blueprint for national implementation, particularly in compelling greater responsibility from Municipalities and Government Departments.

Keywords: Law Enforcement Peace Officer (LEPO), Enforcement, Veldfire, Compliance, Fire Protection Association (FPA), North West Umbrella Fire Protection Association (NWUFPA)

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A Comparative Case Study From Pacific Northwest of Us and Türkiye to Create the Holistic Management For the Large Fires

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Abstract

The increasing frequency and severity of mega-fires worldwide are driven by factors such as climate change, anthropogenic fires, past fire suppression policies, and socio-economic changes. These radical shifts in fire regimes have led to catastrophic ecological damage, economic losses, and threats to human life and property. The study argues that traditional technical solutions alone are insufficient to address the challenges posed by large-scale fires. Instead, a fundamental shift in the perception of fire is necessary—moving away from the dominant Western mechanistic view and embracing a broader ecological and social perspective.

For forest ecosystems to adapt to changing climatic conditions, forestry management must integrate ecological realities both during and after fires. This requires a transformation in political and social approaches to fire management. Specifically, societies must undergo an intellectual shift that acknowledges fire as an essential ecological process rather than solely a destructive force. Additionally, the study highlights the importance of reinvigorating traditional ecological knowledge—developed over millennia by local communities—to enhance fire management strategies. This traditional knowledge offers valuable insights into sustainable natural resource management, emphasizing a balanced relationship between humans and nature.

To explore these ideas, the research compares the fire ecology and management histories of the Pacific Northwest of United States (PNW) and Türkiye. Various research methods, including literature reviews, surveys, interviews, focus groups, and observational techniques, were employed to analyze fire management approaches in these distinct ecological regions. The study examined how ecological restoration techniques can contribute to developing climate-resistant forests and how traditional knowledge can be incorporated into fire management.

Furthermore, the research assessed how intellectual frameworks that promote coexistence with fire are communicated to the public. The ultimate goal of the study is to establish an interdisciplinary fire management cooperation model that could be applied globally. By integrating insights from fire ecology and environmental ethics, the study aims to influence international forestry policies and develop sustainable fire management strategies. The findings highlight the need for a holistic approach that combines scientific knowledge, traditional ecological wisdom, and policy reforms to address the escalating fire crisis.

Keywords: Holistic fire management, large fires, fuel storage management, traditional ecological knowledge

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Beyond Places and Assets: Reframing Valuation in Quantitative Wildfire Risk Assessments to Capture Stakeholder Perceptions and Value

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Abstract

As the wildfire crisis continues to intensify, cross-boundary landscape treatment prioritization is becoming more commonly integrated into future forest and fire planning globally. With this, the usage of wildfire management decision support tools and frameworks is expanding solely from fire and natural resource managers to a diverse variety of users including city officials, non-government organizations (NGOs), utility corporations, transportation services, and community wildfire protection planners. Quantitative Wildfire Risk Assessments (QWRAs) have been used as a framework for treatment prioritization in wildfire management for several years. These assessments heavily document the quantitative component and output for management objectives but often overlook reporting on the nuances of the collaborative stakeholder process. Highly Valued Resources and Assets (HVRAs) are a primary component of QWRAs; depicting spatially where values and assets are found on the landscape and how these values respond to varying degrees of fire intensity. Values included as HVRAs, as well as their response functions and relative importance, are designated by the stakeholders facilitating the QWRA. We sought to understand how stakeholders' perceptions of wildfire risk and treatment prioritization influence the HVRA valuation process. Our mixed methods study uses two qualitative methods, semi-structured interviews and participatory mapping, to investigate how stakeholders' experiences and perceptions of wildfire risk influence the collaborative risk assessment process; and how well the HVRA valuation process in QWRAs represents assets and values. We conducted interviews with 21 stakeholders involved in land management in northern and central Arizona. Additionally, we had stakeholders select their top three HVRAs for prioritization as well as provide feedback on a predetermined list of HVRAs from a standardized QWRA. Our results revealed that the Wildland Urban Interface (WUI) and perennial rivers and streams were the most prioritized values. Stakeholders' criticism of the predetermined HVRA list focused on missing values such as watersheds and culturally significant values, and an underrepresentation of ecological values. We discuss this theme further in stakeholders' selection of HVRAs and their corresponding response functions. Our results further explore the valuation process, embellishing how values are represented and misrepresented in QWRAs. These findings highlight potential implicit biases towards the built environment in QWRAs and call for improvements to the valuation process to better include ecological values. More research is needed on response functions to address

these partialities in the valuation process of risk assessments.

Keywords: Quantitative Wildfire Risk Assessment, stakeholder valuation process, Highly Valued Resources and Assets, value-action gap, stakeholder perception of wildfire risk

Fire in the Earth System Abstracts
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Devegetation Is a Pervasive Fire Driver in the Brazilian Cerrado

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Abstract

The Cerrado is the largest tropical savanna in the world, spanning approximately 24% of Brazil's territory. Its rich biodiversity and its heterogeneous landscapes, ranging from open grasslands to forested areas, are closely intertwined with fire, that has historically been present both as an ecological process and as a traditional land management tool by Indigenous communities. In recent decades, the Cerrado has experienced significant vegetation loss due to land-use conversion (i.e., devegetation), and neat alterations to its fire regime, including changes in frequency and seasonality, with profound implications for ecosystems and local communities. Although it is acknowledged that devegetation may influence fire activity in the Cerrado, the strength and scale of this relationship have rarely been quantified. This study aimed to assess, over the period 2003-2020, the amount of burned area and the number of fire events associable to devegetation, focusing on the portion of the Cerrado included in the state of Mato Grosso and in the MATOPIBA region. Using geospatial datasets on devegetation (i.e., PRODES Cerrado), fires (i.e., Global Fire Atlas), and land use (i.e., MapBiomas), we classified vegetation fires into two categories: Devegetation-Related Fires (DRFs), defined as fires ignited within, or up to 1 km from, devegetated areas, at the time of the land-use change; and devegetation Independent Fires (IFs). We further examined differences in fire regime attributes (seasonality, size distribution) between the two classes and evaluated their occurrence across different land tenure types (e.g., Indigenous territories, Protected Areas, and private lands) to assess how land governance structures may mediate the process. Our results show that over the 18-year study period, DRFs burned, with reduced average size and delayed seasonality, approximately 20 million hectares across the whole study area, corresponding to roughly a quarter of the total native vegetation area. These fires accounted for about 12% of the total burned area in the study region, and their extent is comparable to that of devegetated land during the same period. Although governance regimes such as Protected Areas and Indigenous Territories limited devegetation, they were less effective in curbing the cascading impacts of DRFs, which could spread into these areas. Our findings highlight the urgent need to halt illegal devegetation and to regulate fire use in the Cerrado through integrated fire management practices.

Keywords: Deforestation, Cerrado, Governance

Fire in the Earth System Abstracts
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Fire-Box: Innovative Tools For Science-Based Fire Risk Management

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Abstract

Wildfires under global climate change and anthropogenic land transformations are projected to increase in both frequency and severity, threatening ecosystems and local communities. In densely populated regions such as Italy, coordinated information and actions are essential to prevent and mitigate impacts. To support integrated fire risk management across administrative boundaries, the development of effective modelling tools requires access to high-quality data harmonized at a broad scale. The project FIRE-BOX addresses this need by delivering a standardised wildfire risk management toolbox at the Italian national scale, as key instrument for multiple stakeholders, including land managers, fire fighters, and researchers. FIRE-BOX comprises three core tools. i) a Fuel Tool, consisting of a standardised fuel-type map at the national scale, designed to support fire behaviour modelling. ii) a Fire Severity Tool, based on a wildfire database including all fire events occurred in Italy between 2007 and 2022, with related information on fire weather at the starting date, fire severity metrics, and fire emission estimates. iii) a Fire Risk Box, consisting of a modelling platform that simulates fire propagation across all the Italian National Parks, allowing to assess fire hazard, vulnerability, and exposure for landscape-scale risk management. The three tools will be available through a Web Box interface, providing diverse users with the project outputs. FIRE-BOX's innovation lies in delivering the first open-access tool for fire risk management harmonised at the Italian national scale, providing robust, science-based support for integrated management aimed at shaping a fire resistant and resilient landscape.

Keywords: Prevention, Risk Management, Climate Change, Fuel, Emissions

Fire in the Earth System Abstracts
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Common-Bases: Strengthening Collaborative Governance of Community Lands to Prevent Wildfires and Foster Sustainable Rural Development

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Abstract

In Portugal, approximately 15% of forest land is community-owned, known as *baldios*. These areas, managed by local rural communities, face persistent structural challenges due to the lack of up-to-date, systematized information regarding their boundaries, uses, and vulnerabilities. Despite their strong potential to promote social cohesion, generate employment, and conserve biodiversity, baldios are among the land tenure types with the highest wildfire risk in recent decades.

The COMMON-BASES project aims to address this critical governance gap by creating the first open-access, georeferenced national database of baldios, coupled with a wildfire hazard map at the national scale. Led by CEABN-InBIO (ISA/University of Lisbon), the project stems from a long-standing collaboration with ICNF, IFAP, baldio associations (e.g., BALADI), researchers, and local authorities. This participatory approach is key to strengthening collaborative forest governance models, such as the *Communal Lands Groups*, also discussed in this congress.

COMMON-BASES aligns with the goals of decentralization and shared land management by offering practical, evidence-based tools for decision-making. By systematizing up-to-date data from multiple sources, the project promotes transparency, institutional interoperability, and the empowerment of local actors. The wildfire hazard map will help prioritize risk prevention interventions in the most vulnerable areas, supporting adaptive and resilient forest management practices.

The project's contribution to this session is clear: it enhances the connection between science, public policy, and communities in wildfire prevention, while shedding light on the challenges of decentralization—such as institutional fragmentation, bureaucratic hurdles, and inconsistent support for community land governance. COMMON-BASES stands as a concrete example of how knowledge production and sharing can support more effective governance of forested territories under various ownership regimes.

In the long term, the tools and data produced by COMMON-BASES are expected to support new research, guide public policy, and foster more coordinated, transparent, and adaptive management of community lands — both in Portugal and as a reference for other countries facing similar governance challenges.

Keywords: Community-based forestry, Wildfire risk mapping, Commons management

Acknowledgments: The COMMON-BASES team acknowledges the support of FCT for funding the project under reference 2023.14216.PEX.

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Prescribed Fire, a Bridge Between Forestry and Grazing in Communal Lands

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Abstract

Portuguese communal land property (Baldio) is a remnant of an ancient governance model found in rural mountain regions. Today, it spans approximately 550.000 hectares, involves around 1.100 rural communities, and represents 13.8% of the country's forested area.

For centuries, these lands were essential to local livelihoods, supporting traditional agriculture and grazing systems. In the early 20th century, under the dictatorship regime, the State took control of these lands, implemented intensive afforestation, and severely restricted traditional uses. Only after the April 25, 1974 Revolution, communities regained their rights over these territories. By then, however, Portugal had undergone major socio-economic transformations: industrialization had led to the abandonment of agriculture and grazing, accelerating rural depopulation and contributing to an accumulation of biomass - factors that have recently contributed to large-scale wildfires.

Today, Baldios face conflicting public policies that heighten internal tensions and weaken the economic capacity of families to remain in rural areas.

This presentation shares the outcomes of a rural extension initiative carried out in three communities managing communal land, in the municipality of Mondim de Basto (Vila Real region). The project aimed to promote multifunctional forestry while respecting traditional land uses and economic activities. Prescribed fire was used as a bridge between ancestral grazing practices and modern forestry, improving pasture quality and significantly reducing wildfire risk. Through strong community participation and the involvement of key local leaders, the initiative also helped strengthen communal governance and reduce internal conflicts.

Keywords: Communal Lands, prescribed fire, communal governance, rural extension

Fire in the Earth System Abstracts
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Current Trends in the Management of Portuguese Baldio'S Area

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Abstract

The Portuguese communal lands – baldios – has hundreds of years of history. Since its beginnings, local rural populations have used these lands for their subsistence, which led to a progressive landscape change of forests, agricultural fields, and pastures. This process created the current local economic and social characteristics of the baldios. At the beginning of the last century, most baldios were nationalized by the State and were soon afforested. After the 1974 April Revolution, these territories were returned to their traditional owners – local rural communities– giving rise to the starting of their management and governance decentralization process. Currently, the Portuguese community forest areas occupy more than half a million hectares and are organized into more than 1100 units. Different stakeholders, such as commoners, Forest Services, and local authorities, are involved in their management. Their natural resources provide important support for the development of the rural economy. However, the current state and dynamics of the management processes of these lands are still little discussed. In addition, there is almost no information about the baldios of the Portuguese Atlantic islands of Azores and Madeira.

Several roundtables and interviews with stakeholders were held within the framework of Safer-Lands project, to discuss community-based forest management in Portugal. Among the topics discussed were: (1) The legislative framework of the forest regime, its impact on the management of baldios forest areas, and the need for its reform; (2) The main risks influencing the quality of forest management in baldios; (3) New management models such as clusters of baldios.

This presentation aims to discuss the topics mentioned above also presenting the final results of the SaferLands project.

Keywords: commons, commoners, forest management, Baldios governance, challenges, opportunities

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Nature-Based Solutions in fire management

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Nature-Based Solutions in fire management

Fire in the Earth System Abstracts
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Who Is Who About Forest Fires in Iran

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Abstract

Wildfires in Iran have shown a significant environmental concern as seven percent of the country is severely affected. Iran's forests are vital to maintaining biodiversity, regulating hydrological cycles, and providing essential resources to local communities in a country affected by Climate Change. We conducted a comprehensive review to elucidate key trends and patterns within the scholarly discourse on forest fires in Iran, focusing on the temporal distribution of articles, prominent authors, top journals, highly cited articles, and the geographical distribution of research efforts. This comprehensive analysis provides valuable insights into the dynamics, drivers, and implications of forest fires in Iran, informing future research, policy interventions, and management strategies. A bibliographic approach was necessary to know the contribution of the scientific community to understand the role of wildfire in Iranian nature and society.
This research reveals a significant growth in scholarly interest in forest fires in Iran over the past two decades, with a notable increase in publications from the 2010s onward, which is accelerated in the last three years due to the increase in forest fires as a consequence of climate change and land abandonment. Our investigations show that fire risk prediction and modeling are primary research focuses, with methodologies including GIS, remote sensing, statistical modeling, and machine learning algorithms advancing fire risk assessment and management strategies. Forest fires significantly impact hydro-ecological systems, altering vegetation dynamics, soil properties, and hydrological processes. Immediate effects include reductions in vegetation cover, soil compaction, increased runoff, and erosion, with long-term implications for ecosystem health and resilience. Climatic variables such as temperature, humidity, and wind patterns are critical drivers of fire behavior and risk, further exacerbated by climate change. The socio-economic dimensions of forest fires, although underrepresented in the literature, highlight significant economic losses, disruption of livelihoods, and community displacement. Effective fire management requires integrating community participation, robust policy frameworks, and advanced management strategies.
Forest fires in Iran are a growing interest for the scientific community and this is expected to increase in the next decade due to global warming and the greening of the landscape as a consequence of land abandonment and the governmental policies to restore ecosystems.

Keywords: Fire, Iran, Publications, Research, Findings, State-of-the-Art

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Fire in the Earth System Abstracts
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Advancing Climate Adaptation Through Forest-Based Nature-Based Solutions: a European Database Approach

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Abstract

Nature-based solutions (NbS) in forests offer a range of strategies to mitigate and adapt to climate change and support ecosystem resilience and biodiversity. Key options include ecosystem based reforestation, afforestation, rewilding, Sustainable Forest Management, Forest Conservation and Agroforestry. These NbS options in forests do not only help mitigate climate change by sequestering carbon but also enhance the adaptability of both ecosystems and human communities to the impacts of a changing climate. An inventory of all NbS for forests that are enhancing climate change adaptation (and important co-benefits for biodiversity and soil health) is being made in a database form. The database will include suitability mapping for: natural forest management and production forests in different climate zones in Europe, and under different socio-economic opportunities across Europe. The metadata collected such as geospatial, temporal, biophysical and socio-economic data, will be used to document and organize NbS in forestry systems, making it easier to analyze, share, and apply these solutions effectively. This metadata helps ensure that nature-based solutions are well-documented, transparent, and facilitating better decision-making, reporting, and replication of successful NbS initiatives.

Keywords: Biodiversity, Carbon Sequestration, Soil Health Metadata, Suitability Mapping, Socio-economic Factors, Ecosystem Resilience, Climate Change Risks

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From Ashes to Life: Microbial Insights Into Post-Fire Soil Recovery in Ávila´s Mediterranean Forest Ecosystem.

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Abstract

Wildfires have become a significant global threat, exacerbated by human activities that have increased their frequency and intensity, impacting human health, ecosystems, biodiversity, and the global climate (Luo et al., 2024; Baldrian et al., 2023). Forest fires are recognized as primary disturbances in forest ecosystems, profoundly affecting soil microorganisms through high temperatures and altering soil characteristics (Pausas et al., 2021). However, literature on this subject remains limited. In 2021, the province of Ávila experienced one of its most devastating fires in history, destroying 12,000 hectares. Our study aimed to isolate extremophilic bacteria capable of surviving the high temperatures of forest fires and to conduct a preliminary screening of their potential to rehabilitate fire-affected environments. To assess their survival under fire-related stress conditions, we performed a high-temperature assay and evaluated their anaerobic growth rate. Additionally, we tested their plant growth-promoting mechanisms *in vitro a*nd *in vivo.* Sampling was conducted near the village of Sotalbo (Ávila, Spain), and isolation on specific media resulted in the recovery of 21 bacterial strains. Identification of the isolates by 16S rRNA gene sequencing revealed that the predominant phyla were *Bacillota, Actinomycetota*, and *Pseudomonadota*. Among these, strain A.1, identified as *Bacillus licheniformis*, demonstrated the ability to thrive within a temperature range of 45°C to 400°C and to grow under anaerobic conditions. Furthermore, a soil recovery assay using burned soil samples, monitored over a 60-day period, showed that strain A.1 significantly contributed to soil recovery and enhanced plant development. To better understand its functional potential, the genome of strain A.1 was analyzed. Results verified the presence of genes associated with the plant growth-promoting traits and stress tolerance observed both *in vitro* and *in vivo*. In conclusion, our findings highlight the potential of *Bacillus licheniformis* A.1 as a promising candidate for the biotechnological rehabilitation of fire-affected soils, combining stress resilience with plant growth-promoting capabilities.

Keywords: wilfires, soil-microbiome, forest-recovery

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Fire in the Earth System Abstracts
Vol. 4 FES-461-In-person Oral
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Biodiversity and Carbon Credits as Means to Encourage Forest Management and Wildfire Prevention

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Impact Angle

Abstract

The Iberian Peninsula as other regions in Europe (mostly in the south) is hit with large scale forest fires that have been increasing in number as well as in area, every year. A context that has been set to worsen with climate change among other variables.
Forest management has been extensively argued as one of the key elements to decrease forest fires (in intensity and number). However, encouragement (regulatory enforcement or financial supports) for basic forest management is not efficient for landowners.
This work has explored how the carbon credit market and newly arrived biodiversity market influence potential income streams of landowners in the Iberian Peninsula. Mostly focusing on those income streams that can create a long-term stable forest management grounded on sustainable development and/or regenerative practices.
EU granted projects have been targeted using publicly available platforms such as CORDIS and the EU CAP network database and repositories such as Zenodo. These projects have been analysed from the extension of their interventions (km2 or hectares); the typology if these interventions (eg.: are they mainly focused on CO2 capturing without regard for species diversity and locally indigenous species OR species that can support regenerative practices?); including as well the timeline of these interventions and the recommendations at the end of project (mainly those focused on continuity of forest management and fire prevention).
With a listing of key projects chosen within the region of the Iberian Peninsula, a virtual analysis was made started with the question: could these projects have benefited from current established standards for carbon and biodiversity credits?
A mapping was created to illustrate the scope of the extent to which resources could be expected from these markets but also what preparatory steps (eg.: baselining analysis and project registration) would have been mandatory and could these realistically be expected from the landowners participating in the projects.
A proposal for next steps in accessing levels of support from these markets is made for long-term robust practice (and cultural change).

Keywords: biodiversity credits, carbon credits, regeneratives practices, sustainable practices

Wildfires and Climate

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Fire is a natural disturbance of ecosystems, a necessary element for the ongoing survival of ecological communities. Negative impacts arise when fire cannot be controlled in time and space. The co-occurrence of several factors, such as high temperature, low humidity, and the lack of moisture in fuels drives wildfires. All these factors are directly or indirectly related to climate variability and climate change. Recent climate changes induce warmer and drier weather conditions, increasing fuel aridity, leading to longer and more active fire seasons and increasing the burned area in several parts of the world. There has been reported an increase in extreme wildfires in Chile, North America, Australia, and Brazil, among other regions and several climate models projected that these tendencies will continue. Understanding the link between wildfires and current and future climate patterns and variations in the fire regime in response to climate change is crucial for better-defining management and prevention measures. The impact of climate on fire behaviour is still a challenging research topic due to the role played by individual and composed factors, such as climate, vegetation and fire activity. This session aims to encourage experts to analyse this topic from different perspectives, contributing to the increase of our understanding of the nexus between climate and wildfire, namely using new methods in remote sensing, ground observation, and field campaigns.

Fire in the Earth System Abstracts
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Convective Potential and Fuel Availability Complement Near-Surface Weather in Regulating Global Wildfire Activity

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Abstract

Wildfires are favored by hot, dry, windy, rainless conditions – this knowledge about fire weather informs both short-term forecast and long-term prediction of wildfire activity. Yet, wildfires rely on the availability of ignition and fuel, which are underrepresented in fire forecast and prediction practices. By analyzing satellite measurements and atmospheric reanalysis, here we show that near-surface weather only partially captures wildfire occurrence and intensity across the daily to seasonal timescales. Beyond near-surface weather, convection and fuel abundance play a complementary role in regulating burning processes. Specifically, enhanced atmospheric convection is identified for over 40% of the low-human-impact regions and 61% of global burnable areas during wildfire ignition and spreading periods, respectively. Meanwhile, 56% of shrublands and 54% of grasslands see higher fuel load with actual occurrence of fire. Our results highlight the role of convection and fuel in wildfire forecast, prompting a revisit of wildfire prediction under intertwined atmospheric and terrestrial changes.

Keywords: fire weather, ignition, convection, fuel

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Understanding the Ignition Mechanism of Lightning-Induced Forest Fires: From Smoldering Ignition to Flaming Transition

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Abstract

Lightning is a major natural driver of forest fires, and its associated wildfire frequency has been exacerbated by global warming. However, the ignition mechanisms underlying lightning-induced forest fires remain poorly understood, posing significant challenges for the early detection and warning. This study aims to elucidate the ignition mechanisms of lightning-induced forest fires by experimentally simulating the full combustion process—from initial ignition and smoldering to the transition to flaming—under controlled laboratory conditions. Experiments were conducted using twelve representative surface fuel types collected from six typical forest types in the Daxing’anling region, a lightning fire-prone area in northern China. Three fundamental stages of fire behavior development were systematically investigated: lightning-induced ignition, smoldering propagation, and the smoldering-to-flaming transition. Fuel moisture content was varied from 5% to 45%, and wind speed was adjusted between 0 and 5 m/s. The results demonstrated that discharge energy and wind speed significantly increased ignition probability, while fuel moisture content was negatively correlated with smoldering spread rate. Wind speed exerted the greatest influence on the smoldering-to-flaming transition. Moreover, analysis of 2024 lightning fire data from Daxing'anling, combined with ERA5-Land remote sensing products, validated the experimental findings. This research advances the understanding of the combustion dynamics of lightning-induced forest fires and provides scientific insights to support the early detection, risk monitoring, and management of lightning-induced forest fires.

Keywords: Lightning-induced fires, Forest lightning fires, Forest fuels, Wildfire, Forest fire risk.

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Fire Recovery Analysis of Recurrently Burned Vegetation Across Mediterranean Regions Worldwide

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Abstract

Warmer and drier climate conditions in the past decades have been changing fire regimes worldwide, leading to longer and more severe fire seasons in many regions. The Mediterranean ecosystems are an evident case, experiencing frequent fires within short return periods. However, although strongly adapted to fire exposure and exhibiting several adaptations to stimulate post-fire reproduction, the recovery dynamics of Mediterranean vegetation can be severely disturbed under compound effects of repeated weather extremes and changes in disturbance regimes.
Aiming to estimate the recovery rates of recurrently burned Mediterranean vegetation across different regions, we use a remotely-sensed product from MODIS, the Enhanced Vegetation Index (EVI), within the period 2001-2022. A mono-parametric statistical model is applied to the EVI time-series over pixels burned twice over the mentioned period. This approach allows to overcome the limitations of space-for-time substitution approaches, as it resolves recovery dynamics in space and time.
We find that vegetation tends to recover faster after the first event than the second, although large variability is detected, explained by regional differences in vegetation-type, fire severity, and post-fire meteorological conditions. Our results also show a strong dependence of recovery rates on fire severity, particularly for the more extreme fires. Fire severity can promote a faster vegetation recovery, especially in forested ecosystems. Furthermore, an important modulating role of pre-fire conditions on fire severity is also found, as higher EVI before the fire event can result in stronger relative greenness loss. Precipitation and air temperature play an important role in recovery rate, reflecting the importance of water availability in Mediterranean ecosystems and how precipitation regimes and temperature changes in the future may have the potential to affect the recovery of recurrently burned ecosystems.

Keywords: climate variability, EVI, fire severity, post-fire recovery, pre-fire vegetation conditions, remote-sensing

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Extracting Space-Time Pm10 Patterns During Fire Seasons in Portugal From Cams Reanalysis Data

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Abstract

Fire smoke significantly affects air quality as it contains a mixture of harmful pollutants such as fine particulate matter (PM10, PM2.5), carbon monoxide and volatile organic compounds. These pollutants can travel long distances and penetrate deep into the lungs, increasing the risk of respiratory and cardiovascular problems, especially in vulnerable populations. Therefore, air quality can deteriorate rapidly during wildfire (WF) events, raising public health concerns.
In this work, Particulate Matter (PMx) concentrations emitted during recent WF events in Portugal are analysed with a statistical approach based on functional principal component analysis when spatiotemporal correlations are present. For this purpose, three severe WF events with significant impacts on air quality in central and southern Portugal were analysed -those occurring in June and October 2017, and August 2018 - using CAMS European regional air quality reanalysis data.
Our results show that the proposed statistical approach can effectively extract the main spatiotemporal patterns of PM10 captured with CAMS reanalysis data. In the next steps, we will evaluate the effectiveness of this statistical approach as a feature engineering method for air quality classification, which can be very useful in informing populations living in areas less (or not) covered by the national air quality monitoring network.

Keywords: Wildfires, Air Pollution, Space-time patterns

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Vegetation fuel management for fire prevention and rural population retention. Pyric herbivory: prescribed burning and targeted grazing

Soil erosion and forest fires. The fate of sediments, water, nutrients, and soils in landscapes affected by fires

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Soil erosion is a key process to understand the landforms and their evolution. Forest fires determine the spatial and temporal changes in soil erosion rates. This is therefore that forest fires induce changes in vegetation and soil properties that finally trigger changes in soil infiltration, soil water retention, sediment transport, and runoff generation. The measurement scale highly affects the impact of fire on soil and watershed hydrology and soil erosion. Measurements and experiments carried out at different scales show that fire induces a sudden increase in runoff (less interception, lack of soil litter, water repellency…..) and an increase in sediment transport, soil crust development, and finally a more degraded soil. There is a need to understand better the impact of fire on the

connectivity of flows and sediments, the role of water repellency, and the strategies to recover the ecosystems after the forest fire. This session welcomes pure and applied scientific research to discuss the best methods to manage fire and avoid the impact on soil and watersheds due to fire. Experimental and theoretical research with site demonstration and literature review are welcome. Soil erosion measurements, estimations, models, and case study sites will be shown in this scientific session in Setubal, in June 2025.

Fire in the Earth System Abstracts
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A Literature Review of the Impact of Forest Fires Effects on Watershed Water Resources

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Abstract

Forest fires pose significant environmental challenges globally, profoundly affecting watershed hydrology. As human activities increase and climate change exacerbates, the incidence and severity of forest fires have escalated, leading to profound modifications in watershed hydrological behavior. This review synthesizes findings from numerous studies conducted between 1966 and May 2024, focusing on the short- and long-term effects of forest fires on watershed runoff, peak flow, sediment transport, and water quality. Key findings include significant increases in runoff volume and peak flow, with post-fire runoff in some regions increasing by up to 500 %. Fires also alter soil properties, reducing infiltration and increasing erosion. These changes persist over time, impacting groundwater recharge, baseflow, and water quality. Elevated levels of phosphorus, nitrate, and other pollutants in post-fire runoff present risks to aquatic ecosystems and human health, with potential for eutrophication and contamination of drinking water. The study highlights regional differences in hydrological responses to forest fires, with Mediterranean regions experiencing rapid runoff increases, while boreal forests exhibit more gradual hydrological changes. This review also discusses the methodologies employed, including hydrological models and remote sensing technologies, and outlines future research needs to address gaps in our understanding of fire-watershed interactions. Improved management strategies are essential to mitigate the hydrological impacts of increasing fire activity in forested regions worldwide.

Keywords: Watershed, Forest fires, Water, Resources, Hydrology

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Burning Versus Chipped Pruned Branches in Olive Plantations in Eastern Iberian Peninsula

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Abstract

The use of fire to remove the pruned branches is a traditional management in olive plantations. To chop the branches is a new option for farm management. Within the REACT4MED PRIMA project, we establish an experimental layout to determine the soil erosion in both plots under rainfall simulation experiments. At the municipality of Font de la Figuera, we measured in July 2022 the soil losses in 10 plots covered with chipped pruned branches (Mulch) and 10 plots in an area without (Burnt). Both plots, Burnt and Mulch, used herbicides to remove the weeds (Ghyphosate). A rainfall event of 55 mmh-1 over one hour was produced in each of the 20 plots (10 Burnt and 10 Mulch covered) and runoff was collected each minute and samples transported to the laboratory to determine the sediment concentration and later calculate the soil erosion. The results show that Ponding (Tp) and Runoff generation (Tr and Tro) were faster in the Burnt plots (65', 93', and 123' for Tp, Tr, and Tro) than on the Mulch treated plots (124', 254', and 302' for Tp, Tr and Tro, respectively). The mean runoff discharge was 56,54 % and 23,53 % for the Burnt and Mulch plots. Mean soil erosion reached 3,56 Mg ha-1 h-1 and 0,5 Mg ha-1h-1. The results show a positive influence on the runoff and sediment yield. The use of chipped pruned branches caused a quick decrease in runoff and soil losses as they acted as mulch.

Keywords: Mediterranean, Olive, Runoff, Soil Erosion, Rainfall Simulators

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Impact of Fire on Soil Nutrients and Understorey Vegetation in Chir Pine Dominated Forest in Garhwal Himalaya, India

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Abstract

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Abstract
In the Indian Himalayan region, Chir-Pine forests are frequently affected by forest fires. The study was carried out in *Pinus roxburghii* Sargent (Chir pine) forest in the Indian Himalayan region to assess the effect of fire on soil nutrient status at different altitudes (700 m, 800 m, and 1000 m), soil depths (0–20 cm, 20–40 cm and 40–60 cm) and on understory vegetation.
The soil nutrients and understory vegetation were assessed before fire (pre-fire) and after fire (post-fire). The results of the study indicate that fire plays an important role in soil nutrient status and understory vegetation. The nutrients (soil organic carbon, nitrogen, phosphorus and potassium) status decreased in post-fire assessment and with increasing altitudes, and soil depths compared to pre-fire assessment. The understory vegetation diminished after fire in all forest sites.
The study concludes that in Chir pine forest, fire plays a role in reducing soil nutrients along the altitudinal gradient, soil depths and understory vegetation. Thus, these nutrients can be saved through some management practices e.g., by early controlled burning and by educating local villagers about the negative impacts of severe wild fires on soil and vegetation.

Keywords: Himalaya, Forest fire, Soil nutrients, Altitude, Depths

References

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Acknowledgments: -

Fire in the Earth System Abstracts
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Hydrological Impact of Wildfire: Bohemian Switzerland National Park

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Abstract

In 2022, Bohemian Switzerland National Park in the Czech Republic experienced the largest recorded forest fire event in a recent Czech history, affecting over 10 km2 of forested landscape and triggering significant ecological and hydrological changes. Recognizing the crucial role that forests play in regulating hydrological processes, this study investigates the impact of the forest fire on Curve Number (CN) values, a key parameter in modelling precipitation and runoff. We investigated temporal changes in hydrological responses, variability in runoff generation and infiltration capacities in the burned sub-catchments near Stribrne Steny and Sucha Bela sub-catchments. The analysis utilized the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) to simulate pre- and post-fire hydrologic conditions. Land cover changes were quantified using Sentinel-2 satellite imagery, Unmanned Aerial Vehicle (UAV) data, and field validation surveys using a minimum distance classification method. Fire severity was mapped using the differentiated Normalized Burn Ratio (dNBR) derived from Sentinel-2 imagery. Soil samples taken from both burned and unburned areas were analyzed at specific intervals after the fire. Van Genuchten model parameters were used to determine changes in hydraulic conductivity and soil water retention. Meteorological stations installed after the fire provided real-time climate data (precipitation, temperature, humidity, wind speed, soil water content). The CN values calculated from satellite and UAV imagery, covering seven distinct periods between 2022 and 2024, enabled comprehensive HEC-HMS simulations. The analysis investigates the extent to which runoff peak responses shift under varying precipitation conditions during the gradual post-fire recovery period, highlighting the importance of understanding catchment behaviour following wildfire events.

Keywords: Wildfire, Curve Number, HEC-HMS, Soil Hydrology

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Small Fires Dominate the Recent Increase in Dust Emissions From Burned Landscapes

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Abstract

Wildfires reduce vegetation cover and soil biocrust, thus expanding bare grounds susceptible to wind erosion, as confirmed by in situ and satellite measurements. However, global characterization of post-fire dust emissions has remained qualitative and focused only on landscapes disturbed by relatively large wildfires. Here, by applying principles from fluid mechanics to multiple satellite measurements, we find that 61% of global wildfires at various extents are followed by enhanced dust emission, injecting 5.6 (3.3–9.2) Tg of dust per year during 2003 to 2022. 95% of this post-fire dust emissions are sourced to small wildfires, which occur more frequently and broadly than large wildfires especially across sparsely vegetated regions. Despite the recent decline in global burned area and a resultant decreasing occurrence of post-fire dust events, the total amount of global post-fire dust emission has increased by 77% during the last two decades. This elevation in total post-fire dust emission is attributed to intensifying burning and worsening fire-induced land degradation, which trigger a 155% increase in the intensity of post-fire dust emissions. With an ongoing enhancement of extreme wildfires and synchronized droughts under global warming, our results indicate the emerging importance of post-fire dust emissions globally and regionally.

Keywords: fire, dust emission

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Meng et al. (2025) Nature Geoscience, in press.

Fire in the Earth System Abstracts
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Practical Example of Opportunities in the Management of Marginal Mountain Lands in Northern Portugal - the Case of Life Maronesa

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AguiarFloresta/LIFE Maronesa

Abstract

LIFE Maronesa is a Governance, Information and Climate Action project that aims to implement strategies for adaptation and mitigation of climate change through a sustainable model of extensive livestock production. It targets commonland (re)use and management and linked Maronesa extensification breeding practices that increases potential for climate mitigation/adaptation, through soil carbon content maintenance and increased sequestration of CO2.

The main aim is to set up an integrated framework to encourage climate action on these communities which takes into account:

• peer-to-peer based knowledge transfer, among cattle breeders and local population;

• effective and broad monitoring, assessing and communicating socio-economic and climatic outputs, at the landscape, producer and market level;

• increasing overall governance and awareness raising, ensure improved understanding and valuation of the economic and social benefits by consumers and society;

• last but not the least, ensure replication with increased engagement of local breeders and at
larger scale with other native breeds.

The main success of this initiative is the demonstration that it is possible to improve the environmental and economic performance of extensive animal production systems at the same time. The LIFE Maronesa production system is increasing forage production in pastures and hay meadows. This is being achieved by increasing plant stock and nutrient cycling, and by replacing disturbance by intense fire with a combination of prescribed fire and herbivory (pyric herbivory).
This approach increases vegetation cover and favours perennial grasses, many of which have long rhizomes that anchor the soil. This process explains why the mountains have supported more domestic herbivores in the past and why shepherds have seen an increase in carrying capacity in recent years. It is a fundamental principle in ecology that replacing intense disturbance patterns with less intense ones has a positive effect on

biodiversity. Grass residues produce stable forms of soil organic carbon and are key to recovering the stock of soil organic carbon oxidised by forest fires.
As part of the marketing strategy, in order to economically optimise the proposed model, an ecological brand Clima Mais Positivo, was created to disseminate the project information to the stakeholders, peers and general public.

Keywords: pyric herbivory, extensive livestock farming, carbon sequestration, rural economic profitability

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https://www.lifemaronesa.eu/en/

Acknowledgments: Avelino Rêgo, Carlos Aguiar, Duarte Marques, Marco Fernandes, Rafael Costa, Tommy Ferreira

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Experimental Study of Post-Fire Wind-Drift and Dust Emission of Ash, Pyrogenic Carbon and Unburnt Litter in European Broadleaf and Coniferous Forest Environments

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Abstract

Information on post-fire aeolian dynamics in Central European temperate forests is scarce but crucial to understand effects on regional forest ecology, soil development, and air quality in a changing environment. To investigate and quantify wind drift and dust emissions of organic material immediately after fire, we conducted laboratory wind tunnel tests on two types of forest surfaces typical for North-Eastern Germany. We reconstructed natural forest stand surfaces including litter and duff layer of English oak (Quercus robur), and Scotts Pine (Pinus sylvestris) in metal trays, and initiated a controlled fire. The resulting surfaces contained a mixture of completely combusted ash, pyrogenic carbon and unburnt organic material. The trays were placed in the ZALF laboratory wind tunnel and exposed to wind velocities ranging from 3.5 m s^{-1} to 12.7 m s^{-1} for a test duration of each 10.0 minutes. Horizontal transport was quantified by collection in five heights between 0-0.3 m immediately at the end of the wind tunnel, and particulate matter (PM) emissions of 10, 2.5 and 1 µm in diameter were measured by aerosol monitors at two positions after passing a deposition chamber.
The quantity of total wind-drifted material and PM emissions were found related to tree species, state of combustion, and wind velocity. Broad leaf litter showed much higher horizontal transport and dust emissions than coniferous litter. While the oak leaves disintegrated quickly during wind impact, even completely combusted pine needles maintained their integrity longer. Threshold wind velocities were lower on oak (3.5 m s^{-1}) than on pine (5.1 m s^{-1}). Short wind events were found sufficient to mobilize a high percentage of total emitted organic mass: the emission peak was found at 1.5 (oak) and 2.0 min. (pine) after test start, and at 3.0 min., 65% and 55% of total emissions have occurred on oak and on pine, respectively. These results emphasize the impact of short, gusty wind on both post-fire forest surfaces.
The results underline post-fire wind-drift as a crucial factor to redistribute larger particles including pyrogenic carbon and unburnt organic material on site, horizontally and in wind direction, while post-fire PM emissions including mainly dust-sized ash lead to nutrient net-loss from site.

Keywords: Wind tunnel, nutrient dynamics, surface fire, fuel properties, experiments

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Effects of Fire Severity on the Coupling Relationship Between Fine Root Functional Traits and Soil Physicochemical Properties in Pinus Tabuliformis Forest

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Abstract

Plant functional traits are key for understanding the adaptive strategies to environments, and fine roots play a crucial role in nutrient acquisition. Examining the variation of functional traits of fine root and soil physicochemical properties, and investigating their coupling relationships and dominating factors, could provide a theoretical foundation for ecological restoration in the burned forest. We established 12 plots within Pinus tabuliformis Carrière forests subjected to light, moderate, and severe fire severities. Through detailed analysis of fine roots and soil physicochemical properties, we evaluated the variations and coupling effects in fine root functional traits and soil properties using the Coupling Coordination Degree Model (CCDM) and Partial Least Squares Path Modeling (PLS-PM). Our results showed significant differences in the functional traits of fine root and soil physicochemical properties across fire severities ($P<0.05$). The coupling coordination degrees between fine root functional features and soil physicochemical properties ranged from 0.4 to 0.6, with the following order: unburned, moderate, severe, and light severity. Forest fire negatively impacted the coupling coordination degree indirectly, primarily influenced by the direct positive effects of fine root morphological traits (e.g., specific root length) and soil nutrient properties (e.g., nitrogen, available phosphorus). The synergistic recovery of fine root-soil systems in Pinus tabuliformis forests was most pronounced following moderate fire severity, showing a medium-level coordination degree. For light-severity fires, enhancing fine root morphological characteristics through soil warming is recommended. In contrast, it is suggested to apply appropriate nitrogen and soil fertilizers for improving soil conditions after severe fire.

Keywords: Fine root functional traits, Soil physicochemical properties, Coupling Coordination Degree Modelling, Synergistic recovery

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Prescribed Burning in Global Research: a Systematic Review and Bibliometric Analysis

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Abstract

Prescribed burning, or controlled burning, has become an indispensable technique in the management of rangeland and forest ecosystems, where the intentional application of fire under strictly controlled environmental conditions serves as a vital strategy for achieving multiple ecological and management objectives. These objectives include the reduction of hazardous fuel loads, control of invasive plant species, enhancement of forage quality for grazing animals, stimulation of biodiversity, and the maintenance of native fire-adapted plant communities. In semi-arid ecosystems, where fuel limitations can affect fire dynamics, customized burn prescriptions have proven effective in generating desirable ecological outcomes without compromising plant productivity; indeed, studies demonstrate that late-winter prescribed fires, under moderate grazing pressure and normal precipitation regimes, can even improve forage nitrogen content and overall habitat quality. Furthermore, when combined with complementary techniques such as biosolids application, prescribed fires contribute to enhanced soil fertility and favorable wildlife responses, playing a critical role in nutrient cycling, soil stabilization, and ecosystem resilience. However, the broader implementation of prescribed fire programs faces significant challenges, including regulatory barriers, concerns about public safety, liability issues, variable weather conditions, and insufficient public understanding of fire’s ecological role, necessitating robust stakeholder engagement, education campaigns, and adaptive management frameworks. With the growing intensity and frequency of catastrophic wildfires driven by climate change, prescribed burning is increasingly recognized as an essential, cost-effective, and sustainable approach to landscape restoration, climate adaptation, and risk mitigation. A bibliometric analysis highlights the accelerating growth of research interest in this field: between 1970 and 2024, approximately 6000 scientific publications have been produced, with about 16% published before 2000, 26% between 2000 and 2010, 37% during 2010–2020, and 21% from 2020 to 2024, demonstrating a substantial upward trajectory in scholarly attention. Geographically, the United States leads with a commanding share of publications, followed by Australia, Canada, Spain, the United Kingdom, China, France, India, Germany, and Iran, illustrating that while research on prescribed burning was historically concentrated in specific regions, it is now gaining global relevance as environmental challenges become more widespread. Overall, this review synthesizes the ecological benefits, operational complexities, bibliometric patterns, and future prospects

of prescribed burning as an indispensable tool for sustainable natural resource management and climate resilience.

Keywords: : Prescribed burning, Fire ecology, Fuel load management, Climate resilience, Rangeland restoration

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Fire in the Earth System Abstracts
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A Review of Soil Erosion on Agricultural Lands in Iran

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Abstract

Soil is a fundamental resource sustaining agricultural productivity, rural livelihoods, and food security. In Iran's arid and semi-arid regions, soil erosion has emerged as a major environmental threat, with annual soil loss rates often exceeding 16.5 to 30 tons per hectare, severely surpassing global averages. Critical erosion hotspots include the Zagros Mountains, Alborz foothills, and provinces like Fars, Kurdistan, and Kerman. This article reviews soil erosion on Iranian agricultural lands, focusing on its causes, impacts, assessment methods, and management strategies. Natural factors such as steep topography, intense and irregular rainfall, and fragile soil structures predispose agricultural lands to erosion. Human activities, including improper tillage, overgrazing, inefficient irrigation, and unregulated land-use changes, exacerbate these vulnerabilities, especially where marginal lands are cultivated without conservation measures. Soil erosion leads to the depletion of topsoil rich in organic matter and nutrients, reducing crop yields and escalating farmers' reliance on chemical inputs, thus increasing production costs. Furthermore, sediment runoff pollutes rivers and reservoirs, impairing irrigation systems and threatening water security. The cumulative effects directly undermine Iran's national food security by elevating food production risks and increasing dependence on external supplies. Various techniques are used to assess and monitor erosion across Iran, ranging from field-based methods like rainfall simulation and sediment traps to remote sensing (RS) and geographic information system (GIS) applications. Empirical models such as the Universal Soil Loss Equation (USLE), Revised USLE (RUSLE), and Water Erosion Prediction Project (WEPP), often integrated with RS-GIS, offer valuable insights into erosion dynamics, although challenges remain in calibration and data availability. Effective soil erosion control relies on integrating biological approaches like planting cover crops and preserving natural vegetation with mechanical measures such as terracing and drainage construction. Sustainable soil management practices, particularly conservation agriculture emphasizing minimal tillage and continuous soil cover, have shown positive results, notably in Fars Province. Successful experiences from integrated watershed management projects in the Zagros region also illustrate the benefits of combining strategies tailored to local conditions. Despite these successes, widespread implementation faces obstacles related to financial limitations, technical capacity, and policy enforcement. Strengthening farmer education, providing financial incentives, and advancing localized research are essential to enhance soil conservation efforts and secure the future productivity of Iran's agricultural

landscapes.

Keywords: Soil degradation, Conservation agriculture, Sustainable land management, Erosion assessment methods

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Fire in the Earth System Abstracts
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Low-Cost, Low-Latency Wildfire Monitoring With Smallsats and Onboard Ai

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OroraTech

Abstract

The increasing frequency and intensity of wildfires, driven by climate change and land use pressures, calls for innovative detection and monitoring strategies. While traditional satellite-based systems have supported global wildfire surveillance for decades, their often coarse spatial resolution and limited revisit frequency constrain their effectiveness for early detection. This study explores the novel application of smallsats equipped with real-time on-orbit fire detection capabilities as a flexible and cost-effective alternative for global wildfire monitoring. We present a conceptual framework and initial performance assessment of a constellation of low-Earth orbit (LEO) smallsats that integrate compact thermal infrared sensors with onboard fire detection algorithms. By enabling rapid processing and alert generation directly in orbit, this system significantly reduces the latency between fire ignition and ground response. This high-frequency observation is particularly effective at closing the so-called “afternoon gap”—a critical window in the early afternoon (typically 13:00–17:00 local time) when many wildfires ignite but go undetected due to the lack of overpasses of existing Earth observation systems. With a ground sample distance (GSD) optimized for fire monitoring, the system is capable of detecting fires as small as 4×4 meters, allowing for the identification of ignitions in their earliest and most controllable stages. The integration of edge computing and satellite miniaturization marks a paradigm shift in Earth observation, empowering a new generation of fire management strategies.

Keywords: Wildfire detection, Smallsats, On-orbit processing, Edge computing, Thermal sensors, Afternoon gap, Fire monitoring

Fire in the Earth System Abstracts
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Evaluating Soil Conditioners For Erosion Control Over Three Years After Prescribed Fire in Mediterranean Shrublands, Ne Portugal

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Abstract

The increasing frequency of wildfires in Portugal, driven by higher fuel availability and the Mediterranean climate, has led to the growing use of prescribed fire as a vegetation management strategy to mitigate wildfire risk. However, the practice may compromise soil quality and conservation. This study aimed to evaluate the effectiveness of three soil conditioners in controlling post-prescribed fire erosion processes.
The research was conducted in a shrubland area within Montesinho Natural Park, NE Portugal, where spontaneous shrub vegetation had regrown after a wildfire, which partially destroyed a Pinus pinaster stand in 1998. In March of 2021, a prescribed fire was applied to reduce fuel load and protect approximately 12 hectares of remaining *Pinus pinaster* forest.
Eight erosion microplots (4 m2 each) were installed post-prescribed fire along the steepest slope gradient to assess erosion dynamics. The study compared the effectiveness of three soil conditioners – technosol (25 kg/m2), olive pomace compost (1 kg/m2), and polyacrylamide (0,005 kg/m2) against a control (burned area only). Sediment collections took place between March 2021 and April 2024 following rainfall events.
The global mean erosion rates over the three-year study period (1st year: 61.4 g/m^2, 2nd year: 50.9 g/m^2 and 3rd year: 7.9 g/m^2) and the surface runoff over two-years period (1st year: 7,6 mm and 2nd year 7,4 mm) suggest that post-fire erosion processes initially intensify but gradually decline over time. The erosion reduction was driven by soil conditioners, with technosol showing the highest efficacy (15% lower sediment loss and 48% less surface runoff versus control), followed by olive pomace compost (12% sediment loss reduction and 6% runoff decrease). The low values observed are associated with the level of soil degradation in the study area.

Keywords: Post-fire erosion, soil conditioners, Mediterranean ecosystems, prescribed fire.

Fire in the Earth System Abstracts
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Exploring the Influence of Wildfires on Hydrological Cycle Using Isimip Fire-Enabled Land Surface Models

Grillakis, Manolis, Tarasi, Dimitra and Voulgarakis, Apostolos

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Abstract

Wildfires can disrupt watershed hydrology for extended periods, primarily through the destruction of vegetation that modulates interception, transpiration, and soil properties. These disturbances may reduce water uptake and increase surface runoff, while in some regions, such as the boreal zone, fires may accelerate permafrost thaw and alter subsurface flow pathways. To investigate these processes on a global scale, we examine outputs from six fire-enabled land surface models participating in ISIMIP3a, covering the historical period 1850–2019. Our analysis focuses on changes in the runoff coefficient between the decades with the highest and lowest fire activity. To disentangle fire effects from background climate change, we utilize counterfactual simulations that exclude the global warming signal by applying detrended climate inputs. Preliminary findings indicate broad agreement with observed post-fire hydrological changes reported in literature, though inter-model variability remains considerable. This study evaluates the capacity of current land surface models to represent post-fire hydrological responses and seeks to improve their realism by highlighting the complexities of fire-water interactions.

Keywords: Wildfires, Runoff, ISIMIP,

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Can Conventional Forest Management Affect Soil C Stocks of Burnt Cork Oak Under Semi-Arid Conditions?

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Abstract

Forest ecosystems are one of the most important components of terrestrial carbon stocks.. The effects of conventional forest management on different C pools are poorly understood and may not be adapted to local edafoclimatic conditions, potentially reducing C stocks and/or altering stable carbon forms in the soil. The aim of this study was to evaluate the effect of conventional forest management on C stocks in a cork oak system affected by fire in 2004.
The study was carried out in the cork oak system of Serra do Caldeirão (Algarve, southern Portugal). Several plots of 706 m² each were selected in the area burned in 2004 (n=6/scenario; MP: managed; UMP: unmanaged). Conventional management of cork oak included felling and scrub clearance every 10 years. Most of the soils are classified as Leptosols and the climate is Csa (Köppen classification). In both scenarios, the amount of litter was quantified and soil samples collected (0-5 cm of depth) for analysis of bulk density, % fine fraction, total C, total organic C, labile C, total N. Soil C stock was calculated using the formula suggested by FAO, while litter was considered as 50% of the biomass amount.
Independently of the scenario, the organic C fraction had the largest contribution to total C in soils. Although organic C concentrations in soils were similar, concentrations of labile C and total N differed significantly between scenarios. Although there were no differences between the C/N ratios (MP: 32.4, UMP: 16.9) values indicated different rates of organic matter decomposition. The labile C concentration was lower in the unmanaged soils (mg/kg, MP: 5.23, UMP: 3.15), while the opposite was obtained for N (g/kg, MP: 1.81, UMP: 3.06). Unmanaged soils showed slower decomposing carbon forms and higher stability of organic matter.
The plots with forest management had higher total C stocks in the litter (t/ha, MP: 10.4, UMP: 3.5), mainly due to the higher number of trees. Litter does not seem to have influenced soil C stocks, as no difference was found between the scenarios for this parameter (t/ha, MP: 14.6, UMP: 12.2). Although soil C stocks were similar, the

contribution of soil to total ecosystem C was greater in the unmanaged plots (% of total system, MP: 25, UMP: 43).
The results suggest that forest management has not mitigated the effects of climate change by maintaining stable carbon stocks, and further studies are needed to better understand these dynamics.

Keywords: shrub clearing, Algarve, Quercus suber, C forms, litter.

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The Impact of Fire and Chipped Pruned Branches on Soil Erosion in Vineyards. the React4Med Research Project Contribution

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Abstract

The use of fire to remove the pruned branches is a traditional management in vineyards. Chopped branches are an option due to the improvement of the machinery, the subsidies and the reduction in labor and cost.. Within the REACT4MED PRIMA project and the CONERO project, we establish an experimental layout to determine the soil erosion in plots under rainfall simulation experiments; burnt branches versus chipped pruned branches. At the municipality of Moixent, Les Alcusses district, we measured in July 2022 the soil losses in 10 plots covered with chipped pruned branches (Mulch) and 10 plots in an area without (Burnt). Both plots, Burnt and Mulch, used tillage to remove the weeds. A rainfall event of 55 mmh-1 over one hour was produced in each of the 20 plots (10 Burnt and 10 Mulch covered) and runoff was collected each minute and samples transported to the laboratory to determine the sediment concentration and later calculate the soil erosion. The results show that Ponding (Tp) and Runoff generation (Tr and Tro) were faster in the Burnt plots (61', 91', and 110' for Tp, Tr, and Tro) than on the Mulch treated plots (120', 334', and 392' for Tp, Tr and Tro, respectively). The mean runoff discharge was 60.50 % and 29.59 % for the Burnt and Mulch plots. Mean soil erosion reached 6.56 Mg ha-1 h-1 and 0.67 Mg ha-1h-1, respectively. The results show a reduction from 6.56 to 0.67 Mg ha-1h-1. and a reduction in sediment concentration from 9.7 gl-1 to 2.19 gl-1 . The use of chipped pruned branches is very positive to achieve a sustainable agriculture management in vineyards.

Keywords: Soil, Water, Vineyards, Erosion, Runoff, Spain

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The Impact of Fire and Chipped Pruned Branches on Soil Erosion in Almond Plantations. the React4Med Research Project Contribution

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Abstract

Fire has been the solution to remove pruned branches in groves and orchards. Under rainfed agriculture the use of mulches can contribute to improve the soil health. The REACT4MED PRIMA and CONERO Projects research the impact of chipped pruned branches to reduce the soil losses in agriculture land. establish an experimental layout to determine the soil erosion in plots under rainfall simulation experiments; burnt branches versus chipped pruned branches. At the municipality of Font de la Figuera, we measured in June 2023 the soil losses in 10 plots covered with chipped pruned branches (Mulch) and 10 plots in an area without (Burnt). Both plots, Burnt and Mulch, used tillage to remove the weeds. A rainfall event of 55 mmh-1 over one hour was produced in each of the 20 plots (10 Burnt and 10 Mulch covered) and runoff was collected each minute and samples transported to the laboratory to determine the sediment concentration and later calculate the soil erosion. The results show that Ponding (Tp) and Runoff generation (Tr and Tro) were faster in the Burnt plots (68', 99', and 119' for Tp, Tr, and Tro) than on the Mulch treated plots (130', 366', and 456' for Tp, Tr and Tro, respectively). The mean runoff discharge was 55.55 % and 32.23 % for the Burnt and Mulch plots. Mean soil erosion reached 8.08 Mg ha-1 h-1 and 0.98 Mg ha-1h-1, respectively. The results show a reduction in sediment concentration in 6.34 times. The use of chipped pruned branches is very positive to achieve a sustainable agriculture management in almond plantations.n.

Keywords: Fire, Mulches, Agriculture, Erosion, Rainfed

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Post-Fire Recovery Time Effects on Soil Redistribution in Steep Rangelands: a ^{137}Cs-Based Assessment

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Abstract

Post-fire soil erosion poses significant societal and ecological concerns, particularly in managed ecosystems where it can cause severe degradation. This study investigated the effects of fire and post-fire recovery time (1, 5, and 10 years) on soil erosion rates (using the ^{137}Cs technique) and selected soil physicochemical properties in steep-sloped rangelands of western Iran. Three sites with similar slope gradients and parent materials were selected, each including burnt (sampled at 1-, 5-, and 10-year intervals post-fire) and unburnt treatments. Soil samples were collected from five depths (0–2.5, 2.5–5, 5–10, 10–20, and 20–40 cm) with triplicate replicates. Results revealed significant differences ($p < 0.05$) between burnt and unburnt treatments across all post-fire intervals for available phosphorus (P_{ava}), available potassium (K_{ava}), electrical conductivity (EC), clay and sand content, and magnetic susceptibility measures (χ_{lf}, χ_{hf}). However, no significant differences were observed in any soil properties between the 10- and 5-year post-fire treatments. Soil erosion rates, quantified via the ^{137}Cs-based profile distribution model (PDM), averaged 38.9 Mg ha^{-1} yr^{-1} in burnt areas compared to 23.02 Mg ha^{-1} yr^{-1} in unburnt rangelands.

Keywords: Soil degradation, Fire event, Radionuclide, Steep land, Soil properties, Profile distribution model.

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Pyric herbivorism: a forest fire prevention management tool

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Spain is one of the EU countries with the largest history of forest fires, but both the causes and the impact differs enormously across the different Spanish biogeographic regions. The combination of prescribed/controlled fires is a technique used across the globe to reduce biomass and therefore forest fire intensity to allow fireman to extinguish the fires as fast as possible. However, the efficiency of these prescribed/controlled fires can be promoted if after the vegetation sprout grazing is allowed. This session will discuss the last advances of the pyric herbivorism in three biogeographic regions of Spain (Andalucia, Navarra and Galicia). Papers from other regions linked to this topic will also be more than welcome.

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Fighting Fire With Fire: the Stoch Kalahari Formation in Practice: a Collaboration Between the North West Umbrella Fire Protection Association and Stenden University (South Africa)

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Abstract

This study presents the Stoch Kalahari Formation, a scientifically grounded approach to fire management developed through a partnership between the North West Umbrella Fire Protection Association (NWUFPA), the North West Provincial House for Traditional and Khoi-San Leaders, Farmers Associations and Unions, and Stenden University's Disaster Management Program. Designed specifically for traditionally underfunded drought-prone and arid regions of Southern Africa, this methodology integrates indigenous fire management techniques with contemporary fire science. The approach aims to mitigate wildfire risks while enhancing ecological and socio-economic resilience for the 4 million citizens across the North West Province's 10.5 million hectares. Students from Stenden University participate through Design-Based Education (DBE), undertaking monitored internships in the region under NWUFPA mentorship. The integration of fire management and mitigation into Stenden's Bachelor of Business Administration in Disaster Relief Management Programme creates a practical educational framework that bridges theory and field application. Research focuses on key areas including the Eastern Cape Province, the amaNdebele area of Mpumalanga under HRH King Mabhoko III, Northern Cape Province, Botswana border regions, and particularly the North West Province. The study highlights indigenous Tswana practices such as rotational grazing burns, patch mosaic burning, and fire as a rangeland restoration tool - practices that have evolved over generations of ecological observation and adaptation. By implementing strategically prescribed burns, the Stoch Kalahari Formation reduces fuel loads and restores degraded ecosystems while preventing catastrophic wildfires. This approach requires minimal water resources and limited firefighting vehicles, making it particularly suitable for resource-constrained environments. Scientific analysis includes comprehensive fire behaviour modelling, assessment of soil and vegetation responses to controlled burns, and evaluation of biodiversity impacts across multiple ecosystems. The research examines complex interactions between climate variability, fire frequency, and human activity in these fire-prone landscapes, creating predictive models for adaptive management. Findings confirm that integrating Indigenous knowledge into structured fire management enhances ecosystem resilience, ensuring fire functions as a regenerative rather than destructive force. The study contributes to sustainable fire governance discourse and proposes policy recommendations for incorporating traditional fire practices within modern regulatory frameworks. The research ultimately highlights the value of collaboration between scientific institutions, fire management authorities and indigenous communities in developing adaptive, region-specific solutions that address both environmental and socio-economic challenges in vulnerable drought-prone regions.

Keywords: Indigenous fire management, Ecological resilience, Drought-prone regions, Traditional knowledge integration, Sustainable fire governance.

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From Ancestral Practice to Modern Solution: Nwufpa'S Pyric Herbivorism Safeguarding North West'S Livestock, Game and Eco-Tourism

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Abstract

Pyric herbivorism, the ecological interaction between fire and grazing animals, represents a time-tested approach to fire management that is experiencing renewed appreciation in sustainable land management circles. This ecological strategy leverages the natural relationship between controlled burns and herbivore grazing patterns to reduce fuel loads and create heterogeneous landscapes that are more resistant to catastrophic wildfires. The North West Umbrella Fire Protection Association (NWUFPA) has successfully revitalised this age-old practice through collaborative partnerships with diverse stakeholders, including established commercial agricultural operations, Tribal Authorities, and subsistence farmers. While the North West Province has limited commercial forestry, it is dominated by bushveld and varied biomes rich in trees, shrubs, and bushes that form crucial ecological and economic resources. NWUFPA's work focuses on protecting veld and grazing rangelands, which are vital to the region's livestock production, game management, and burgeoning eco-tourism sector. By safeguarding these ecosystems through controlled burning and grazing, NWUFPA simultaneously preserves biodiversity and sustains livelihoods dependent on healthy rangelands. NWUFPA's approach is distinguished by its community-centred methodology that honours traditional ecological knowledge alongside contemporary fire science. By establishing agreements with Tribal Authorities, the organisation has respectfully reintegrated indigenous burning practices that have been refined over generations, creating fire management protocols that preserve cultural heritage while meeting modern safety standards. These partnerships have proven effective in communal lands where traditional governance structures remain influential in land management decisions. For commercial farmers and game managers, NWUFPA is developing incentive programs that encourage the strategic rotation of livestock and game through recently burned areas, creating economic benefits while simultaneously reducing fire hazards and improving habitat quality. Technical support enables land managers to adjust grazing schedules to align with controlled burn operations, optimising both productivity and fire mitigation outcomes. NWUFPA's work with subsistence and emerging farmers has transformed stakeholders from passive recipients of fire management services to active participants in regional fire prevention strategies. Through capacity-building initiatives, smaller-scale producers have reintegrated controlled grazing into their operations following NWUFPA-coordinated burns. Preliminary data indicate a reduction in unplanned fire incidents in areas where pyric herbivorism has been systematically applied. Additionally, participating land managers report improved forage quality, reduced invasive species prevalence, and more reliable ecosystem services. These results suggest that NWUFPA's stakeholder-inclusive approach to revitalising pyric herbivorism represents a promising model for regions seeking to balance ecological resilience, economic development, and cultural preservation, particularly in bushveld and savanna ecosystems where fire plays a natural ecological role.

Keywords: Pyric herbivorism, sustainable agriculture, bushveld, fire, veldfire, grazing, coordinated burns.

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Microbial Rhythms in Mediterranean Shrublands: the Impact of Fire and Grazing on Plant-Soil Interactions

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Abstract

Mediterranean-type ecosystems, known for their high plant diversity and resilience to disturbances such as fire, grazing, and drought, provide valuable opportunities to explore plant-soil microbe interaction strength. Recent advancements in sequencing technologies have shed light on these relationships, but studies in Mediterranean environments remain scarce. Even less attention has been given to how traditional Mediterranean shrubland management practices, such as prescribed burning and grazing, affect the interplay between plant and microbial communities. When used together, these practices form pyric herbivory—a traditional, cost-effective approach that not only reduces fuel loads but enhances short-term plant diversity. The present study was conducted in a pyric herbivory living lab in Mediterranean shrublands of the Sierra de los Filabres, Andalusia (south-eastern Spain). Three treatments were applied: control without prescribed burn and grazing, prescribed burn without grazing, and pyric herbivory with prescribed burn and grazing. Sampling was conducted at four distinct time points: pre-fire (t0), immediately after the fire (t1), one year post-fire (t2), and two years post-fire (t3). At each stage, vegetation was surveyed, and soil samples were collected. Microbial communities were analysed using next-generation sequencing of the V3-V4 regions of bacterial 16S rRNA genes and fungal ITS2 regions, and network analyses were applied to investigate their dynamics. The results demonstrated that temporal dynamics linked to prescribed burn effects on vegetation exerted a great impact on microbial communities, with grazing also having a relevant effect mainly on bacterial communities. Immediately after the fire (t1), the sparse vegetation allowed a legacy effect from pre-fire plant community to shape microbial composition until new vegetation began to establish. Over time, microbial communities closely mirrored the trajectory of plant community development. Bacterial diversity increased significantly in t2 and t3, while fungal diversity peaked in t1 and t2, reflecting distinct developmental patterns. Additionally, inter-annual climatic variations, independent of vegetation dynamics, likely influenced microbial community composition. These findings align with existing literature,

emphasizing the high interconnection between plant and soil microbe communities. By enhancing our understanding of plant-microbe dynamics and the influence of management practices, this study provides valuable insights for sustainable ecosystem management in Mediterranean environments.

Keywords: prescribed burns, grazing, pyric herbivory, plant-soil microbe interconnectedness, Mediterranean ecosystems

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Cortijo Clavero, an Ongoing Living Lab to Study Pyric Herbivory Effects on Mediterranean Shrublands in Se Spain (Dalías, Almería).

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Abstract

Pyric herbivory (the combination of prescribed burning and target grazing) is gaining interest in South East Spain in recent years as a preventive silviculture and ecological restoration tool. COMPAS project includes a number of living labs, being one of them Cortijo Clavero (sited at Sierra de Gádor, Dalías, Almería). This living lab included 4 adjacent shrublands dominated by 1) S1: Macrochloa tenacissima, 2) S2: Genista spartioides subsp. retamoides 3) S3: Genista ramosissima and Genista spartioides subsp. retamoides 4) S4: a mixture of Ulex parviflorus, Rhamnus myrtifolia, Phlomis purpurea, Cistus clusii and Cistus albidus. Each shrubland was split into three treatments were set: 1) prescribed burning in autumn 2023, 2) prescribed burning in spring 2024, 3) no burning (control). Within each treatment, six 1 x 1 m plots were set, three of them were excluded from grazing with fences (prescribed burns) and the other three were allowed to be grazed (pyric herbivory). The area is grazed by a herd of 400 white Blanca Serrana goats (endangered goat breed). In total, 72 quadrats were set up, each marked with two corrugated steel rods at the vertices of the diagonal, labelled with an iron plate, and geo-referenced with a precision GPS. Plant cover, phytovolume, richness and diversity in the quadrats have been continuously estimated in spring and autumn since 2023 (before the burnings and after them). Since the start of the experiment, grazing intensity has been monitored at a fine scale using six GPS satellite collars. Additionally, since the beginning of the experiment 24 soil moisture and temperature sensors were installed, four sensors per treatment combination and a meteorological station (equipped with rain, temperature, radiation and wind sensors). We studied the evolution of structural (plant cover and phytovolume) and floristic parameters (species richness and diversity) since spring 2023. In this work only data from prescribed burning in autumn are shown. One year after autumn burning structural parameters experienced a significant reduction: phytovolume (60-85% decrease) and cover (45-80% decrease). However, species richness experienced small decreases in S1 and S2 (between 9 and 11%) and increases for S3 and S4 (15 and 19%), comparing spring 2023 and spring 2024. Although this are still preliminary data, and livestock impact could not be really observed, prescribed burns seem to have a positive impact on fuel control and an almost neutral o even positive effect on species richness and diversity.

Keywords: Pyric herbivory, goats, Mediterranean shrublands, floristic parameters, phytovolume,

plant cover

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How physics can contribute in understanding wildfire behaviour

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How physics can contribute in understanding wildfire behaviour

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Study on the Thermodynamic Characteristics of Wood Pyrolysis Gas Combustion Based on Openfoam Simulation

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Abstract

The pyrolysis of wood produces a mixture of gases, including carbon monoxide, hydrogen, and methane, among others. The combustion of these gas mixtures generates high temperatures and pressures, which can have significant environmental impacts. This study proposes a method for calculating the thermodynamic parameters of wood pyrolysis gas mixtures during combustion using computational fluid dynamics (CFD) simulation software. The temperature field, velocity field, and turbulent kinetic energy variations formed during the combustion of different wood pyrolysis gas mixtures in air were simulated using open-source software. The thermodynamic characteristics of the combustion process for different gas mixtures were analyzed from both single-component and multi-component perspectives. This study provides a deeper understanding of the combustion process of wood pyrolysis gases, which can contribute to optimizing combustion efficiency and reducing environmental impacts.

Keywords: Wood Pyrolysis Gas Mixture, Combustion, Thermodynamic Characteristics, CFD

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Workshop on the interactions between land use change and fire risk management

Climate and Wildfires: Modeling, Indicators, and Future Projections

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Understanding the intricate links between climate patterns and wildfires is essential for advancing fire management and developing proactive prevention strategies. Despite progress in recognizing how climate influences wildfire behavior, this field remains complex due to the interplay of factors such as climate variability, vegetation (fuel), and the feedback mechanisms they create. This session will bring together experts exploring these critical connections across various spatial and temporal scales. The focus will be on the use of climate indicators (such as fire weather indices) and modeling techniques to assess the role of climate in driving wildfire occurrences, severity, and patterns. Contributions are encouraged from studies employing novel methods in remote sensing, ground-based observations, statistical analysis, and simulations that enhance our understanding of wildfire dynamics in the context of ongoing and future climate change. We welcome submissions that provide insights into how shifting climate conditions will influence fire regimes globally and in specific ecosystems, offering a platform for advancing our ability to predict and mitigate wildfire risks in a changing world.

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Increasing Overlap of Australia – North America Fire Weather Seasons

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Abstract

Australia, the USA and Canada are part of a long-standing international partnership that shares firefighting resources each year, including personnel and equipment such as aircraft. This partnership is threatened by an increasing overlap of Northern and Southern Hemisphere fire seasons. This study investigates the historical and projected trends in fire weather season overlap between eastern Australia and western North America to understand the emerging pressures on this international partnership.

Using the Canadian Fire Weather Index (FWI), we define overlapping fire weather days as those when the FWI exceeds a region-specific climatological threshold on the same day in both regions. To quantify the probability of fire weather season overlap, we analyze ERA5 reanalysis data and historical and future projections from four CMIP6 climate model large ensembles. The use of large ensembles allows us to robustly characterize variability and trends in fire weather under both historical conditions and future climate scenarios.

We find that fire weather season overlap between eastern Australia and western North America has increased by approximately one day per year since 1979. The increase is driven primarily by the earlier onset of the eastern Australia fire season, overlapping with the tail end of the western North America fire season. Projections for the future indicate that the overlap of fire weather seasons will increase further, with estimates ranging from 4 to 29 additional overlapping days by the mid-century. Additionally, years of high fire weather season overlap co-occur with El Niño-like sea surface temperatures, specially with a Central Pacific El Niño signature. These findings suggest that future changes in the fire weather season overlap might not only depend on the projected changes in the mean climate, but also on the variability of the tropical Pacific.

Our results indicate that simultaneous fire weather in eastern Australia and western North America will likely become a recurring feature of the fire seasons in the coming decades. Such overlaps will shorten the temporal buffer that currently enables resource-sharing agreements, constraining the capacity of these nations to respond to large-scale wildfires.

Keywords: Fire weather season, Overlap, eastern Australia, western North America, El Niño

Fire in the Earth System Abstracts
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Shrinking Windows: the Impact of Changing Weather Patterns on Firebreak Preparation in Grassland Ecosystems

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Abstract

Fire plays a crucial role in maintaining the ecological balance of grassland ecosystems. The increasing unpredictability of weather patterns due to climate change is significantly reducing window periods available for prescribed burning and firebreak preparation. Challenges posed by shrinking firebreak windows and their implications for biodiversity and conservation efforts are explored. Prescribed burning is a widely recognized fire management tool used to reduce fuel loads, promote ecosystem health, and create strategic firebreaks mitigating wildfire spread. Firebreaks serve as critical barriers to slow fire spread, protect vulnerable habitats, and provide safe zones for firefighting operations. Changing weather conditions, marked by irregular rainfall patterns, prolonged droughts, increased wind speeds, and temperature fluctuations limit the number of viable days available for controlled burns. Landowners, conservationists, and Fire Protection Associations (FPAs) must thus adapt fire management strategies. The North West Umbrella Fire Protection Association (NWUFPA) South Africa, highlights the tangible impact of climatic changes on firebreak preparation and provides evidence suggesting that the annual window for firebreak implementation is decreasing. NWUFPA has recorded a minimum extension of 87 days in the fire season, emphasizing the urgency of adapting fire management practices to align with emerging climatic realities. Fire management teams are incorporating advanced technologies i.e. artificial intelligence, predictive modelling, and satellite fire observation systems into firebreak planning. By leveraging real-time data and historical climate patterns, these innovations enhance the ability to forecast fire behaviour and optimize firebreak scheduling. Traditional knowledge and experience remain integral to decision-making. Collaboration between governmental bodies, private landowners, conservationists, and local fire protection agencies is paramount. FPAs are playing a key role in facilitating training programs, disseminating research, and fostering community-based fire management practices. Regulatory frameworks also need to evolve to accommodate the shifting fire season, ensuring that prescribed burning remains a viable and effective tool. Biodiversity conservation is directly affected, as fire plays a role in maintaining certain ecosystems while threatening others. Species that rely on periodic fires for habitat regeneration may suffer from altered fire regimes, while increased fire intensity and frequency could lead to habitat degradation and loss. The decreasing number of available days for firebreak preparation necessitates a proactive and integrated approach to fire management in grassland ecosystems. By leveraging modern technology, fostering inter-agency cooperation, and adapting traditional fire management practices, it is possible to maintain biodiversity, protect ecosystems, and enhance the resilience of fire-prone landscapes in the face of climate change.

Keywords: Grassland Ecosystems, Prescribed Burning, Firebreaks, Climate Change, Fire Management, Conservation, Adaptive Strategies

Fire in the Earth System Abstracts
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Peatland Wildfires in Finland

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Abstract

Peatland ecosystems are important for carbon cycle, water-balance and biodiversity in northern latitudes. In Finland, peatland covers around 30% of land and 60% of that are drained for the forestry, agriculture or peat production. Peatland is organic soil that store approximately 10 times more carbon than mineral soil, that is, one-third of the global soil carbon stock. Wildfire processes reduce carbon uptake and sink in peatland causing carbon loss.

In our study, we are using process-based ecosystem model JSBACH that is combined with fire model SPITFIRE. Based on our previous study of modeling forest fires in the mineral soil period under six climate scenario (Kinnunen et al. 2024 BG), forest fire seasons will be longer, number of fires increase and the burnt area is larger at the end of the century compared to conditions in reference period.

In JSBACH-SPITFIRE model the wildfire risk depends on fuel properties and weather. Ignitions are caused by humans or lightning. Based on number of fires, fire duration and rate of spread the model estimates the burnt fraction and consequent CO2 emissions. Accumulated litter is the primary surface fuel that drives firebehavior .In peatlands the litter accumulation differs from mineral soils because litter decomposition is slowed down in water-logged layers. However, in peatlands drained for various uses such as peat extraction for energy, the formerly water logged peat layers dry out and get more prone to fires.

In my presentation, I will explain how we are going to implement the wildfires in peatlands to JSBACH-SPITFIRE model by taking a account the special properties of peatland vegetation and soil. Our target is to improve the accuracy of wildfire carbon emissions estimates in Finland and later over northern Europe. The first tests of the vegetation and soil impacts to wildfire variables are done in Jyväskylä region in middle part of Finland. Some preliminary results and follow-up plans will be presented.

Keywords: Wildfire, peatland, ecosystem model, climate change

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Harvest-Induced Changes in Forest Landscapes Does Not Fully Compensate For Climate-Induced Increase in Landscape Flammability in Eastern Canada

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Abstract

Wildfires are a major natural disturbance in boreal ecosystems, strongly influenced by both climate-driven fire weather and fuel characteristics. While climate change is intensifying fire-prone weather conditions, other natural and human-related disturbances, as well as natural evolution of forest stands, are reshaping forest composition, potentially altering landscape flammability. The net effect of these opposing forces remains uncertain in eastern Canada's boreal forest.We assess whether changes in the forest fuel landscape as well as changes in fire weather have mitigated or exacerbated the potential behavior of wildfire across Quebec’s commercial forest zone. Specifically, we analyze trends in predicted intensity and speed of potential fires from 1978 to 2023 as well as the effect of harvesting and other disturbances on these trends. Using the Canadian Forest Fire Behavior Prediction (FBP) System, we estimated potential head fire intensity and speed based on reconstructed ERA5 daily fire weather at local solar noon and high-resolution (~14ha) annual fuel maps. We disentangled climate-driven (top-down) and fuel-driven (bottom-up) influences by comparing scenarios with fixed vs. dynamic fuels and weather conditions. Landscape flammability has increased significantly in some regions over the study period, primarily due to rising fire-prone weather conditions. Despite a general long-term decline in flammable fuels caused by intensive harvesting and associated post-disturbance succession, these changes were sometimes insufficient to counteract climate-driven increases in potential head fire intensity and speed. The western and northern regions of the study area exhibited the most pronounced trends toward exacerbated fire behavior, aligning with increased temperatures and fire-prone weather. Fire weather intensification is emerging as the dominant driver of landscape flammability, overriding mitigation effects from fuel changes in many regions. This suggests that future wildfire risk in eastern Canada will continue to rise under climate change, despite ongoing shifts in forest composition. These findings highlight the need for adaptive fire management strategies that account for both fuel and climate-driven changes in wildfire regimes.

Keywords: wildfire behavior, fire weather, boreal forest, fuel dynamics, climate change, landscape flammability

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Preparing For Future Wildfires: the Role of Global Models in Understanding Local Fire Trajectories

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Abstract

Recent changes in wildfire activity have highlighted the need to develop locally relevant fire management strategies. Statistical models can be used to evaluate the controls of wildfires on various spatial scales and project how wildfire activity may respond to future conditions. It is generally assumed that globally trained models are less well suited than locally trained models to capture the specificity of regional fire regimes needed to develop appropriate wildfire management policies. Here we test this assumption by comparing a globally trained model of burnt area (Haas et al., 2022) and the same model structure trained using local, higher resolution data from Metropolitan France. We compare the two models' performance at simulating wildfires across the country in recent decades and examine the impact of differences between the two models on projected burnt area under future scenarios of climate, vegetation and human activity. We show that, not only does the globally trained model predict burnt area at high resolution better than the locally trained model, but also that this model has different underlying relationships from the locally trained model. The differences in the underlying relationships can be explained by the range of values on which they are trained. By considering the whole distribution of fire on Earth, globally trained models provide a more robust way of assessing how changes in the underlying physical drivers of wildfires will affect a given region. Furthermore, since future climate and vegetation conditions may differ substantially from those used to train the local model, globally trained models are more likely to capture future fire risks.

Keywords: modelling global local future

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Lessons Learned From the Onfire Project: Advancing Understanding and Prediction of Climate-Driven Wildfires

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Abstract

The ONFIRE project (On the climate-driven evolution of fires across time scales and regions worldwide) addresses critical gaps in our understanding of fire–climate interactions by developing harmonized datasets, advancing attribution science, and improving fire danger prediction from seasonal to decadal scales.
A central achievement is ONFIRE v1.0, the first global, gridded, monthly burned area (BA) dataset derived from harmonized in-situ fire records. This open-access product provides a robust foundation for assessing fire trends, validating satellite data, and benchmarking climate–fire models (Gincheva et al., 2024a, b).
ONFIRE has made notable progress in attributing recent fire trends to anthropogenic climate change. In California, human-induced warming has significantly increased the likelihood of extreme fire seasons (Turco et al., 2023). Complementary work examines long-term changes in fire danger based on advanced fire weather metrics (Matteo et al., 2025).
We also explored spatio-temporal synchronicity in fire danger, revealing increasing co-occurrence of extreme fire weather across Europe—an emerging signal with implications for compound fire events and cross-border coordination (Torres-Vázquez et al., 2025a).
ONFIRE supports the development of operational climate services. We released 4DROP, a global tool for probabilistic seasonal drought forecasting (Torres-Vázquez et al., 2024), and are finalizing 4FIRE (Torres-Vázquez et al., 2025b), a prototype system for predicting fire anomalies using machine learning. Both are openly accessible platforms designed to inform preparedness and planning.
In summary, ONFIRE demonstrates how integrating ground-based observations, predictive modeling, and open science can enhance fire–climate understanding and support risk-informed decision-making. Its international and multidisciplinary framework has fostered innovation, collaboration, and new insights into exposure and resilience (Johnston et al., 2024).

Keywords: Climate change, Fire Weather Index (FWI), Wildfire danger assessment, seasonal forecasts

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Wildfire Educating and training: Addressing the elephant in the room – who/what did we forget?

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In many regions, traditional land use practices incorporated fire as a management tool for hunting, grazing, and agriculture. Historically, there were no fire breaks, organized management systems, or formal training for the public. Fire regimes developed through the intentional use of human-set fires alongside natural occurrences, which evidence suggests were ecologically beneficial. However, the traditional knowledge that helped manage and rejuvenate vegetation is often overlooked by modern fire managers.
Recent changes, driven by climate change, population growth, political policies, and technological advancements changed land use practices, have disrupted these long-standing fire regimes, leading to an increase in catastrophic fires. Today, scientific advancements have provided crucial insights into ecological systems and their needs. Researchers have identified effective methods for using fire to restore degraded ecosystems and mitigate the risks of uncontrolled fires. With this growing understanding comes the responsibility to apply this "rediscovered" knowledge. Key questions arise: Who should be educated and trained? Who will deliver these services? What should be included in our strategies, and how will we fund them?
Scientists, educators, fire managers and fire authorities are invited to share their views and research to provide answers to these questions.

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Fanning the Flames or Educating the Public? Media Narratives on Fire and the Scientist's Role

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Abstract

Fire can destroy infrastructure, disrupt livelihoods, and claim lives. Yet, it is an inevitable natural process that has played a crucial role in shaping ecosystems for millennia. Planned fires also serve various social and ecological functions, as traditional communities knew well. However, urbanization and modern lifestyles have alienated many humans from co-existing with fires, leading to a lack of understanding not only of the dangers of fire, but also a lack of basic understanding of fire behaviour, the importance of holistic fire management (as opposed to a focus on reactive fire suppression) and the ecological importance of fire. The media and scientists have the means and knowledge to play a key role in educating society on these issues and create more fire resilient communities, especially at the urban-wildland interface. This study conducted a critical media content analysis of 390 media reports (print, online and broadcast) on fires in South African National Parks over a two-year period to examine how fire is portrayed by the mass media. The findings reveal a strong emphasis on reactive fire suppression along with a predominantly negative sentiment towards fire (93.9% of total media reach). Media coverage focussed primarily on losses, destruction and the threat of fires to infrastructure, human health or lives and vegetation. In the few cases where scientists were consulted (2.3% of total media reach), the narrative, sentiment and images provided a more nuanced perspective of fire as having both detrimental and beneficial consequences (63.6%). In addition, media reports where scientists were consulted explained key fire ecology concepts related to fire behaviour and highlighted the importance of proactive fire-risk reduction measures. Given the mass media's significant influence on views and opinions of the public and policymakers – along with social-political and management implications - stronger collaboration between scientists and journalists is essential to foster a more balanced and informed discourse on

fire and providing relevant and balanced perspectives towards fire in society.

Keywords: Science communication, Mass media, Fire education, Fire narratives

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Fire in the Earth System Abstracts
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Igniting Resilience: Youth, Women, and People With Disabilities at the Forefront of Fire-Affected Rangeland Restoration in the North West Province, South Africa

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Abstract

Restoration and rehabilitation of fire-affected rangelands in the North West Province of South Africa is critical for the environmental and socio-economic well-being of diverse stakeholders, including emerging farmers, communities governed by Communal Property Associations (CPAs), small villages, commercial farmers, and those residing within game reserves and protected areas. These landscapes, vital for livestock farming, biodiversity conservation, and supporting rural livelihoods, face increasing threats from recurrent wildfires, climate change, and land degradation. The dynamics of rangeland restoration and rehabilitation across diverse landscapes, emphasizing the crucial role of youth, women, and people with disabilities, including the deaf community, in fostering long-term sustainability, are explored. For generations, land management practices within these diverse communities have been shaped by local knowledge and experience. Escalating impacts of climate change, exacerbated by overgrazing and encroachment of invasive species, have disrupted finely balanced ecosystems, leaving them increasingly vulnerable to the devastating effects of wildfires. Recognising the urgent need for more resilient approaches, this research emphasises the critical importance of inclusive and collaborative restoration efforts. These initiatives must empower all members of diverse communities, including marginalised groups. The North West Umbrella Fire Protection Association (NWUFPA) has forged strong partnerships with emerging farmers, CPA leadership, small village councils, commercial farmers, and representatives from game reserves and protected areas. Collaborative efforts prioritise the active engagement of youth, women, and people with disabilities. Through carefully designed training programs and capacity-building initiatives, NWUFPA empowers these vital community members to play a leading role in the rehabilitation of fire-affected rangelands. NWUFPA is currently implementing four projects, each involving 30 youth participants, in a one-year learnership program funded by the Fibre Processing and Manufacturing Sector Education and Training Authority (FP&MSETA) and NWUFPA itself. Despite proactive efforts, several challenges persist. Limited financial and technical resources, political complexities, and bureaucratic obstacles hinder the full realisation of restoration and rehabilitation initiatives. Addressing these issues necessitates an integrated approach that includes policy reforms, increased support for community-based conservation initiatives, and strengthened partnerships between all stakeholders, including emerging farmers, CPA leadership, small village councils, commercial farmers, representatives from game reserves and protected areas, governmental agencies, and environmental organisations. Holistic frameworks that acknowledge the socio-cultural, ecological, and economic dimensions of rangeland restoration, by harnessing the knowledge and skills of youth, women, and people with disabilities and integrating traditional practices with modern restoration techniques, are examined. Diverse communities revitalise rangelands, securing livelihoods, while contributing to broader environmental and climate resilience goals.

Keywords: Communal Rangelands, Fire Ecology, Community-Based Conservation, Indigenous Knowledge Systems, Vulnerability and Resilience, Social Inclusion, Sustainable Livelihoods, Climate Adaptation, Disability Inclusion.

Fire in the Earth System Abstracts
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Reversing Desert Encroachment in the North West Province of South Africa

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Abstract

Climate change and land degradation in South Africa's North West Province have accelerated the encroachment of the Karoo and Kalahari deserts, threatening both environmental stability and community livelihoods. The North West Umbrella Fire Protection Association (NWUFPA) has launched "Restoring the Balance," an innovative program that combines ecological restoration with community development, combatting desertification and building regional resilience. The program implements a comprehensive landscape restoration approach, integrating strategic tree planting with grassland rehabilitation. Indigenous and fruit-bearing trees, including drought and fire-resistant species such as Marula, Baobab, Spekboom, and Wild Olive, are planted alongside productive Mango, Citrus, and Fig trees. Native grassland restoration complements the tree plantings, creating a multi-layered ecosystem that enhances soil stability and provides grazing opportunities for both wildlife and livestock. At the local level, extensive root systems of trees and grasses combat wind erosion and strengthen soil structure, while increased vegetation coverage creates favourable microclimates. Enhanced plant density contributes to improved air moisture content, potentially influencing local rainfall patterns. At ecosystem level, the program promotes biodiversity by establishing diverse habitats that support both grazing and browsing wildlife species while maintaining crucial pollinator populations. Socioeconomic dimensions of the program address pressing community needs through sustainable resource management. Fruit trees provide nutritional security and income generation opportunities for remote villages. Managed wood harvesting supplies materials for construction and fuel. Restored grasslands offer sustainable grazing areas for livestock, strengthening traditional pastoral livelihoods. Integrated approaches ensure that environmental conservation directly supports community well-being and economic development. NWUFPA's program distinguishes itself through comprehensive capacity building, incorporating fire management training and water conservation strategies. Local communities receive education in sustainable land management practices, including rotational grazing techniques and grassland management, ensuring long-term program viability. The initiative's water conservation component includes innovative techniques to maximize water efficiency and maintain reliable supply for vegetation establishment and maintenance. NWUFPA’s holistic approach to restoring environmental balance while improving community livelihoods presents a replicable model for arid regions facing similar challenges. By addressing both ecological degradation and socioeconomic needs, "Restoring the Balance" demonstrates how targeted interventions create lasting positive change. The initiative's emphasis on indigenous species selection, grassland restoration, community engagement, and integrated resource management provides valuable insights for similar projects globally. Combinations of traditional environmental conservation with community development objectives create sustainable pathways toward greener, more prosperous futures for citizens. Careful ecosystem restoration, community empowerment, and sustainable resource management provide a blueprint for restoring balance to degraded landscapes.

Keywords: Desertification, Resilience, Reforestation, Biodiversity, Sustainability

Fire in the Earth System Abstracts
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From the Ashes of Tradition: Reclaiming South African Fire Management Techniques For Modern Application

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Abstract

Amid escalating wildfire threats across South Africa, a transformative partnership between the North West Umbrella Fire Protection Association (NWUFPA) and the North West Provincial House of Traditional and Khoi-San Leaders demonstrates how reclaiming indigenous fire management knowledge can build resilience in modern fire management systems. This presentation examines this collaborative model and its implications for addressing critical gaps in government-supported fire management infrastructure.

Despite diminishing government funding and institutional support, NWUFPA has pioneered an innovative approach that centres traditional ecological knowledge within contemporary fire management frameworks. In 2021, NWUFPA established a formal partnership with the Provincial House of Traditional Leaders, creating a joint committee that systematically documents traditional burning practices, seasonal indicators, and cultural protocols surrounding fire management. This knowledge repository now informs prescribed burning schedules across the province's diverse ecosystems.

Central to NWUFPA's success has been its comprehensive training program developed in conjunction with traditional knowledge holders. The association has trained and certified over 60 instructors, facilitators, assessors, and moderators who integrate traditional and scientific approaches to fire management. These certified trainers have been strategically deployed across the province's 20 Fire Protection Associations, creating a decentralised but coordinated knowledge network that functions effectively despite limited government assistance.

The collaboration has revitalised traditional burning practices through community-based fire management teams consisting of both younger community members and traditional elders who serve as "fire knowledge custodians." These teams conduct prescribed burns using techniques that combine contemporary safety protocols with traditional timing and application methods. Monitoring data indicates areas managed under this integrated approach have experienced a 47.5% (from the 2021 to the 2024 fire season) reduction in uncontrolled wildfire incidents compared to areas using conventional approaches alone.

This model of resilience-building through knowledge integration offers valuable lessons for other regions facing similar challenges. By formalising the relationship between traditional governance structures and modern fire management organisations, NWUFPA has created a sustainable framework that persists despite inconsistent government support. The initiative demonstrates how reclaiming traditional ecological knowledge can serve, not only as cultural preservation, but as an essential adaptive strategy in responding to increasing fire risks in the context of climate change and reduced institutional capacity.

Keywords: Fire threats, escalating threats, climate change, prescribed burns, traditional knowledge.

Fire in the Earth System Abstracts
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Seasonal Burning Wisdom: Lessons From South African Traditional Communities For Contemporary Wildfire Prevention

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Abstract

Indigenous knowledge systems related to fire management offer valuable insights for contemporary wildfire prevention strategies. This abstract examines the traditional seasonal burning practices of South African communities, specifically focusing on the Tswana tribes and Traditional Commercial (Boer) farmers, whose approaches to fire management demonstrate sophisticated ecological understanding developed over generations.

The Tswana people have historically employed carefully timed mosaic burning practices, aligning their fire management with seasonal indicators including rainfall patterns, vegetative growth cycles, and wildlife behaviour. Their approach creates landscape heterogeneity that effectively limits uncontrolled wildfire spread while promoting biodiversity. The traditional "go šhumisa" practice involves community-coordinated burns during the early dry season, creating strategic firebreaks along natural landscape features that serve as containment boundaries for controlled burns.

Traditional Commercial (Boer) farmers developed the "brandpad" system, establishing protective fire belts around farmlands through controlled burning. They ingeniously incorporated existing transportation infrastructure, using roads and railway lines as anchors for firebreaks, effectively utilising these linear features as permanent fire management boundaries. This integration of human infrastructure with fire management strategy demonstrates an adaptive approach that maximises efficiency while minimising resource requirements.

Both knowledge systems share common principles: the recognition of seasonal timing as critical, strategic use of landscape features and infrastructure, community-coordinated efforts, and the understanding of fire as an ecological management tool rather than merely a threat to be suppressed. This contrasts with modern fire suppression policies that have often resulted in dangerous fuel accumulation.

Integrating these traditional practices into contemporary wildfire management offers promising directions for policy reform. By re-establishing seasonal burning calendars adapted to local conditions, utilising and expanding strategic fire breaks along

transportation networks, engaging communities in fire management decisions, and recognising the cultural and ecological value of controlled burning, South Africa can develop more effective and sustainable approaches to coexisting with fire in an era of increasing climate volatility.

Keywords: Tswana tribes, Commercial (boer) farmers, traditional practice, fire suppression, fuel accumulation

Fire in the Earth System Abstracts
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Wildfire Educating and Training: Addressing the Elephant in the Room

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Abstract

What we once knew has been forgotten. Human activity, fire, and climate change are some of the natural forces that have altered landscapes as we know them today. Anthropogenic activities are responsible for some of the most significant alterations to its natural systems. It wasn't until roughly 100,000 years ago that the cognitive development of Homo sapiens became essentially modern, during which time they mastered the art of fire (James, 1989; Berna, et al; 2012). This has changed the earth system forever. With the evolvement of Homo sapiens, their use of planned fire was mastered, and then forgotten, and the more sophisticated humans became, the more destructive they became to planet earth (Gowlett, 2016). In the “new worlds” (Americas, Australia and Africa), beneficial use of fire by first nations that was established in simple land use systems, were forgotten. In addition, as new land use activities were introduced by modern society, fire regimes did not always support healthy ecosystems. As a result of the quest for human rights, and governments' struggle to understand their responsibilities, many perceptions about the use of fire have been formulated. This has led to confusion among citizens, who frequently think they are environmental experts, and occasionally environmentalists and scientists who think they are the best fire managers (IPCC, 2015). Against the aforementioned backdrop, devastating fires have marked the progress of humankind, giving rise to research projects that aimed to assess the growing wildfire dilemma. Unfortunately, the gap between scientific recommendations, and the implementation of these ideas on ground level, never seems to shrink. This can often be attributed to the lack of political will to implement change. Even though managing and suppressing wildfires requires new competencies, there is a dearth of broad information regarding the depth and specialization required to master these skillsets. At the same time, established jobs that supported earlier land use systems are losing their ingrained knowledge and experience. There are gaps in the ranks of fire control organizations and authorities because of this loss of expertise (ForestTECH, 2025). The challenge faced by the current generation demands awareness and recognition of the required skillsets required by firefighters, firefighting pilots, fire managers, natural resource managers, chemical- and mechanical engineers, teachers and authorities. In identifying these skillsets, the past, present and future of fires in the Earth system must be considered.

Keywords: anthropogenic activities, first nations, responsibilities, perceptions, lost knowledge.

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Fire in the Earth System Abstracts
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Transforming Wildfire Management Education: a Problem-Based Learning Approach

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Abstract

Wildfire events have become more frequent and complex, highlighting the need for adaptable, critical-thinking wildfire managers. Traditional education models often placed emphasis on memorisation rather than deep understanding, leaving graduates ill-equipped to tackle real-world challenges. To address this gap, this presentation advocates for the integration of Problem-Based Learning (PBL) into wildfire management training. The forestry sector in South Africa has played a vital role in livelihood development, particularly given the youth population bulge, high unemployment rates and global sustainability challenges. Higher Education Institutions (HEIs) have been well-positioned to equip graduates with the skills necessary to advance climate-smart forestry and align with South Africa's National Climate Change Adaptation Plan. However, there has been a significant discrepancy between industry needs and the skills taught in forestry education. FOREST21, a collaborative project co-funded by the Erasmus+ Programme of the European Union, sought to reform forestry education by embedding PBL methodologies. Running from 2020 to 2024, FOREST21 brought together five South African HEIs and three institutions from Finland and Norway to cultivate problem-solving skills, entrepreneurial thinking and climate-smart strategies among forestry graduates. Through student-centred learning and real-world business challenges in international teams, the project fostered knowledge co-creation rather than passive knowledge acquisition. This presentation explores the role of PBL within FOREST21 and its relevance to wildfire management education. By shifting from a teacher-centred approach to discovery-based learning, educators have been able to better prepare students for the unpredictable and dynamic nature of wildfire scenarios. The collaboration between academia and industry ensured that emerging wildfire managers developed the analytical reasoning and resilience needed to navigate fire-prone landscapes effectively. This presentation will highlight key lessons from FOREST21, detailing educator and student development workshops, field-based student challenges and the successes and hurdles encountered in implementing PBL-driven forestry education. Ultimately, we argue that adopting PBL can enhance wildfire management training by equipping graduates with the competencies required to address climate change, foster sustainability and generate economic opportunities within the forestry sector.

Keywords: Problem-Based Learning (PBL), Wildfire Management, Climate-Smart Forestry

Acknowledgments: Erasmus+ Programme of the European Union, Forestry South Africa

Fire in the Earth System Abstracts
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Restoring Balance Through Fire: Bridging Indigenous Burning Practices and Current Fire Management

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Abstract

For millennia, Indigenous nations across North America have used fire to manage, shape, and sustain diverse ecosystems. Traditional fire practices, rooted in deep ecological knowledge, maintained healthy landscapes, enriched biodiversity, and supported essential ecosystem services. The suppression of cultural burning, driven by land dispossession, land-use changes, and modern fire policies, has contributed to the increased frequency and severity of wildfires, threatening both human and ecological communities. Examining the historical and contemporary roles of Indigenous fire stewardship offers insight into how revitalizing traditional burning can complement contemporary fire management strategies. Successful partnerships between Indigenous fire practitioners and land management agencies illustrate potential pathways for integrating traditional ecological knowledge into current wildfire mitigation efforts. Bridging Indigenous knowledge with Western fire science presents an opportunity to cultivate more resilient landscapes and restore the balance that fire has long provided. Fire professionals are urged to engage with Indigenous communities, advocate for policy reforms, and support collaborative fire stewardship as an essential strategy for addressing today's wildfire challenges.

Keywords: Collaborative fire stewardship, Traditional ecological knowledge (TEK), Cultural burning, Fire policy reform

Yesterday and Today - Chronosequential Changes After Fires in the Environment

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This session will explore the sequential changes that occur after fires in various ecosystems, highlighting both the immediate post-fire impacts and the long-term transformations that shape the landscape over time. We invite researchers who deal with shifts in vegetation, soil processes, hydrology, and biodiversity through a chronosequence lens, drawing on case studies and interdisciplinary research methods. By comparing “yesterday” and “today,” the session aims to provide fresh insights into how fire-adapted systems recover, adapt, and ultimately inform better management, restoration, and policy decisions in fire-prone regions.

Fire in the Earth System Abstracts
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Environmental Factors Regulating the Fire Effects on Soil Organic Carbon Across Malagasy Ecosystems

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Abstract

Frequent fire with well-known effects on the aboveground biomass (AGB) of tropical ecosystem can affect carbon dynamics and, subsequently, ecosystem functioning. However, fire impact on soil organic carbon (SOC), a key indicator of soil health, remains unclear, as does the role of environmental factors in shaping soil resilience to fire. This study explores how environmental factors such as land cover, topography and pedo-climatic conditions influence SOC responses to varying fire frequencies. We assume that soil responses to fire are driven by these environmental factors and their complex interactions controlling SOC levels, rather than a simple decline with more frequent fires. AGB carbon and SOC stocks were assessed across 307 plots in three bioclimatic zones: the subhumid central highlands, dry northwest, and subhumid southeast of Madagascar. Soil samples were taken from the 0-30 cm topsoil at 10 cm intervals. The study design captured the combined effects of key environmental drivers, including land cover, bioclimatic conditions, soil type, topography, with fire frequency —defined as the number of burn events over multiple years— ranging from unburned to annually burned areas.Soils store far more carbon than AGB in all forests, shrublands, grasslands and reforestation sites. SOC levels under forests and shrublands declined significantly—as the AGB carbon—with increasing fire frequency. Under reforestation, however, SOC stocks were primarily shaped by the age of reforestation, the species planted, and prevailing climatic conditions—rather than fire occurrence. In grasslands, fire frequency alone did not significantly affect SOC stocks, although significant interactions with environmental factors were observed. Furthermore, fire effects extended throughout the entire 30 cm soil profile, not just the top 10 cm layer as commonly assumed. Ferruginous soils were more vulnerable to SOC depletion (−22 %) under high fire frequency compared to Ferrallitic soils (−3 %). In grasslands, SOC decreased with increasing fire frequency, by up to 27 % under annual burning below 500 m elevation, while it showed a slight increase between 1000-1500 m in the subhumid central highlands, but no clear trend in other zones at the same elevation range. Frequent fires can increase SOC under specific environmental conditions, challenging the assumption of consistent SOC depletion. These findings show the strong influence of environmental factors on soil resilience to fire, leading to varied patterns in topsoil. Understanding these interactions can improve fire management strategies, enhance carbon sequestration outcomes, and support sustainable land management and restoration in Malagasy fire-prone ecosystem.

Keywords: fire frequency, interaction, land cover, pedo-climatic condition, topography

Fire in the Earth System Abstracts
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From Fire to Forest: Recovery of Soil Quality Under Post-Fire Management in Portuguese Pyrenean Oak Woodlands

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Abstract

Wildfires are a major disturbance in Mediterranean landscapes, where fire-adapted ecosystems such as Pyrenean oak (*Quercus pyrenaica* Willd.) woodlands face increasing pressure from more frequent and severe fires. In Portugal, most post-fire restoration interventions focus on soil stabilization, re-establishment of vegetation, and active afforestation. These interventions usually prioritise above-ground vegetation recovery, while comparatively less attention is given to below-ground processes such as soil carbon dynamics. Soil carbon dynamics play a crucial role in post-fire ecosystem resilience and recovery, due to their impact on soil fertility and structure. However, the long-term effects of post-fire management on edaphic processes remain poorly understood. We surveyed 15 post-fire afforestation projects with Pyrenean oak, implemented between 1994 and 2006 in northern and central Portugal, in landscapes dominated by Pyrenean oak woodlands. We aimed to: (1) assess whether post-fire afforestation projects contributed to changes in soil physicochemical properties related to soil quality and increased Soil Organic Carbon (SOC) stocks; (2) determine whether differences in post-fire management interventions among projects influenced SOC stocks. In addition, we explored the use of "time since project implementation" and "time since fire" as temporal proxies to assess SOC recovery patterns.

Each project site was paired with a nearby control area affected by the same fire event but without postfire afforestation or management. At each site (project and control), we collected superficial soil samples (up to 20 cm depth) in 2021 for general physicochemical characterization related to soil fertility. We also collected data on site characteristics, stand structure, oak regeneration, floristic composition, and litter quantity. Preliminary results suggest that SOC accumulation is influenced by a combination of factors, including time since project initiation, site-specific conditions (e.g., altitude), vegetation structure (e.g., understory biomass and cover), and soil chemical properties (e.g., C/N ratio, pH, and nutrient availability), rather than by any single post-fire treatment.

Ongoing analyses will further investigate how soil fertility, nutrient dynamics, and chemical composition relate to SOC stocks, and the extent to which they explain spatial variability across sites. These findings underscore the complexity of post-fire soil recovery and highlight the importance of including soil indicators in the evaluation of restoration success.

Keywords: Post-fire management, Afforestation, Soil dynamics, Mediterranean, Physicochemical soil characteristics

Fire in the Earth System Abstracts
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Evaluating Soil Carbon Stock Variability Across Fire Histories Using Field Data and Remote Sensing

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Abstract

Forests are important carbon sinks, storing CO_2 in biomass and soil. However, wildfires can turn them into carbon sources, releasing CO_2 during combustion and through post-fire decomposition and reduced photosynthesis. Forest soils, often richer in carbon than vegetation, are heavily impacted, with soil organic C recovery taking years to decades due to complex interactions between fire and different soil components.

This study evaluated soil organic carbon (SOC) stocks in a fire-prone cork oak forest in the Serra do Caldeirão (southern Portugal). Soil samples were collected to full depth from sites with different fire histories (unburned: 24, one decade after fire; 62, two decades after fire: 17) and analysed for bulk density, particle size and SOC content. SOC stock content was calculated using the FAO (2013) method.

Statistical analysis using Welch's ANOVA assessed differences between fire scenarios, while multiple linear regression with spectral and topographic covariates was used to map SOC. Results were validated by comparing predicted values with field measurements.

SOC stocks showed some variability (Mg C/ha - unburned: 40.5±7.9, one decade: 47.3±6.6, two decades: 58.7±21.5) and Welch's ANOVA revealed significant differences in SOC stocks between the three fire history groups ($F(2, 49.3) = 9.21$, $p < 0.001$). Post hoc Games-Howell tests indicated that SOC stocks were significantly higher in areas burned two decades after fire compared to unburned and one decade burned soils, while no significant difference was observed between them. The regression model presented an R2 of 0.20 for unburned one and two decades after fire (n=105), with NDVI elevation being the most appropriate covariate. The total SOC stock for Serra do Caldeirão was 3612133 Mg C, with an average of 48.83±11.65 MgC/ha. The results of the map data validation showed that the mapped SOC stock underestimated the field data with a difference of 7%.

These results highlight the critical role of SOC stocks in cork oak forest ecosystems and suggest that the effects of fire on soil carbon are long-lasting. A significant increase in SOC stocks, along with greater variability, was observed only two decades after fire. Mapping efforts using multiple linear regression with NDVI and elevation showed promising trends but low accuracy. Future research should focus on assessing net changes in SOC stocks between disturbances and management treatments and include a wider range of soil covariates to improve mapping accuracy.

Keywords: soil organic carbon stock , cork oak, SOC stock mapping , fire, longterm

Fire in the Earth System Abstracts
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Post-Fire Soil Dynamics Over Two Decades in Mediterranean Cork Oak Ecosystems

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Abstract

Wildfire is an inherent ecological process in many forested ecosystems, particularly in the Mediterranean basin. However, ongoing climate change and alteration of land management in some areas have increased the frequency and severity, making it a major disturbance.
Short-term soil responses to fire are well-documented, but long-term dynamics remain poorly studied, often lacking comprehensive analyses of chemical, physical, and microbiological soil functions. This study evaluated long-term integrated soil quality following fire in Serra do Caldeirão (southern Portugal), an ecologically and economically significant cork oak forest area protected under the Natura 2000 network. A total of 141 soil samples were collected at 5 cm.
across three scenarios: unburned reference sites, one and two decades after fire Comprehensive analyses were conducted encompassing chemical (pH, EC, total C, organic C, labile C, total N, available concentrations of N, P, Ca, Mg, Na and K, CEC), physical (bulk density, total porosity and % fine fraction), and microbial (activity of dehydrogenase, phosphatase, urease, cellulase, glucosidase) properties. Principal Component Analysis revealed that Axis 1 (36.4% variance) was primarily driven by organic matter-related variables and nutrient availability, with the highest loadings corresponding to total C (0.83), organic C (0.78), total N(0 .77), CEC(0.75), and non-acid exchange cations (K (0.71), Ca (0.70)) and available P (0.68). These were predominantly associated with the two decades sites. Besides, axis 2 (12.8% variance) included variables as pH (0.60), NH_4 concentration (-0.53), bulk density (0.49), and fine fraction (0.48), distinguishing unburned sites. Sample distribution in PCA space indicated a clear successional gradient, with unburned and two decades sites forming distinct clusters, one decade sites occupied an intermediate position. Spearman correlation analyses further supported this trajectory.Unburned soils showed moderate positive correlations between organic carbon fractions and enzyme activities. One decade after fire, these correlations weakened, while new links appeared between organic carbon and essential nutrients (P, N, K, Mg), alongside shifts toward enzymes breaking down resistant carbon forms. After two decades, soil organic carbon strongly correlated with biological and chemical properties, indicating improved microbial activity, nutrient cycling, and structural recovery.These findings suggest that the fire initiates a prolonged reorganization of soil processes with effects spanning more than two decades, with

organic matter evolving as a key driver of soil functionalities. The study highlights the necessity of incorporating long-term soil monitoring into fire ecology, particularly to understand different ecosystem post-fire pathways for more informed ecosystem management under changing fire regimes.

Keywords: fire, soil, long-term, physico-chemical characteristics, enzymatic activities.

Fire in the Earth System Abstracts
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Long-Term Post-Fire Soil and Vegetation Changes in the Southern Baikal Region, Baikalsky State Nature Reserve

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Abstract

In the Baikal Nature Reserve forest fires occur due to natural causes, namely, dry thunderstorms. Lightning strikes the elevated parts of the relief on the Khamar-Daban ridge. The areas affected by fires in 1974, 2011, 2015 were studied, research was conducted in 2016.
The soils of the areas are Skeletic Cambisols and Albic Skeletic Podzols, and the mean plant communities are Siberian cedar (Pinus sibirica) and fir (Abies sibirica) forests.
For the post-fire soils a decrease in the thickness of the litter-peat horizons was revealed, and the appearance of new pyrogenic subhorizons was shown. A decrease in the concentration of labile carbon, ammonium and labile nitrogen in the soils after the fire was observed. At the same time, an increase in the content of labile phosphorus in the soils of the burnt area was found, especially in the lower part of the slope. A decrease in the PAH (polycyclic aromatic hydrocarbons) content in soils was shown with an increase in fire intensity, as well as in the case of repeated fire passage through an existing burnt area. In the background soils higher concentrations of the total PAH were found, in comparison with the burnt areas, which may be due to the burning of organic material sorbing PAHs. At the same time the concentration of high-molecular PAHs increases in pyrogenic soils. By factor analysis of the PAH content in soils, a group of pyrogenic autochthonous hydrocarbons formed in situ was identified - naphthalene, benz[a]anthracene, pyrene, chrysene, anthracene, and a group of pyrogenic allochthonous polyarenes accumulating in soils due to atmospheric transfer of ash - benzo(a)pyrene and benzo(ghi)perylene.
When talking about post-fire vegetation, we must mention that the structure of forest layers is simplified (number of layers and their projective cover decrease), the total number of species and species diversity of ecological-coenotic groups of species significantly reduced, forest stand completely destroyed. With a single disturbance by fire, taiga forests retain potential for restorative vegetation change, coniferous species replacing by small-leaved ones (Betula pubescens, Populus tremula, Salix caprea), and then back to primary dark coniferous. Vegetation change has distinct stages: ca. 40 years after fire, black burnt area, herb stage, shrubs and small tree new growth sequentially change one another, leading to young coniferous or small-leaved forest. The herb-dwarf shrub layer, except certain species, is restored the fastest, while the moss-lichen layer remains fragmented for a longer time.

Keywords: forest fires, multiple fires, polyarenes, polycyclic aromatic hydrocarbons, total and microbial carbon, nitrogen, phosphorus

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Acknowledgments: The authors are grateful to T.E. Yazrikova for assistance in conducting the analysis of labile carbon, nitrogen and phosphorus, and to N.I. Khlynina for the analysis of PAH content in soils.

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Post Fire Chronosequence of Water Retention Properties in Pine Forest Arenosols

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Abstract

Wildfire frequency and intensity are rising in temperate Europe, yet the trajectory of post-fire soil-water recovery remains poorly quantified. We analysed a 33-year chronosequence in Scots-pine (Pinus sylvestris L.) stands of the Olkusz Forest District (Poland) (burned in 2022, 2012 and 1992) plus an unburned control to elucidate changes in the water-retention properties of coarse-textured Arenosols. From three depth intervals (0–5, 5–20, 20–50 cm) we collected n = 330 undisturbed cores. Bulk density (BD), actual and maximum water-holding capacity (Sa, Smax), and soil hydrophobicity—quantified by water-drop penetration time (WDPT) and ethanol molarity of wetting (MT)—were measured along with organic-matter content (LOI 700 °C).

One year after fire, the surface horizon (0–5 cm) showed a 15 % increase in BD ($p < 0.001$), 19 % and 17 % reductions in Sa and Smax ($p < 0.001$), and markedly stronger hydrophobicity: WDPT lengthened by ≈50 s and MT rose by 6.4 mol % (≈25 % relative increase) compared with the control. Deeper layers were far less affected. Multifactor linear regression, supported by Kruskal–Wallis, Mann–Whitney and Spearman tests ($\alpha = 0.05$), revealed that time since fire, depth, canopy status, BD and organic matter jointly explained 42–71 % of the variance in raw data and 39–68 % when using adjusted R^2. By 33 years post-fire, Sa, Smax, WDPT and MT no longer differed statistically from the unburned benchmark, indicating near-complete hydrological recovery within three decades.

Our results demonstrate a progressive restoration of soil-water functions after wildfire and highlight the first decade as the critical window for management. Rapid reforestation combined with measures that limit soil compaction and preserve surface organic matter can shorten the hydrological recovery time and foster resilient post-fire succession in pine-dominated landscapes.

Keywords: water storage, water holding capacity, bulk density, soil hydrophobicity, soil water repellency, Arenosols

Fire in the Earth System Abstracts
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Recurrent Fires and Burn Severity Variability in Headwater Catchments: a Case Study From Montesinho Natural Park

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Abstract

Forest fires alter landscape and hydrological dynamics, especially in mountainous Mediterranean regions where fires are frequent and reach high levels of severity. In this study, we analyzed the spatial variability of burn severity (estimated with the differenced Normalized Burn Ratio (dNBR)) in a headwater area (31.7 km2) located in the transboundary area between northern Portugal (Montesinho Natural Park) and northwestern Spain (province of Zamora). Using high-resolution aerial orthophotos and satellite images (Landsat 5, 7, 8), we analyzed ten past temporal scenarios (SC) from 1997 to 2020, namely: 10/1997 (SC1), 08/2001 (SC2), 07/2004 (SC3), 08/2006 (SC4), 07/2008 (SC5), 07/2010 (SC6), 07/2011 (SC7), 07/2014 (SC8), 07/2017 (SC9) and 08/2020 (SC10). The total area affected by fires over the 24 years amounts to 1,581.4 ha, which represents 49.8% of the total surface. Recurrence of fires during the study period was to the north. The spatial analysis, through superposition, of the burned areas yielded the following results at the same areas: one fire (1,389.4 ha, 43.7% of the study area), two fires (164.7 ha, 5.2%), three fires (23.8 ha, 0.7%) and four fires (3.4 ha, 0.1%). Regarding the fires, moderate-low fire severity was the most frequent in SC1, SC2 and SC3, with 4, 14 and 15 separated burnt areas at each scenario. Low fire severity prevailed in Sc4, Sc5 and Sc6, with 17, 16 and 7 burnt areas, respectively. In SC7, fire severity increased to moderate-low with 8 burnt areas. And then, low fire severity prevailed in Sc8, Sc9 and Sc10, with 15, 10 and 4 burnt areas, respectively. In the four scenarios with higher severity, the average burnt surface was 116.72 ha per scenario and 275.75 ha per polygon (individual burnt area); whereas during the six low severity scenarios, the average burnt surface was 10.14 ha per scenario and 26.90 ha per polygon. The largest analyzed area, corresponding to scenario SC1, with an area of 50.18 ha, has an average dNBR value of 0.3514 (moderate to high severity). A spatial analysis

was done considering four fire parameters (location and extension of the burnt areas, average fire severity, and fire recurrence) and six physiographic parameters (elevation, topographic aspect, slope gradient, density of vegetation, distance to the lameiros, and distance to the trails and firebreaks). Our findings highlight the importance of considering landscape features like lameiros (traditional water meadows) in fire management and sediment transport studies.

Keywords: forest fires, burn severity, dNBR, Mediterranean landscapes, sediment transport

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COMMUNITY-LED WILDFIRE SOLUTIONS: FROM INNOVATION TO ACTION

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The session's focus is on actionable, community-driven solutions in wildfire resilience. By integrating technical expertise with the lived experiences of fire-prone communities, we can move beyond a technology-driven approach to wildfire preparedness—ensuring that resilience strategies are both scientifically robust and deeply grounded in local knowledge, needs, and capacities. This session challenges conventional paradigms by exploring how governance, social innovation, and participatory engagement can complement advanced technologies to create fire-adaptive landscapes. Through real-world examples, we will highlight how communities can drive meaningful change in wildfire management. Call to Action: Join us in rethinking wildfire resilience — placing communities not as passive recipients of solutions but as key actors in shaping the future of fire management.

Fire in the Earth System Abstracts
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Indigenous Knowledge Systems: Mapping Traditional Fire Management Practices of South African First Nations

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Abstract

South Africa's diverse indigenous communities have employed sophisticated fire management techniques for millennia, creating a mosaic of fire-adapted landscapes that sustained biodiversity and reduced catastrophic wildfire risk. However, colonial practices, followed by modern land management policies, have systematically marginalised these traditional approaches, resulting in the current crisis of mega-fires that devastate ecosystems and communities alike. This presentation documents an extensive three-year ethnographic study conducted across five distinct traditional communities in South Africa: the Khoi-San of the Northern Cape and the North West Province, the amaXhosa of the Eastern Cape, the Venda of Limpopo, the Zulu of KwaZulu-Natal, and the Ndebele of Mpumalanga. Through interviews with elders, participatory mapping exercises, and seasonal field observations, we identified region-specific fire management practices tied to seasonal indicators, including flowering patterns, migratory bird arrivals, and astronomical markers. Our findings reveal sophisticated fire rotation systems operating on multi-year cycles that maintained habitat diversity through patch-mosaic burning. Communities demonstrated nuanced understanding of fire behaviours across different vegetation types, utilising techniques such as backing fires (backburns or burning against wind), night burns (controlling fire intensity through cooler temperatures and higher humidity), and strategic seasonal timing to achieve specific ecological outcomes. Particularly notable was the integration of fire management with broader cultural and subsistence practices. Fire was not viewed as a standalone management tool but as part of an interconnected system that included grazing rotation, wild resource harvesting, and spiritual ceremonies acknowledging fire's regenerative power. We present a framework for integrating these documented practices into modern fire management systems, including: (1) community-led seasonal burning programs aligned with traditional calendars; (2) incorporation of traditional fire knowledge into formal training curricula; (3) development of cross-cultural fire management forums; and (4) creation of demonstration sites where traditional techniques can be observed and scientifically monitored. By recognising and revalidating indigenous fire knowledge, we can address the critical gap in contemporary wildfire management while simultaneously honouring cultural heritage and enhancing community resilience in the face of increasing climate-driven fire risk.

Keywords: Indigenous fire management, Traditional ecological knowledge, Patch-mosaic burning, Cultural integration, Knowledge revalidation

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Exploring Future Fire Regimes in Serranía De Cuenca, Spain Through an Integrated Fire Management Lens

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Abstract

The dynamic interaction between natural fire regimes and traditional human land use has long shaped Mediterranean landscapes, distinctively characterised by their heterogeneity and multifunctionality. In Spain, traditional land use regimes such as agropastoralism, transhumance and low intensity burning historically maintained a mosaic of open woodlands, grasslands and cultivated areas. However, rural depopulation and the abandonment of these practices have driven shifts in land use leading to more homogenous, densely vegetated landscapes with greater fuel accumulation and continuity, that when combined with increasing climate variability, increases the probability of high intensity wildfires. Although the ecological dimensions of landscape change and wildfire behaviour are well understood, there has been less emphasis on collaborating with local communities to co-develop pathways for land and fire management that are grounded in their specific socio-ecological contexts, an approach that is increasingly needed in future fire research and practice. Building these pathways requires an understanding of how governance supports or constrains local practices and how management strategies shape social, economic and environmental outcomes.

This project aims to apply an Integrated Fire Management (IFM) approach, influenced by growing interests from the local community of Cuenca, Castilla-La Mancha, Spain, in co-developing fire and land management strategies for the region. Preliminary insights from initial stakeholder engagement in the *Serranía de Cuenca* reveal key challenges that include landscape homogenisation due to rural depopulation and loss of traditional land practices, increasing distrust towards certain external initiatives and government bodies and differing visions for the future of the landscape. These findings highlight the need for participatory, place-based approaches that integrate diverse perspectives into land- and fire-management planning. This research will employ a mixed-methods design that will combine a series of semi-structured interviews to explore local fears, values and desired futures for the region with a stakeholder scenario-development workshop and fire-landscape simulations using the REMAINS model (Pais et al., 2023). In doing so, it will help advance understanding of how participatory-scenario development approaches combined with modelling tools, can inform adaptive fire and land management strategies. The goal of the project is to contribute to the generation of practical insights for strengthening landscape resilience, revitalising rural communities and promoting inclusive governance in Mediterranean landscapes.

Keywords: Future fire regimes, participatory, scenarios, Integrated Fire Management, Mediterranean, Spain, REMAINS

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Fire in the Earth System Abstracts
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Community Perspectives on Wildfire Risk: Insights to Rethink Local Resilience Strategies

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Abstract

In the climate change context, especially in more fire-prone regions such as Portugal, promoting community-driven resilience to wildfires is essential to mitigating risks and increasing preparedness. This work presents the perceptions of Portugal's municipal civil protection services about the role communities play in managing wildfire risk. Based on 212 responses from 181 municipalities in mainland Portugal, out of a total of 278 municipalities, to which we added insights from 15 national experts. The research identifies a complex scenario where there is awareness among the population, but structural limitations persist.

The results demonstrate that approximately 60% of municipal civil protection services consider their communities to be reasonably informed about the risks of wildfires. However, barriers such as insufficient financial (43.4%) and human (31.6%) resources, limited access to helpful information, and weak inter-institutional coordination continue to be serious problems. Despite these challenges, respondents most advocate for greater community involvement as information benefits and co-creators of innovative prevention and response strategies.

This work is aligned with shifting wildfire resilience from a high-tech model to a more participatory and community-rooted paradigm. By incorporating local knowledge and municipal experience, this work provides real-world insights into how risk governance, civil society engagement, and social innovation can contribute to building more fire-adaptable territories and communities.

Keywords: Wildfire resilience, Community engagement, Risk governance, Civil protection, Portugal

Fire in the Earth System Abstracts
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From Perception to Prevention: What Rural Communities Know About Fire? — a Mental Models Approach to Inform Risk Communication

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Abstract

Risk communication plays a pivotal role in wildfire prevention, especially when it is grounded in both scientific evidence and local perceptions. In rural Portugal, where traditional burning remains a widespread land management practice, bridging the gap between expert knowledge and community understanding is essential to promote behaviour change and reduce fire ignition risks.
This study presents the application of the Carnegie Mellon University (CMU) mental models approach (Morgan et al., 2002) to inform the design of wildfire risk communication strategies that align expert knowledge with the socio-cultural realities, perceptions, and lived experiences of rural communities.
The research was conducted in the central region of Portugal (CIM Região de Coimbra: Lousã, Góis, and Miranda do Corvo), focusing on risk perception linked to traditional burning. A total of 28 interviews with wildfire experts (from industry, public entities, academia, and associations) were conducted to build a reference influence diagram reflecting scientific and operational understanding of wildfire risks (Souza et al., 2023). Afterwards, 47 semi-structured interviews with rural residents were conducted to explore local perspectives and beliefs. All interviews were transcribed, coded, and analysed using NVivo software.
These two sets of interviews supported the construction of two mental models — one expert-based, the other community-based. Their comparison enabled the identification of "dissonances", namely, knowledge gaps, misconceptions, and beliefs that shape fire-related behaviours.
Findings from the fieldwork highlight the persistence of traditional burning, as central to land management. While most participants report through the official fire-use notification platform (often done with the support of the local parish council). The results reveal terminological confusions between "burns" and traditional "pastoral burning" practices. Additionally, participants expressed growing concern about the uncontrolled presence of wild animals, namely wild boar (Sus scrofa), red deer (Cervus elaphus) and roe deer (Capreolus capreolus), which is perceived as a factor that contributes to land abandonment and reduction of agricultural activities.

This approach reframes wildfire communication from a top-down, one-way message to a collaborative process rooted in local knowledge and values. It empowers communities not just as recipients of information, but as co-creators of wildfire prevention strategies. The findings offer a replicable model for integrating community voices into wildfire resilience planning and contribute to building socially legitimate and context-specific risk communication.

By placing communities at the heart of wildfire communication design, this work exemplifies how social science and citizen engagement can complement technical expertise to co-create fire-resilient territories.

Keywords: Risk communication, wildfire risk, community prevention, community engagement, traditional burning

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Fire in the Earth System Abstracts
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Bridging Policy and People: Collaborative Wildfire Risk Governance in the Rural–Urban Interface of Lousã

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Abstract

In fire-prone landscapes such as Lousã, located at the rural–urban interface (RUI) of Central Portugal, wildfire prevention depends not only on ecological and operational factors but also on the coherence of policies and the capacity of diverse actors to act collaboratively. Within the FIRE-RES project, we piloted a participatory methodology designed to support inclusive and constructive dialogue on wildfire-related governance challenges, with a focus on policy implementation at the local level.
The procss began with a series of bilateral interviews with stakeholders from public institutions, local authorities, communal land councils, and civil protection. These interactions helped identify key policy intersections and informed the development of individual Policy Coherence Matrices (PCM), which were later consolidated into a shared version. This collective matrix laid the groundwork for a face-to-face Policy Clinic in Lousã, guided by the OPERA methodology, fostering structured and respectful discussion across different perspectives.
Two priority challenges were addressed: (1) the socio-economic constraints that affect rural landowners' ability to comply with national wildfire legislation, and (2) the operational difficulties encountered when implementing fuel management in Natura 2000 areas. Rather than assigning blame, the clinic focused on understanding root causes, building mutual trust, and co-developing feasible, context-sensitive solutions.
Participants jointly proposed a range of actions, including tailored economic incentives, capacity-building, improved inter-agency coordination, and knowledge-sharing platforms. A key insight was the recognition that many implementation challenges stem from systemic conditions—such as land fragmentation, demographic shifts, and overlapping legal mandates—rather than from resistance or lack of will on the ground.
This experience demonstrated that structured participatory processes can be a valuable complement to existing governance efforts. By creating a safe space for open dialogue and collective problem-solving, policy clinics help uncover blind spots, clarify institutional roles, and strengthen community-led pathways for wildfire resilience. By placing communities at the heart of wildfire communication design, this work exemplifies how social science and citizen engagement can complement technical expertise to co-create fire-resilient territories.
Key message: The Policy Clinic in Lousã illustrated how inclusive, locally grounded approaches can bridge implementation gaps and support fire-smart, community-oriented

governance. When diverse voices are brought to the table - not as critics but as co-creators - new solutions emerge that are both pragmatic and anchored in real territorial conditions.

Keywords: Wildfire risk governance, Rural–Urban Interface, Policy coherence, Community-oriented governance, Participatory methods, OPERA, Socio-economic factors, fuel Management, Collaborative Solutions

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Fire in the Earth System Abstracts
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Fire-Explorer: a Fire Education Platform

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Abstract

Extreme wildfires pose a global threat, and the European Commission is investing considerable resources in researching and developing new models and approaches to tackle them. One of FIRE-RES project main goal is to share knowledge, raise awareness, and engage society. Extreme wildfires are not a common or well understood process in Europe. An online tool called Fire-explorer: a Fire Education Platform is being developed to address this gap, aiming to share best practices related to wildfire communication and awareness among countries.
This international multimedia tool gathering information from different countries, targeting multiple audiences (politicians, educators, students, and local communities), explores the fire culture concept and scope in Europe, analyzing topics such as the ecology of fire, fire risk, and its social dimension (oral and artistic pratices, traditions and fire use by local rural communities). The platform will be open-access and displayed in five languages.
The platform is being developed with a common core, which includes fire culture and a 5 minutoes fire guide. The separate core includes three areas: to teach, targeted at teachers and educators; to learn, targeted at the general public; and to apply, targeted at the professional sector. The Fire Education Platform is expected to be online in june 2025 and contribute to improving and fostering more and better knowledge on fire among all types of public to increase fire resilience.

Keywords: Fire resilience, Fire culture, Fire cycle, Multimedia, Platform design

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