FIREURISK - DEVELOPING A HOLISTIC, RISK-WISE STRATEGY FOR EUROPEAN WILDFIRE MANAGEMENT

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Executive Summary

The FirEURisk Central Europe Pilot Site Demonstration Event was held on the 26th January 2024. The event was an on-line event, the only sensible option for January in Central Europe with participants attending from Germany, Poland and Czechia. The event was hosted by the Faculty of Environmental Sciences at the Technische Universität Dresden in Germany.

The event presented a series of four sessions arranged thematically and towards target groups/stakeholder interests. Specifically, fire behaviour, future risks, fuel and weather and the wildland urban interface. This was part of a deliberate attempt to maintain interest in the event and so that stakeholders could focus on relevant information, pertinent to their sectors without the need to attend the event all day. The themes chosen and thus the products were decided upon following in-depth discussions with local and regional stakeholders and an appraisal of the need for specific knowledge about wildfire risk relevant to the Central European landscapes.

The study or urgency to study wildfires is not so well established in Central Europe and has only recently, due to several large and widely reported fires, become of interest to policy-makers, professionals and the public alike. To set the event within a better regional relevance two presentations regarding various aspects of the wildfire occurrences and regime in Central Europe and research were conducted by the Technische Universität Dresden. Though not tools or products as such, the information was well-received by the audience.

The Central Europe Pilot Site Demonstration Event was the second event held in the Pilot Site and followed the FirEURisk Symposium “Forest Fires in Central Europe – Preparing for a New Reality” which took place in October 2022 as part of a FirEURisk Plenary Meeting. It was during this event that the invited stakeholders were able to further express their needs and wishes for specific fire risk management products and tools. Experts from the Pilot Site and those directly involved with wildfire risk management or dealing with its occurrence and aftermath were invited to present some of the issues being faced in the Pilot Site and bring this to the attention of the public. The event, held shortly after the large wildfire in the transboundary national park area close to Dresden, seized upon the heightened public interest in wildfires. This interest and the requirements of stakeholders was a key element in identifying which of the many fire risk management tools produced in the FirEURisk project would be the most appropriate for demonstration event.
62 people registered for the event; this figure does not include people who registered who are part of the FirEURisk project. They represented 42 different institutions/organisations and 5 different Central European countries (Austria, Czechia, Germany, Poland and Slovenia), despite the Pilot Site only consisting of regions from Czechia, Germany and Poland. The institutes/organisations covered sectors such as regional planning, weather services, forestry, national parks (6), fire specialists, research and higher education, nature protection and environment agencies. The national parks that attended represented 3 cross-border regions from Central Europe (Czechia/Germany, Czechia/Poland and Czechia/Austria), highlighting an interest in transnational fire risk management across borders. The future of fire risk in these border regions and the effect of tree mortality was also a key discussion point following presentations by GMV and PIK who demonstrated their work on bark beetle outbreak potential and future scenarios for fire risk in Central Europe respectively.

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Following the large fire of 2022 in the cross-border national parks of Saxon Switzerland (DE) and Bohemian Switzerland (CZ) there was, and continues to be, public discussion of the danger of wildfires in the Wildland Urban Interface in light of the large amounts of deadwood within the forest as a result of the severe bark beetle infestation. This aspect of wildfire risk was covered in the demonstration event by the products Wildfire Urban Interface Mapping, Factors for Building Survivability and Curricula for Extreme Fires and Wildland Urban Interface. These products/tools presented by Haifa University, RISE and SAFE Cluster were amongst those that generated the most interest during the demonstration event. Others products such as Propagation Potential and Wildfire Spread were also received favourably.

Following the demonstrations, via the application of the Mentimeter on-line survey tool, the attendees expressed their wishes for further information about wildfire risk. Key amongst these wishes were: better resolution and localised assessment, better training for practitioners, fuels in the wildland urban interface, access to the data, a firefighting index and detailed fuel maps for fighting fires, more awareness campaigns, fuel management recommendations and cross-border assessment of wildfire risk.

It is clear that the favourable reception of the tools demonstrated and the wishes for further information reflect the types of stakeholders who attended and validates the selection of specific products for testing. The Technische Universität Dresden will hold a further follow-up event towards the finalisation of the project in order to present the FirEURisk Open Platform to stakeholders.

The Technische Universität Dresden wishes to thank project partners GMV, in particular Maria Julia and Marta for their support leading up to and during the event. We would also offer our thanks to the project partners who contributed to the event.

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List of Acronyms

Table 1: List of Acronyms

List of Acronyms	
BFB	Basic Fire Behaviour
BP	Burn probability
CFA	Crown fire activity
DE	Demonstration event
DFDI	Daily Fire Danger Index
DFHI	Daily Fire Hazard Index
DWD	German Weather Service
FL	Flame length
FMD	Fuel model
FMS	Fuel moisture content
FPI	Fire Potential Index
GIS	Geographic Information System
HNEE	Eberswalde University for Sustainable Development, Germany
IEEE	Institute of Electrical and Electronics Engineers
IGARSS	International Symposium on Geoscience and Remote Sensing
IP	Ignition probability
LBP	Landscape Burn Probability
LFMC	Live Fuel Moisture Content
LMS	Land Management Strategies
LUT	Look-Up Tables
MSI	Multispectral Instrument
MTT	Minimum Travel Time Fire Spread
RTM	Radiative Transfer Models
SDI	Suppression difficulty index
SMR	Saxon Ministry for Regional Development
VPD	Visual Perception with Pre-trained Diffusion Models
WAI	Wildland Agriculture Interface
WGI	Wildland Grassland Interface
WUI	Wildland-urban interface

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1 Introduction

The Central Europe Pilot Site Demonstration event provided the opportunity for the FirEURisk project to present a range of products and tools, specifically identified as being of potential interest to the stakeholders attending and reflecting the issues identified in the Pilot Site region considered as being in need of address. However, these products and tools are just a selection of the many outputs of the project, which sets itself out to bring about a change in the way we assess fire danger through the integration of various aspects of risk (Chuvieco et al., 2023), culminating in an overall assessment of risk. The FirEURisk's overall approach to integrating these aspects of risk can be seen below in Figure 1.

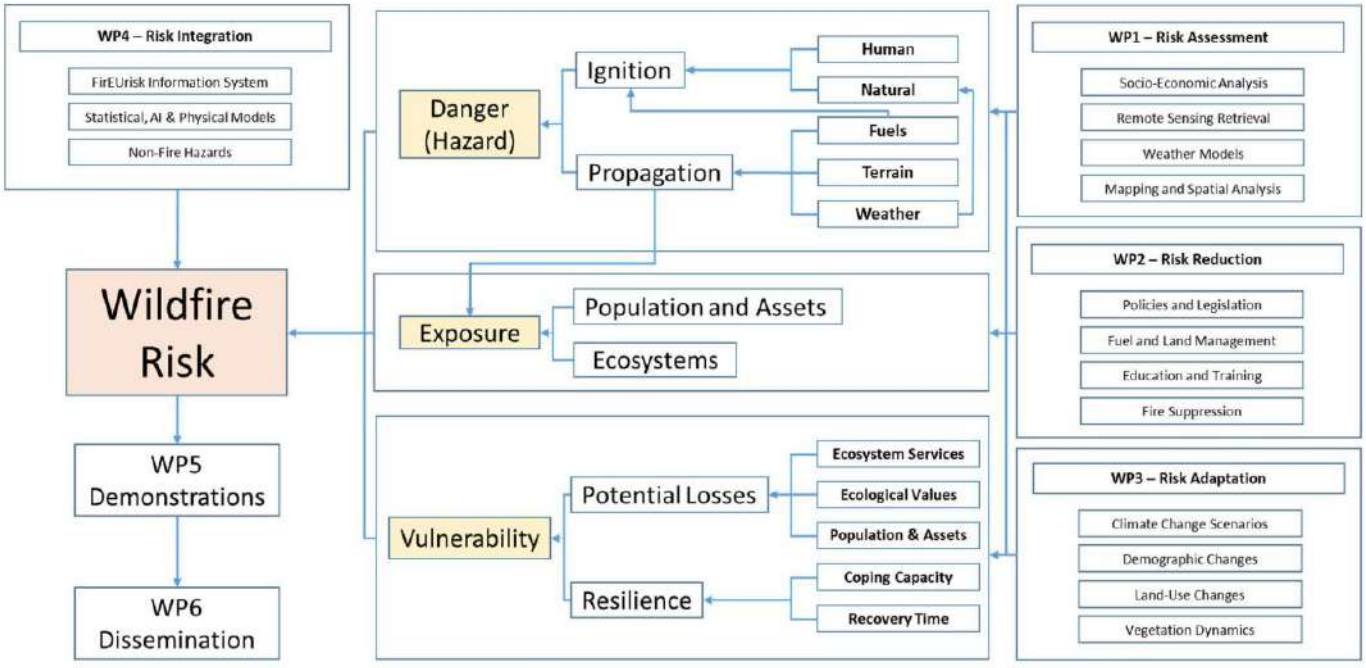


Figure 1: Conceptual Integration Diagram of Fire Risk Components within the FirEURisk Project

3.1. Purpose of the document

This document provides an in-depth description of the Central Europe Pilot Site Demonstration event, its planning, execution and feedback and evaluation regarding the product and tools selected for demonstration. Those products and tools are part of a vast range of outputs from the FirEURisk project's Work Packages 1-4 each of which combine to provide an overall assessment of the integrated wildfire risk, as shown above. Of the many products and tools available only a limited selection could be demonstrated during the event. Those decided upon were chosen as a result of early consultation with stakeholders via a questionnaire at the beginning of the project and further consultation following the large transboundary fire of 2022 and the issues that became apparent. These issues included propagation potential and fire spread and behaviour, Wildland Urban Interface (WUI) and management of fuels, cross-border risk assessment and the future risk of fires as a result of a changing climate.

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3.2. Structure of the Document

This document is structured in such a way as to describe the Demonstration Event's planning and structure, followed by a detailed explanation of the products and tools presented during the event. It then provides the feedback from the attendees with regards to the products and additional comments from them in respect of what else they would like to see in terms of improvements to wildfire risk assessment in the Central European context. It ends with a conclusion and reflection of the event and next steps.

2 The Central European Pilot Site: Saxon-Switzerland National Park.

Location: Germany: Southern Brandenburg and eastern Saxony; Czechia: North Bohemia; Poland: Lower Silesia.

The Central Europe Pilot Site is a cross-border region stretching from Elbe Sandstone Mountains in the west through the Zittau Mountains to the Giant Mountains in the east and to the outskirts of Berlin to the north. It covers around 32,790 km^2 and contains 4 national parks, 3 of which are involved in ground-truthing the outputs of the project, and it encompasses parts of the Czech Republic, Poland, and Germany.

The cross-border nature of the Giant Mountains between Poland and Czech make this Pilot Site particularly interesting in terms of coordinating responses and avoiding forest fires. Just over a third of the area is wooded with 11,819 km^2, located across various topographies including lowlands and mountainous areas as well as close to settlements. The population within the area is 3,764,301 inhabitants.

Broadleaved woodland accounts for just 4.2 % of land cover, coniferous woodland covers 24.5 % and 7.25 % is mixed woodland. Spruce (*Picea* sp.) and Scots pine (Pinus) are the predominant coniferous species in the area, with oak (*Quercus* sp.), ash (*Fraxinus*), birch (*Betula* sp.), rowan (*Sorbus*) and sycamore (*Acer*) making up the broadleaved components of the area's woodland cover. Forest fires occur every year, mostly as a result of negligence of humans.

Other factors such as increasingly longer periods of dry weather and the bark beetle are compounding the risk of larger fires occurring. Ignition through negligence is particularly relevant in areas with large numbers of visitors such as national parks which in this pilot region are heavily wooded landscapes, for example Saxon Switzerland in Germany has 94% woodland cover, Karkonosze National Park Poland 47% and Krkonoše National Park Czech Republic 59%.
The Teltow Fläming and Potsdam Mittelmark pilot sites/demonstration areas are located 50 km south and 40 km south west of Berlin respectively. The Tetlow Fläming site is an abandoned military training ground and is a mix of woodland and heath and has a relatively low local population with a few small settlements on the periphery of the large wooded areas. A wind farm in located within the heathland part of the area meaning important infrastructure could be at risk from forest fires and provides a case study for reacting to and planning for responses to the outbreak of fire and constraints relating to infrastructure.

In contrast, the Potsdam Mittelmark site is a large woodland area with an active military training area, army base and three settlements within the forest and thus forest fire in this area carries with it a greater risk to life and property as

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well as the potential for fire ignition from military exercises and stray munitions. Primary road and rail infrastructure pass through the area underlining the importance for fire risk to be better understood and managed in the area. The area is part of a woodland corridor that reaches Potsdam and the outskirts of Berlin, uncontrolled fires here and an unfavourable wind would have a dire effect on air quality in these two populous cities.

3 Implementation of the Demonstration Event

Originally the Demonstration Event was scheduled for summer/Autumn 2023 but following responses from stakeholders that indicated an interest in themes related products and tools that wouldn't be ready for that date it was decided to move the event to January 26th, 2024. January isn't the best time of the year to invite attendees to travel from across Central Europe (in the case of the Pilot Site, Czechia, Poland and Germany). In addition, the financial demand of travel to, and accommodation in Dresden, was considered to be a factor that would realise in fewer attendees. FirEURisk is a project with partners participating from across Europe and beyond and asking product and tool developers to attend in person was also considered to be placing an unnecessary financial burden. With a potentially limited in-person attendance by both attendees and presenters, it was decided that an on-line only event would be the most appropriate format under the circumstances. As a result, costs for the event were kept to a minimum consisting of only staff costs.

Over 80 potential participants were identified and to each of them a personal invitation by email was sent with an explanation of the project's objectives and approach. Attendees were invited to view the FirEURisk website and to register for the event. Registration was via the Zoom Webinar software which allowed for a simple registration process and the collection of information about attendees. In all, 62 people registered and 61 attended the event. This figure is for those attendees not directly related to the FirEURisk project. The event was designed in such a way that each session had a broad theme, enabling stakeholders interested in a particular theme to attend when they thought appropriate. These stakeholders included sectors from research and education, town and country planning, forestry management and research, emergency response, nature conservation (including 6 transboundary national parks), a weather service and environment ministries. They came from 5 of the countries that are considered as part of Central Europe; Austria, Czechia, Germany, Poland and Slovenia.

The event took place on 26th January, 2024 between 09:00 and 16:25 and 14 products and tools were presented to the audience. There were additional presentations by two members of the steering committee, an introductory presentation by Junior Professor Matthias Forkel of the Technische Universität Dresden (TUD) outlining some of the wildfire risk issues within Central Europe, a presentation about the transboundary fire of 2022 including the contribution of bark beetle affected trees to the propagation and spread and a further presentation by Johanna Kranz (TUD) about the fire weather and fuel moisture campaign initiated during Work Package 1, using the protocols developed in the project.

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3.1. Meeting Agenda

Timeslot	Action	Presenter	Organization
09:00 - 09:05	Welcome and Event Information		
09:05 – 09:15	Introduction to the FirEURisk Project	Xavier Domingos Viegas	ADAI
09:15 – 09:30	Scientific Overview of the Project	Emilio. Chuvieco	Universidad de Alcalá
09:30 – 09:45	Central Europe, Current and Future Fire Risk (*)	Matthias Forkel	TU Dresden
Fire Behaviour			
09:45 – 09:55	Curricula for Extreme Fires and Wildland Urban Interface	S. Lahaye	SAFE Cluster
09:55 – 10:10	Propagation Potential for Central European Pilot Site	M. Bugarić	FESB University of Split
10:10 – 10:25	Wildfire Spread and Behaviour Outputs "Basic Mode"	M. Bugarić	FESB University of Split
10:25 – 10:40	Suppression Difficulty Index Evaluation	J. Martínez	Universidad de Cordoba
10:40 – 10:55	Fuel Mapping and Fire Behaviour NP Fire 2022 (*)	M. Forkel	TU Dresden
10:55 – 11:10	Short Break		
Current and Future Factors			
11:10 – 11:25	Human Ignition Probability	P. Gelabert	Universidad de Lleida
11:25 – 11:50	Future Fire Regimes	K. Thonicke	PIK
11:50 – 12:05	Forest Condition: Biotic Damages	Á. Carrillo	GMV
12:05 – 12:35	Mentimeter Survey and Questions	M. Ballester	GMV
12:35 – 13:30	Lunch Break		
Weather and Fuel Conditions			
13:30 – 12:45	Satellite-Derived Live Fuel Moisture Content	V. Pampanoni	University of Rome
12:45 – 13:00	Daily Fire Danger Index (DFDI) (*)	V. Pampanoni	University of Rome
13:00 – 13:15	Fire Danger Metric	V. Resco de Dios	Universidad de Lleida
13:15 – 13:30	Fire Weather and Fuel Moisture Field Campaign (*)	J. Kranz	TU Dresden
14:30 – 14:45	Questions		
14:45 – 14:55	Short Break		
Reducing Losses			
14:55 – 15:10	Wildland Urban Interface Mapping	A. Bar-Massada	University of Haifa
15:10 – 15:25	Potential Losses of Ecosystem Services affected by wildfires	J. Martínez	Universidad de Cordoba
15:25 – 15:40	Factors for building Survivability	F. Plathner	RISE
15:40 –15: 55	Spring grassland fire model	J. Sjöström	RISE
15:55 – 16:10	Mentimeter Survey and Questions	M. Ballester	GMV
16:10 – 16:25	Opportunity for further questions		
16:25	Final words and thoughts	X. Viegas, M. Forkel	ADAI, TU-Dresden

(*) Not official outputs from FirEURisk project, but nevertheless produced by FirEURisk partners and highly relevant to the Central Europe Pilot Site and stakeholders' interests

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4 Product Descriptions

4.1. P4 - Curricula for Extreme Fires and Wildland Urban Interface (No. 19)

- **Session:** Curricula for extreme fires and WUI. Sébastien Lahaye, SAFE (France).
- **Developer:** Sébastien Lahaye, SAFE Cluster (France).
- **Activity:** "A2.3.3 Curricula for extreme fires and WUI".
- **Product description:** This product in a form of curriculum provides firefighters and managers an appropriate understanding of extreme fire behaviour and WUI challenges. This Product considers the evolution of fire risk and the transferability of strategies used in Mediterranean countries to fight fires in Northern/higher elevation contexts.
- **Methodology:** Product based on regional experiences (together with Australian and North American practices), elaborates on the way and context to use alternative techniques such as back-burning, which could help addressing escalation of wildfire size and limit challenges of extreme fire behaviour. Materials were customised for the different types of users throughout Europe and to their languages.
- **FirEURisk component of the integrated strategy:** Coping capacity and population & asset vulnerability
- **Technical characteristics:**

Characteristics	Description
Type of products:	Guidelines product
Units:	not applicable
Update Frequency:	Years
Accuracy:	not applicable
Output Format:	.pdf
Fire risk component (accordingly to the Integrated Scheme of the FirEURisk project):	Coping capacity and population & assets vulnerability
Temporal coverage:	not applicable
Spatial resolution:	not applicable
Availability on FirEURisk platform:	Due M36

4.2. P5 - Propagation Potential for Central European Pilot Site (No. 32)

- **Session:** Propagation Potential in Pilot Site 2 – Central Europe, Marin Bugaric FESB (Croatia).
- **Developer:** Marin Bugaric FESB (Croatia).
- **Activity:** "1.3.1. Risk assessment integration".
- **Product description:** This product will include GeoTIFF raster maps of propagation potential indicators for Pilot Sites, as well as report with detail description of methodology and obtained results. Our intention is to use primarily FlamMap Basic Fire Behaviour to create something like 'static' propagation potential maps based on historical past fires in analysed area (Pilot Sites) for the last 20 years having as outputs: Rate of Spread (m/s), Heat per Unit Area (kJ/m2), Flame Length (m), Fireline Intensity (kW/m), Crown Fraction Burned (%) and Crown Fire Activity.

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- **Methodology:** Propagation potential is important part of Wildfire risk estimation having direct influence on Danger (hazard) and Exposure. In this document a detailed methodology for propagation potential calculation on Pilot Sites (PS) level is presented, as well as analysis of all necessary input data and how it could be collected for FirEURisk Pilot Sites (PS). Well known software for wildfire behaviour simulation FlamMap has tools that could be used for propagation potential: a) Basic Fire Behaviour (BFB) or Landscape Fire Behaviour (Basic), b) Minimum Travel Time Fire Spread (MTT) and c) Landscape Burn Probability (LBP).
- **FirEURisk component of the integrated strategy:** Propagation
- **Technical characteristics:**

Characteristics	Description
Type of products:	Geospatial product
Units:	Not applicable
Update Frequency:	If needed
Accuracy:	To be defined
Output Format:	.tiff
Fire risk component (accordingly to the Integrated Scheme of the FirEURisk project):	Propagation
Temporal coverage:	Static layers
Spatial resolution:	100 m x 100 m

4.3. P6 - Wildfire Spread and Behaviour Outputs "Basic Mode" (No. 70)

- **Session:** Modelling wildfire spread and behaviour. Central Europe, Marin Bugaric FESB (Croatia).
- **Developer:** FESB (Croatia)
- **Activity:** "A1.1.5. Analysis of fire propagation, fuel consumption and smoke emission as risk factors".
- **Product description:** This product is a geodatabase that contains the fire spread and behaviour modelling outputs for the "basic mode" runs (i.e., calculations conducted by pixel).
- **Methodology:** http://books.uc.pt/chapter?chapter=9789892622989174
- **FirEURisk component of the integrated strategy:** Danger-Propagation
- **Technical characteristics:**

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Characteristics	Description
Type of products:	Geospatial product
Units:	Fire intensity (kw/m), flame length (m), rate of spread (m/min), crown fire activity (class), crown fraction burned (percentage), and heat per unit area (kJ/m2)
Update Frequency:	not applicable
Accuracy:	not applicable
Output Format:	.gdb
Fire risk component	Propagation
Temporal coverage:	2021
Spatial resolution:	100 m

4.4. P7 - Suppression Difficulty Index Evaluation (No. 39)

- **Session:** Expected economic impacts and suppression difficulty index. J.R. Molina. Universidad de Córdoba, UCO.
- **Developer:** University of Cordoba (UCO, Spain).
- **Activity:** "A1.1.5. Analysis of fire propagation, fuel consumption and smoke emission as risk factors".
- **Product description:** The Product describes the efficiency and limitations of suppression strategies in different landscape fire contexts, determined from productivity rates of fire control as a factor of the strategies adopted with the resources dispatched to fire.
- **Methodology: -**Rodriguez y Silva, Francisco; O Connor, Christopher D.; Thompson, Matthew P.; Martinez, Juan Ramon Molina; Calkin, David E. 2020. Modelling suppression difficulty: Current and future applications. International Journal of Wildland Fire. doi: 10.1071/WF19042.
- **FirEURisk component of the integrated strategy:** Danger-Propagation, Exposure
- **Technical characteristics:**

CHARACTERISTICS	DESCRIPTION
Type of products:	Geospatial product
Units:	Qualitative (classes: Very Low, Low, Medium, High, Very High)
Update Frequency:	Static layer
Accuracy:	85-95%
Output Format:	.GeoTiff
Fire risk component	Propagation/Exposure
Temporal coverage:	2021
Spatial resolution:	100 m

- **Overview:**

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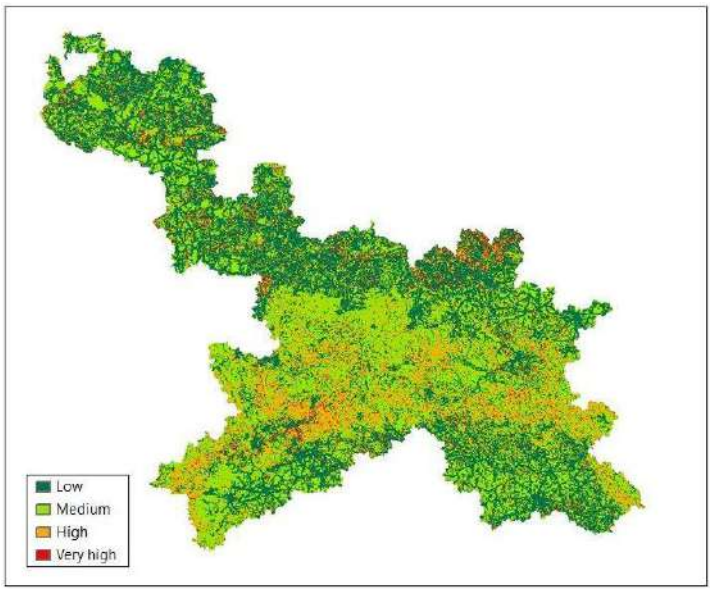


Figure 1. Suppression Difficulty Index product output.

4.5. P8 – Human Ignition Probability Map (No. 63)

- **Session:** Probability of human-caused ignitions in Central Portugal. Pere Gelabert Universitat de Lleida, UdL.
- **Developer:** University of Lleida (UdL, Spain) and University of Zaragoza (Spain).
- **Activity:** "A1.1.3. Human ignition drivers (D,S) & Public participation in fire prevention and preparedness".
- **Product description:** This product estimates the probability that a human caused fire to ignite at the pilot site scale.
- **The final output** – probabilistic raster map (scale 0 to 1) with the spatial resolution of 100m.

Methodology: The product estimates the probability of human-caused ignition at pilot site level. It was obtained by means of Random Forest algorithm using as inputs human fire records and ten static spatial drivers: fuel types, distance to interfaces (WAI, WUI WGI), distance to roads, population density, and percentage of urban/agricultural/wildland covers).

- **FirEURisk component of the integrated strategy:** Human ignition
- **Technical characteristics:**

Characteristics	Description
Type of products:	Geospatial Product
Units:	Probability, % (for raster grid)
Update Frequency:	No updates
Accuracy:	70-80%
Output Format:	.RData (model); .tif (raster grids)
Fire risk component:	Human ignition
Temporal coverage:	Depends on pilot site: PS2, 2008-18; PS3, 2001-21; PS4, 2008-18; PS5,2017-21

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Characteristics	Description
Spatial resolution:	100m (1 ha)

4.6. P9 – Future Fire Regimes (No. 36)

- **Session:** Future Fire Regimes. Kirsten Thonicke, PIK (Germany).
- **Developer:** Kirsten Thonicke, PIK (Germany).
- **Activity:** "A3.2.1 Expected changes in future fire regimes".
- **Product description**: This product contains changes in future fire regimes (fire ignitions, burned area, fire intensity) compiled from simulated spatio-temporal fire variables of fire-enabled DGVMs.
- **Methodology:** Use of land use and climate scenarios to generate a vegetation and fire models, which will be used to generate future fire regimes in EU.
- **FirEURisk component of the integrated strategy:** Ignition / Propagation
- **Technical characteristics**:

Characteristics	Description
Type of products:	Geospatial product
Units:	Not applicable
Update Frequency:	Not applicable
Accuracy:	Not applicable
Output Format:	.netcdf
Fire risk component (accordingly to the Integrated Scheme of the FirEURisk project):	Ignition / Propagation
Temporal coverage:	2020-2100
Spatial resolution:	> 1 km (9 km)

- **Overview**

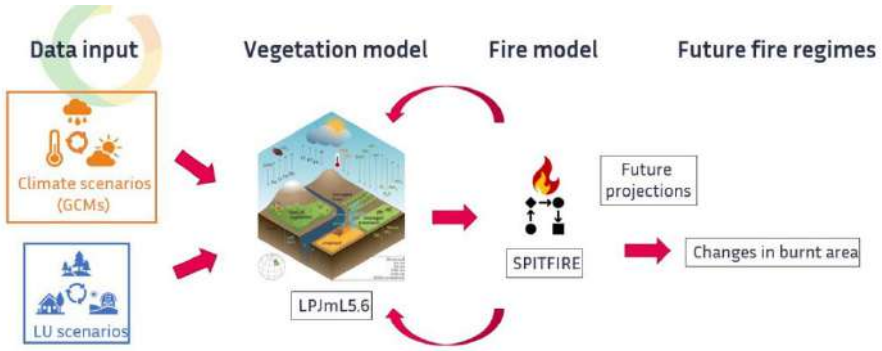


Figure 2. Future fire regimes.

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4.7. P10 – Forest Condition: Biotic Damages (No. 34)

- **Session:** Forest Condition: Biotic Damages, Ángel Fernández Carrillo GMV
- **Developer:** GMV (Spain)
- **Activity:** "A4.2.3 Cascading effects and interactions with other risks"
- **Product description:** This product predicts the probability of a bark beetle (*Ips typographus*) attack assessing a set of risk factors that predispose forests to pest infestations and wildfires for Central-Eastern Europe Pilot Site. This technological solution aims to identify areas predisposed to bark beetle infestation using EO-based and machine learning techniques. Geospatial results will be provided in raster format (.tiff) to help managers optimise their resources and mitigate the negative effects of plagues and wildfires. The output is a map showing predicted bark beetle attack probability from 0 to 100.
- **Methodology:** GMV estimated past biotic damages caused by bark beetle outbreaks (Fernandez-Carrillo et al., 2020) in Central-Eastern Europe (Parts of Germany, Poland, Czechia and evaluated the influence of environmental traits that predispose forests to a bark beetle infestation (Directorate-General for Environment (European Commission) et al., 2020), (Turbé et al., 2012). Pre-processing risk factors involved cleaning data to fill or discard missing records (e.g., clouds), eliminate inconsistencies, and standardise datasets. Different indicators were calculated and selected through a feature engineering process to generate the input variables. These variables were ranked using Gini impurity decrease to understand their effect on bark beetle. Different classical and Artificial Intelligence architectures were tested to produce a predictive model of bark beetle attack. Hyperparameter tuning was carried out using iterative random/grid search and cross-validation. The best model was selected to produce a raster showing the predicted bark beetle damage. The integration of the biotic damages (e.g., Figure 3) will be analysed within the framework of the A4.2.3 Cascading effects and interactions with other risks.
- **FirEURisk component of the integrated strategy:** Cascading effects, Fuels
- **Technical Characteristics**

Characteristics	Description
Type of products:	Geospatial
Units:	Percent (%)
Update Frequency:	Seasonal
Accuracy:	Validated in Saxon-Switzerland National Park
Output Format:	tiff
Fire risk component:	Cascading effects
Temporal coverage:	2017 - Present.
Spatial resolution:	50m

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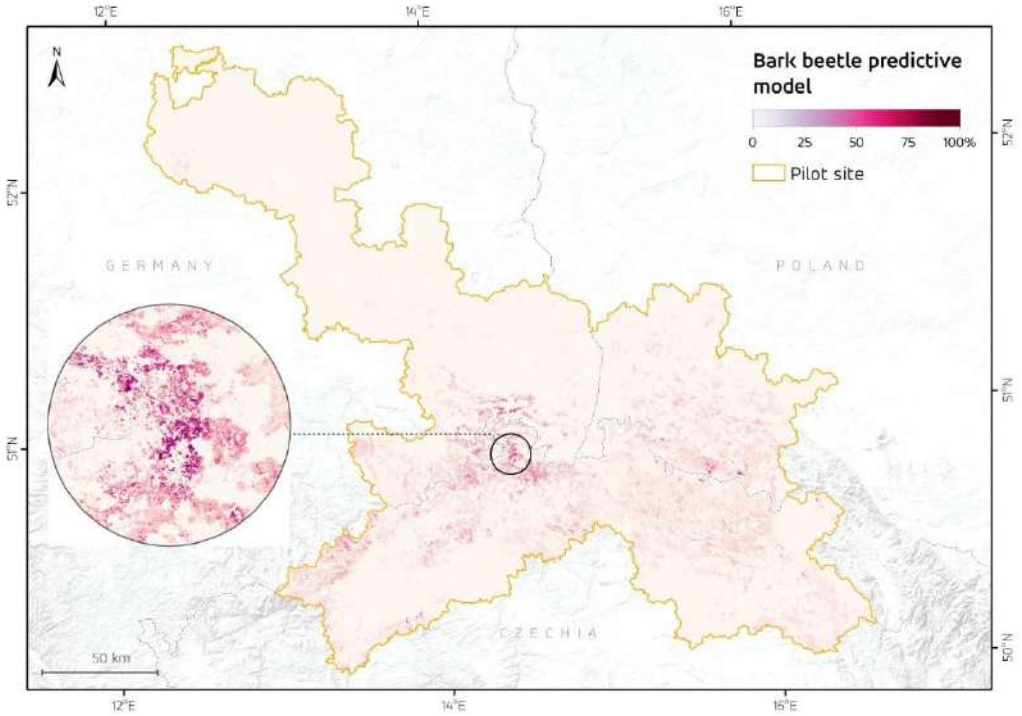


Figure 3. Cascading effects. Bark beetle predictive model.

4.8. P11 – Live Fuel Moisture Content (No. 64)

- **Session:** Satellite-derived Live Fuel Moisture Content. V. Pampanoni, University of Rome
- **Developer:** University of Rome
- **Activity:** "A1.1.1 Fire Weather and Fuel Status Prevention"
- **Product description:** RTM-based LFMC (Live Fuel Moisture Content) product based on the Sentinel-3 SYNERGY and Sentinel-2 L2A surface reflectance product and a LUT-based inversion procedure. Developer: SIA. The product was developed within the Activity "A1.1.1. Fire weather and fuel status prevention".
- **Methodology:** This product is based on the inversion of Look-Up Tables (LUT) created using a combination of the PROSPECT-D, 4SAIL Radiative Transfer Models (RTM) and a modified version of Huemmrich's GeoSail, and convolving the calculated reflectances in the Sentinel-3 SYNERGY and Sentinel-2 MSI channels. The LUTs change depending on the land cover type: PROSPECT-D and 4SAIL are used for grasslands and shrub-lands, while for forests the 4SAIL output is fed into the Geo component to simulate discontinuous vegetation. Latest publication available here: Pampanoni, Valerio, et al. "Early Validation of A Live Fuel Moisture Content Product Based on Sentinel-2 and Sentinel-3 Images." IGARSS 2023-2023 IEEE International Geoscience and Remote Sensing Symposium. IEEE, 2023.
- **FirEURisk component of the integrated strategy:** Danger-Weather
- **Technical characteristics:**

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Characteristics	Description
Type of products:	Geospatial Product
Units:	% moisture content
Update Frequency:	~Daily (Sentinel 3), ~Weekly (Sentinel 2)
Accuracy:	80-90%
Output Format:	.tiff, .nc
Fire risk component:	Prevention - Fuels
Temporal coverage:	2018-today (Sentinel-3) 2017-today (Sentinel-2)
Spatial resolution:	300m (Sentinel-3), 10-20m (Sentinel-2)

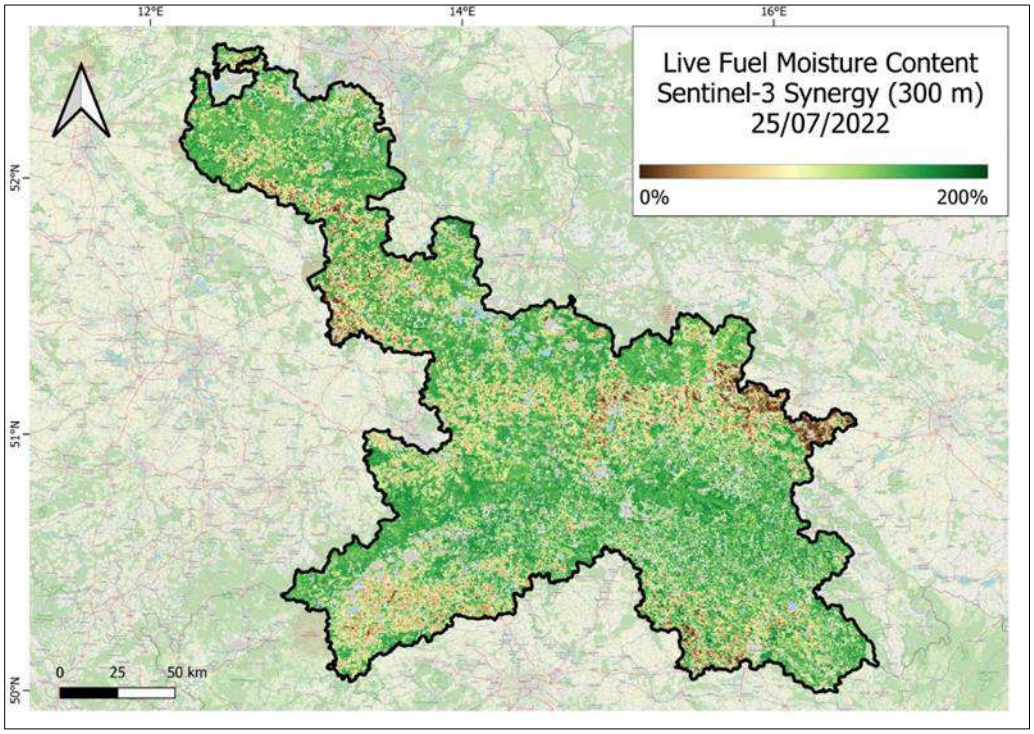


Figure 4. Example of product output in Pilot Site 2 Central Europe on the 25th July 2023

4.9. P12 – Daily Fire Danger Index (DFDI) (No. 16)

- **Session:** Daily Fire Danger Index. V. Pampanoni, University of Rome
- **Developer:** University of Rome
- **Activity:** "A1.1.1 Fire Weather and Fuel Status Prevention"
- **Product description:** The Daily Fire Danger Index (DFDI) is a novel scalable-resolution fire danger index based on weather data and satellite imagery. The product relies on Sentinel-3 SYNERGY and Sentinel-2 2A products to estimate the condition of the vegetation (available dead vegetation and the live fuel moisture content) at moderate and high resolution. Weather variables are used to calculate the dead fuel moisture content, the evapotranspiration and to obtain the wind speed. The Product provides a fire danger forecast: 1) at different

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times of the day and 2) for the following days. Developer: SIA. The product was developed within the Activity A1.1.1 Fire Weather and Fuel Status Prevention.

- **Methodology:** The DFDI derives from satellite-based fire danger indices: it starts from Burgan's Fire Potential Index (FPI) and culminates with the Italian Daily Fire Hazard Index (DFHI). The DFDI improves the DFHI by using satellite measurements of canopy reflectance to estimate live fuel moisture content (LFMC); in addition, it redefines the index calculation by incorporating wind speed data, evapotranspiration and the LFMC itself
- **Technical characteristics:**

Characteristics	Description
Type of products:	Geospatial data
Units:	Percentage danger and categorical danger rating: very low danger, low danger, medium danger, high danger, extreme danger.
Update Frequency:	Daily
Accuracy:	NA
Output Format:	.tif
Fire risk component:	Danger
Temporal coverage:	Daily
Spatial resolution:	300m (Sentinel-3), 10-20m (Sentinel-2)

4.10. P13 – Fire Danger Metric (No. 58)

- **Session:** A metric capturing dead fuel moisture and atmospheric instability. V. Resco. Universitat de Lleida, UdL.
- **Developer:** University of Lleida (UdL, Spain).
- **Activity:** "A1.1.1 Fire weather and fuel status prevention".
- **Product description:** The Product is an algorithm for a fire danger assessment using a novel fire danger metric that couples surface and profile meteorology (different types of atmospheric stability), with dead and live fuel moisture status.
- **Methodology:**

-Rodrigues, Marcos & Resco de Dios, Víctor & Sil, Ângelo & Cunill-Camprubí, Àngel & Fernandes, Paulo. (2024). VPD-based models of dead fine fuel moisture provide best estimates in a global dataset. Agricultural and Forest Meteorology. 346. 109868. 10.1016/j.agrformet.2023.109868.

-Resco de Dios, V.; Cunill Camprubí, À.; Pérez-Zanón, N.; Peña, J.C.; Martínez del Castillo, E.; RodriguesS, M.; Yao, Y.; Yebra, M.; Vega-Garcia, C. ;Boer, M. Convergence in critical fuel moisture and fire weather thresholds associated with fire activity in the pyroregions of Mediterranean Europe. Science of The Total Environment. Volume 806, Part 4. 2022, 151462. ISSN 0048-9697. https://doi.org/10.1016/j.scitotenv.2021.151462.

-Clarke, H., Nolan, R.H., Resco de Dios, V. et al. Forest fire threatens global carbon sinks and population centres under rising atmospheric water demand. Nat Commun 13, 7161 (2022). https://doi.org/10.1038/s41467-022-34966-3.

- **FirEURisk component of the integrated strategy:** Danger-Weather
- **Technical characteristics:**

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Characteristics	Description
Type of products:	Algorithm / Geospatial
Units:	-
Update Frequency:	Daily-weekly
Accuracy:	-
Output Format:	R script
Fire risk component:	Weather
Temporal coverage:	2001-2020
Spatial resolution:	1km (500m)

- **Overview:**

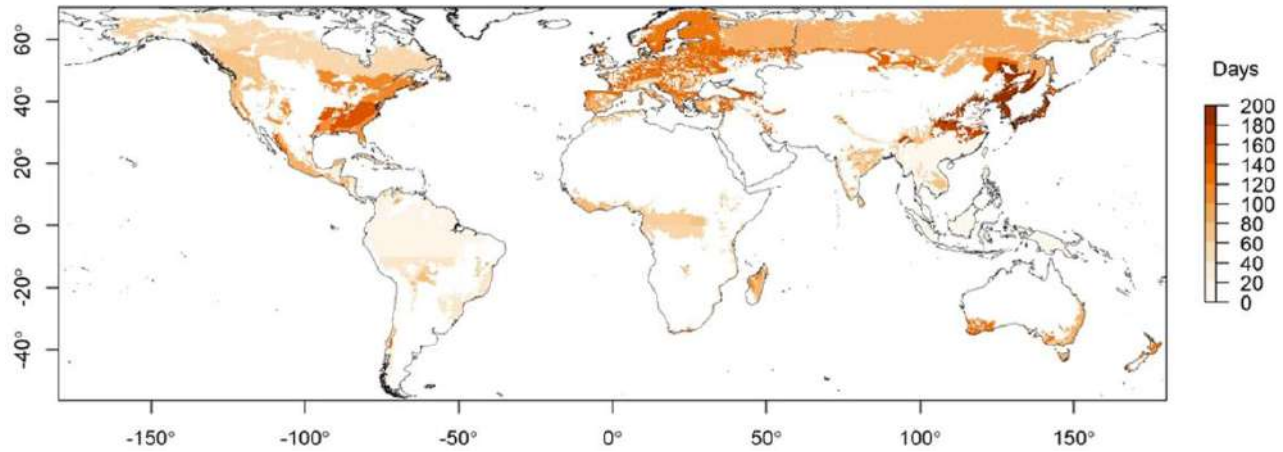


Figure 5. Current mean annual frequency of daily VPD threshold exceedances (days) for global forest biomes.

4.11. P14 – Wildland Urban Interface Mapping (No. 18)

- **Session:** Wildland-urban interface. A. Bar Massada. University of Haifa, Israel.
- **Developer:** The James Hutton Institute, Scotland (United Kingdom).
- **Activity:** "A1.2.2 Societal vulnerability and resilience assessment"
- **Product description:** This product identifies the locations of wildland - urban interfaces (WUI) of two types, interface (where human settlements adjoin flammable vegetation) and intermix (where human settlements are interspersed with a matrix of flammable vegetation).
- **Methodology:** The mapping method builds upon the approach of Bar-Massada et al. (2012). This is a point-based (i.e., buildings) approach, which was converted here to a raster approach due to data availability on settlements. For WUI mapping purposes, only two classes of this dataset were considered: forests and shrublands.

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-Bar-Massada, Avi & Alcasena, Fermín & Schug, Franz & Radeloff, Volker. (2023). The wildland -urban interface in Europe: Spatial patterns and associations with socioeconomic and demographic variables. Landscape and Urban Planning. 235. 104759. 10.1016/j.landurbplan.2023.104759.

- **FirEURisk component of the integrated strategy:** Exposed population and infrastructures
- **Technical characteristics:**

Characteristics	Description
Type of products:	Geospatial product
Units:	Categorical: 0 - non WUI, 1 - intermix WUI, 2 - interface WUI
Update Frequency:	Static
Accuracy:	80-90%
Output Format:	.tiff
Fire risk component	Exposure/vulnerability (Population-Assets)
Temporal coverage:	2020
Spatial resolution:	> 1 ha (10m)

- **Overview:**

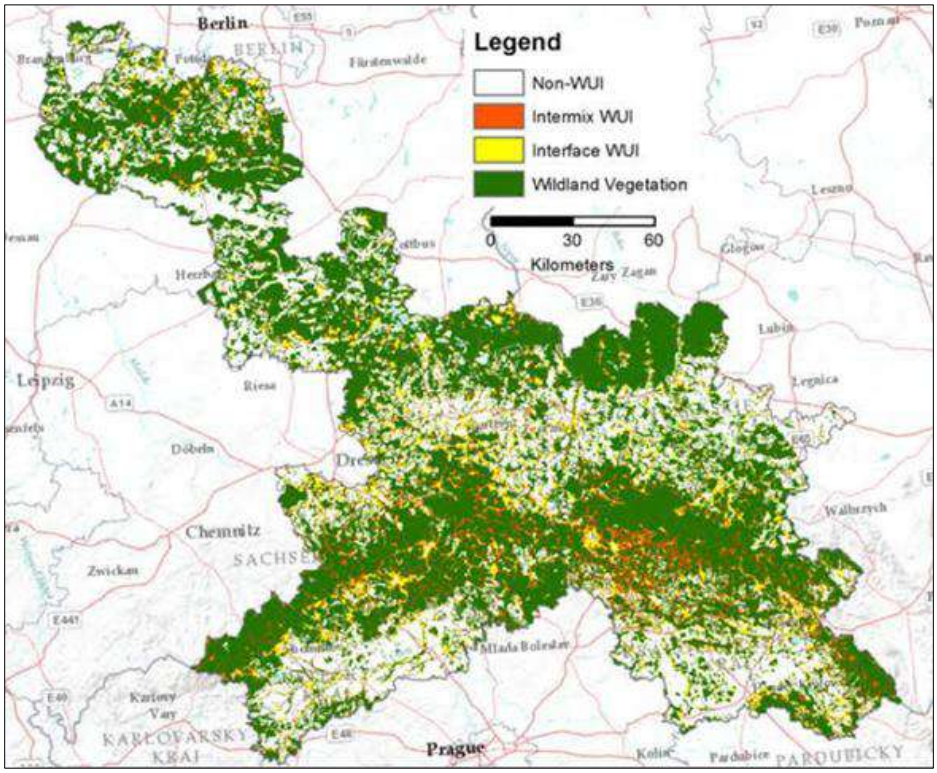


Figure 6. WUI product outputs (Central Europe, Parts of Czechia, Germany and Poland).

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4.12. P15 – Potential Losses of Ecosystem Services Affected by Wildfires (No. 38)

- **Session:** Potential Losses of Ecosystem Services Affected by Wildfires, J.R. Molina. Universidad de Córdoba
- **Developer:** Universidad de Córdoba (Spain)
- **Activity:** "A1.2.4 Economic Impacts of Fire""
- **Product description:** The Product is the result of the integration of the assessment of economic losses in each of the natural resources of the forest landscape potentially affected by wildfires.
- **Methodology:** Evaluation based on algorithms of economic value of resources. The economic impact is determined by the fire intensity level (FIL) that fire spread generate. The model includes a depreciation matrix based on the FIL to calculate the economic losses in each of the natural resources of the forest landscape where the fire has affected
- **FirEURisk component of the integrated strategy:** Vulnerability (Economic Value)
- **Technical characteristics:**

Characteristics	Description
Type of products:	Geospatial product
Units:	€/ha (product at 100m of spatial resolution) €/km2 (product at 1km of spatial resolution)
Update Frequency:	Static
Accuracy:	85-95%
Output Format:	.tiff
Fire risk component	Vulnerability
Temporal coverage:	Current
Spatial resolution:	100m/1km

4.13. P16 – Factors for Building Survivability (No. 72)

- **Session:** Factors for building survivability in Sweden, Frida Plathner, RISE
- **Developer:** RISE (Research Institutes of Sweden)
- **Activity:** A2.2.4 Mapping and guidelines for LMS (land management strategies)
- **Product description:** This product describes list of importance of factors for building survivability in large forest fires in Scandinavia
- **Methodology:** The factors critical for building survival in Scandinavia are assessed by a field inventory on all buildings that were within the perimeter of four forest fires in Sweden 2014 and 2018. The inventory encompassed 187 buildings and their status, management, garden structure and surroundings prior to the fire was assessed in relation to the post fire damages. It was clear that garden structure was most important for survivability and that the three most important factors (statistically significant) were (1) a managed lawn around the building, (2) reduced residential or vegetation fuel in direct contact to the facade and (3) inclusion of deciduous trees around the garden.
- **FirEURisk component of the integrated strategy –** Danger, Fuels

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- **Technical characteristics:**

Characteristics	Description
Type of products:	Document
Units:	NA
Update Frequency:	NA
Accuracy:	NA
Output Format:	Document PDF
Fire risk component	Danger, Fuels
Temporal coverage:	NA
Spatial resolution:	100m/1km

4.14. P17 – Spring Grassland Fire Model (No. 69)

- **Session:** Spring grass fire model for the north, Johan Sjostrom, RISE
- **Developer:** RISE (Research Institutes of Sweden)
- **Activity:** "A1.1.5 Analysis of fire propagation, fuel consumption and smoke emission factors"
- **Product description:** This product is a fire danger model for North spring grasslands that produces fire danger maps with hourly temporal resolution. Developer: RISE. The product developed within the Activity "A1.1.5 Analysis of fire propagation, fuel consumption and smoke emission as risk factors".
- **Methodology:** The fire danger model is based on
    1. 25 years of dispatch statistics in Sweden
    2. Series of grassfire experimental burns during a whole season
    3. Field inventory of grasslands to develop phenological model.

  In regions with cold winters (North America, Scandinavia, Eastern Europe, Russia) the fire danger of grass fuels is very high just after the winter where usually 100 % cured grass litter is very flammable after just a few hours exposure to dry air and sun light. As the spring progresses, fresh green grass grows within the litter and brings high amounts of moisture to the fuel bed, reducing spread rates and intensity until practically arrested spread at beginning of summer, even during dry conditions. The model takes into account dead fuel moisture and thus needs input on the following parameters on an hourly basis:
    - past precipitation (mm/h)
    - relative humidity (2-m)
    - temperature (2-m)
    - wind speed (10-m open ground)
    - solar irradiation
    - daily average air temperature
    - snow cover

  The model also takes into account the local wind speed for Rate of spread and the contribution from green-up of this season's grass using a phenological model. Unlike forest fire danger for which fireline intensity is the

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danger metric, the danger levels are determined based on the rate of spread, the most challenging part of grassland fires. The model is operational in Sweden since 2021 but could be applied also to other regions with cold winters. The danger model, with algorithms, is presented here, A phenology-driven fire danger index for northern grasslands (2023), International Journal of Wildland Fire, https://doi.org/10.1071/WF23013.

- **FirEURisk component of the integrated strategy:** Propagation, Weather
- **Technical characteristics:**

Characteristics	Description
Type of products:	Geospatial product/model
Units:	Categorical: Fire Danger Classes
Update Frequency:	Hourly
Accuracy:	NA
Output Format:	.tiff
Fire risk component	Propagation, Weather
Temporal coverage:	Forecast for five days. Model based on 1996-2021
Spatial resolution:	2.5km

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5 Validation protocol

The questionnaires to be posed to the audience had the following objective:

- A **high-level** valuation of the products and Feedback about the demonstration event itself, accomplished through **MENTIMETER**. This tool is very interactive with attendants BUT does not allow full traceability of the responses back to the person.

The questions shall be kept at a high level (though not overly technical). Key information to measure and retrieve:

- **Clarity** of information provided by presenters and contents.
- **Usability** of the products presented for their daily work.
- **Quality/methodology** aspects of the product (very general).
- **Self-contained** information of the product.

6 Results of Validation

Analysis of the results of the questionnaires collected during the event and after considering the user needs is presented below. The number of answers for each point is shown in brackets. The evaluation is presented on a scale from 0 to 5.

6.1. Session 1

1. What is your organisation's name? (n= 21) *repeated names removed*

HNEE (Eberswalde University for Sustainable Development, Germany)
UAH
BOKU (University of Natural resources and Life Sciences, Austria)
Brandherde
ADAI
TU Dresden
GMV
TU Munich
SMR (Saxon Ministry for Regional Development)
Fraunhofer EMI (Institute for High-Speed Dynamics)
CERIDES
TU Berlin
INCDS
GMV
DWD (German Weather Service)
Slovenian Forestry Institute
UdL
Private Forest Owner
IBL (Polish Forest Research Institute)

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REEFMC
RISE

2. What aspect of wildfire risk assessment is most important in your activity? (n= 54)

a. Ignition causes (natural/human) 20%
b. Fire propagation (fuels, terrain, and weather) 32%
c. Population/assets exposure 9%
d. Ecosystem exposure 11%
e. Potential losses (Ecological/Socio-economic assets) 15%
f. Resistance and response capacity 13%
g. Other 0%

3. What other fire risk components do you deal with in your activity? (e.g.: land management plans, fighter's training, residents' education) (n=12)

a) Risk assessment
b) Forest Management - fuel management, suppression tactics
c) Fuel flammability
d) Burned area
e) WUI
f) Access routes, fire-fighting resources
g) Fuel management
h) Microclimate
i) Disturbance interactions
j) WUI and targeted grazing and fuel management
k) Fuel vertical structure
l) Effectiveness of suppression tactics

4. Were the explanations of the fire risk products sufficient? (n=18)

a) Curricula for extreme fires and Wildland Urban Interface (3.8)
b) Propagation potential indicators (3.6)
c) Wildfire spread and behaviour outputs (4)
d) Suppression Difficulty Index Evaluation (3.4)
e) TUD Fuel mapping and fire behaviour from National Park fire of 2022* (4)
f) Human ignition probability (4)
g) Future fire regimes database (3.8)
h) Forest condition: Biotic damages (4)
**not a FirEURisk product*

5. How suitable are these fire risk products for your territory? (n=15)

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a) Curricula for extreme fires and Wildland Urban Interface (3.8)
b) Propagation potential indicators (3.7)
c) Wildfire spread and behaviour outputs (4)
d) Suppression Difficulty Index Evaluation (3.4)
e) TUD Fuel mapping and fire behaviour from National Park fire of 2022* (4.2)
f) Human ignition probability (3.8)
g) Future fire regimes database (4)
h) Forest condition: Biotic damages (4)
**not a FirEURisk product*

6. What other information about fire risk (assessment, reduction and adaptation) would you need? (n=10)

a) Free GIS friendly datasets for each component
b) Management recommendations
c) Firefighting index
d) Localised assessment
e) Responsibilities and policy
f) Better training for practitioners
g) Post-fire natural vegetation recovery and change
h) Prescribed burning guideline
i) Finer resolution of the data
j) Fuels in the WUI (structures)
k) Cross-border assessment

7. Is the approach of fire risk products comprehensive? (n=16)

a) Curricula for extreme fires and Wildland Urban Interface (4)
b) Propagation potential indicators (3.8)
c) Wildfire spread and behaviour outputs (3.9)
d) Suppression Difficulty Index Evaluation (3.6)
e) TUD Fuel mapping and fire behaviour from National Park fire of 2022* (4)
f) Human ignition probability (4)
g) Future fire regimes database (4)
h) Forest condition: Biotic damages (4.5)
**not a FirEURisk product*

8. How interesting and usable are these products for you? (n=20) (Effort/Impact)

a) Curricula for extreme fires and Wildland Urban Interface (7.5/6.6)
b) Propagation potential indicators (7/7.3)
c) Wildfire spread and behaviour outputs (8/7.9)
d) Suppression Difficulty Index Evaluation (6.4/7.6)
e) TUD Fuel mapping and fire behaviour from National Park fire of 2022* (7.4/7.3)

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f) Human ignition probability (6.7/6.4)
g) Future fire regimes database (7.7/6.4)
h) Forest condition: Biotic damages (8.1/7.7)
**not a FirEURisk product*

6.2. Session 2

1. Was the explanation of the fire risk products sufficient? (n=12)

a) Daily Fire Danger Index (3.8)
b) Satellite-derived live fuel moisture content (4.2)
c) Fire Danger Metric (3.3)
d) Fire Weather and Fuel Moisture Campaign* (4.2)
e) Wildland Urban Interface Map (4.3)
f) Potential Losses of Ecosystem Services Affected by Wildfires (3.8)
g) Factors for Building Survivability (4.6)
h) Spring Grassland Fire Model (4.3)

**not a FirEURisk product, but supported other outputs in FirEURisk*

2. How suitable are these products for your territory? (n=11)

a) Daily Fire Danger Index (3.8)
b) Satellite-derived live fuel moisture content (3.6)
c) Fire Danger Metric (3.4)
d) Fire Weather and Fuel Moisture Campaign* (4.2)
e) Wildland Urban Interface Map (4.7)
f) Potential Losses of Ecosystem Services Affected by Wildfires (3.6)
g) Factors for Building Survivability (3.8)
h) Spring Grassland Fire Model (4.1)

**not a FirEURisk product, but supported other outputs in FirEURisk*

3. What other information for fire risk (assessment, reduction and adaptation) would you need? (n=6)

a) Integration of them all
b) Detailed fuel maps for fighting fires
c) Recommendations, concrete fuel management measures according to the forest type
d) Efficient awareness campaigns
e) Presence of people, types of construction of houses and other buildings

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f) Risk perception

4. Is the approach to fire risk products comprehensive? (n=11)
   a) Daily Fire Danger Index (3.7)
   b) Satellite-derived live fuel moisture content (4)
   c) Fire Danger Metric (3.2)
   d) Fire Weather and Fuel Moisture Campaign* (4.5)
   e) Wildland Urban Interface Map (4.5)
   f) Potential Losses of Ecosystem Services Affected by Wildfires (3.9)
   g) Factors for Building Survivability (3.8)
   h) Spring Grassland Fire Model (4.2)

**not a FirEURisk product, but supported other outputs in FirEURisk*

5. How interesting and useful are these products? (n=11) (Effort/Impact)

   a) Daily Fire Danger Index (6.7/6.3)
   b) Satellite-derived live fuel moisture content (7.8/7.2)
   c) Fire Danger Metric (6.8/6.3)
   d) Fire Weather and Fuel Moisture Campaign* (8.3/5.7)
   e) Wildland Urban Interface Map (8.2/7.7)
   f) Potential Losses of Ecosystem Services Affected by Wildfires (6.6/7.5)
   g) Factors for Building Survivability (8.3/7.5)
   h) Spring Grassland Fire Model (7.7/7.9)

**not a FirEURisk product, but supported other outputs in FirEURisk*

6. Please let us know items to improve or any question to be answered (n=3)
   a) How to make these services operational
   b) Integration tools
   c) Products related to the study area
   d) How can people can reach these products
   e) Operational, in the sense that they are accessible to firefighters and kept up-to-date

7. To what extent do you agree with the following questions? (n=9)

   a) Was FirEURisk project well presented at the start of the demonstration? (4.4)
   b) Were products described in sufficient detail for your needs? (3.8)
   c) Did you understand the use of the products? (3.7)
   d) Did you understand the questions about the product(s)? (3.7)
   e) Were questions answered satisfactorily? (3.8)
   f) The on-line experience was sufficient to validate the product? (3.1)

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7 Conclusions and lessons learnt from the Central Europe Pilot Site Demonstration Event

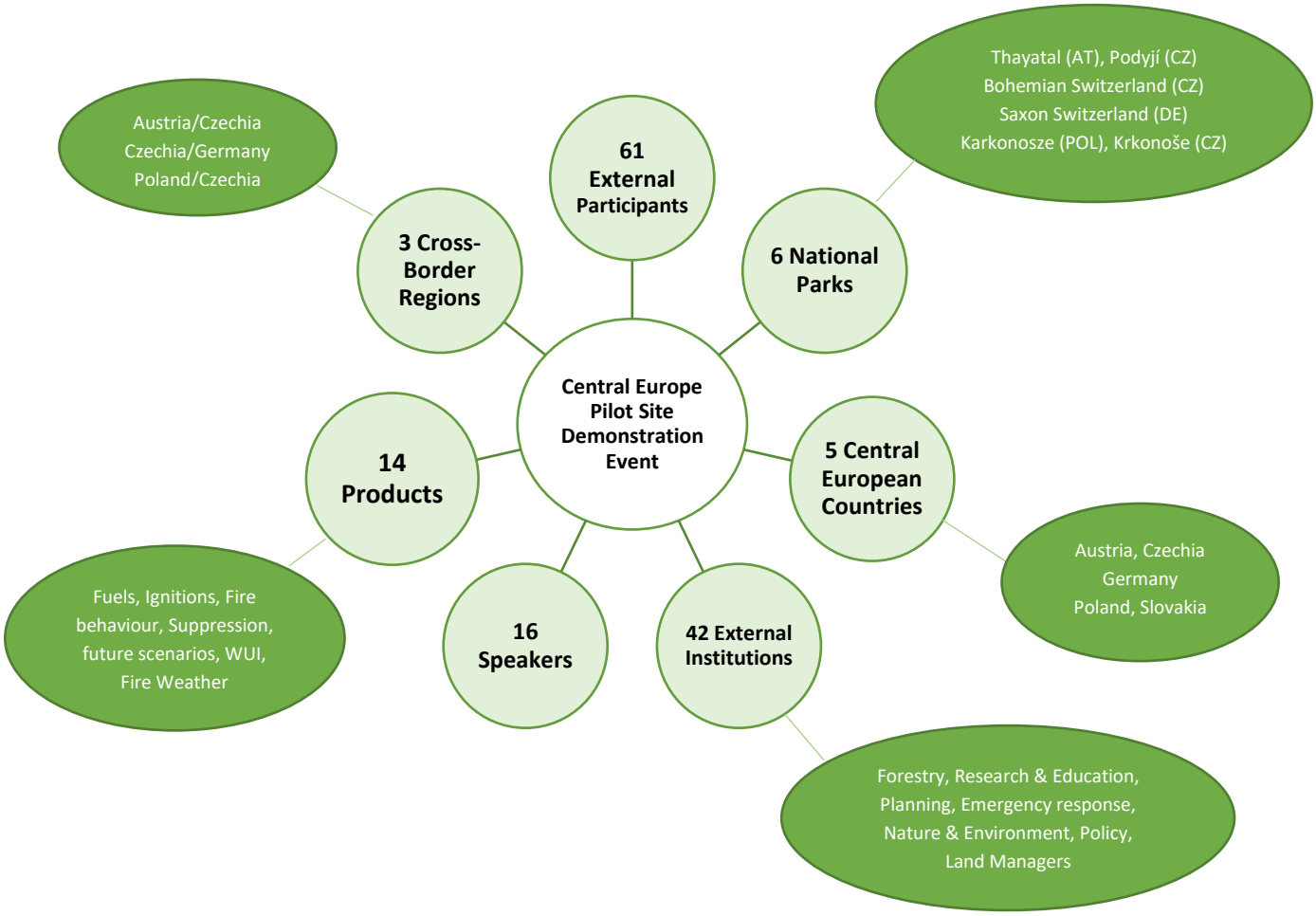


Figure 7. Important numbers from the Central Europe Pilot Site Demonstration Event).

The conclusions and lessons learnt can summarised as follows:

1. Planning and setting-up the event
   In order to successfully reach stakeholders scattered across the three Central European countries covered in part by the FirEURisk Central Europe Pilot Site it was necessary to hold the event on-line. Initially, during the early stages of the project it was thought that individual events could be held in each of the countries, however the logistics of setting up such in-person events along with the cost and the fact that it would essentially mean an additional two pilot site events it was decided to hold it on-line. This had not only the advantage of reduced

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travel and accommodation costs, but it meant that specific target groups potentially only interested in one or two products could still join the event.

Timing of the event was also an issue, one that wasn't solved satisfactorily. All Pilot Site Demonstration Events were, or are being held long before the end of the project. This meant that some products, potentially those that stakeholder would be more interested in were not completed. A prime example is the Open Platform, where stakeholders will eventually be able to download all data and documents etc. Not being able to demonstrate a fully working Open Platform was, in the opinion of the author, one negative aspect of the timing of the demonstration event. In light of this, TUD will now hold an additional event to present the final Open Platform, towards the end of the project.

2. Technical Issues

Whilst the event ran relatively smoothly, there were one or two problems as well as things that went well. What follows are key points covering both good and bad elements of the event.

- To remind all presenters to update their software before the event
- Avoid pre-recorded presentations
- Avoid having a replacement presenter
- Ensure that group managing the event has capacity to have a dedicated presenter that deals with on-line questions
- Ensure a that group managing the event has capacity to have a dedicated working checking with the presenters if they are ready and so on
- This means a minimum of three people are needed in the organising team
- Less is more, despite organising the event to have sessions that appealed to different target groups, by mid-afternoon the numbers attending were steadily dropping. An all-day on-line event is fatiguing.

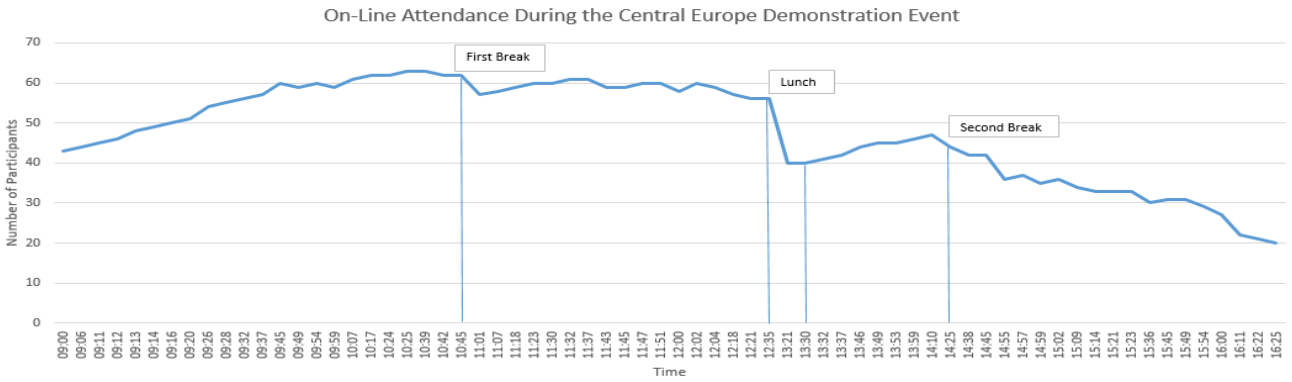


Figure 8. Chart showing attendance steadily reducing in the afternoon

3. Invitation and Attendee Management

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The project partner responsible wrote individual personalised email to over 80 potential attendees. Great care was taken in identifying stakeholders, the majority of which were unknown the organiser and ensuring that the invitation identified why the demonstration event would be relevant to them. The author believes that such an approach was worth the effort, with more than 75% of those invited attending the event.

The organiser used the Zoom Webinar software for the event. It has to be noted that such software, whether that is Zoom or another program is very useful for before/during/after the event. Software that can handle email replies and registration, enable Q&A sessions, manage access for participants and that provides analysis and recordings (video and Q&A transcripts) is a must for such an event.

4. Validation of the Products
   In order to valid the products a Mentimeter on-line survey tool was used. This type of validation is of course only a qualitative reflection of how the attendee perceived the products, which can be biased by a number of aspects, not least preconceptions about how something should be done. Whilst the author considered the questions simple enough, the uptake or rather participation in the on-line survey tools was less than anticipated. The tool is highly visual and provides a real-time display of the results. However, it could be perceived as gimmicky and relies on having to use a mobile phone, which may dissuade some potential respondents. Perhaps, one recommendation the author would provide to others using such tools is to introduce the on-line survey tool at the beginning, so that people can test it and get used to it. This has the added benefit of people being prepared and allows more time for answering the questions. Towards the of the event participation in the survey dwindled and could not be fully relied upon to give any meaningful data or insights.

5. Follow-Up
   A lot of time is invested in identifying stakeholders, and they of course give up their time to attend such events. With such projects it is essential to have something prepared for the stakeholders after the event so that they can look at the products at their leisure and perhaps follow-up with either contacting the organiser/product developer, using the data themselves or perhaps employing the models, approaches and so on to their regions. In this case a number of products were not fully completed or in a state in which they could be shared. It is therefore essential have a plan for follow-up and to have this prepared before the event.

8 References

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9 Annex A: Mentimeter questionnaire.

Part 0: Presentation and introduction





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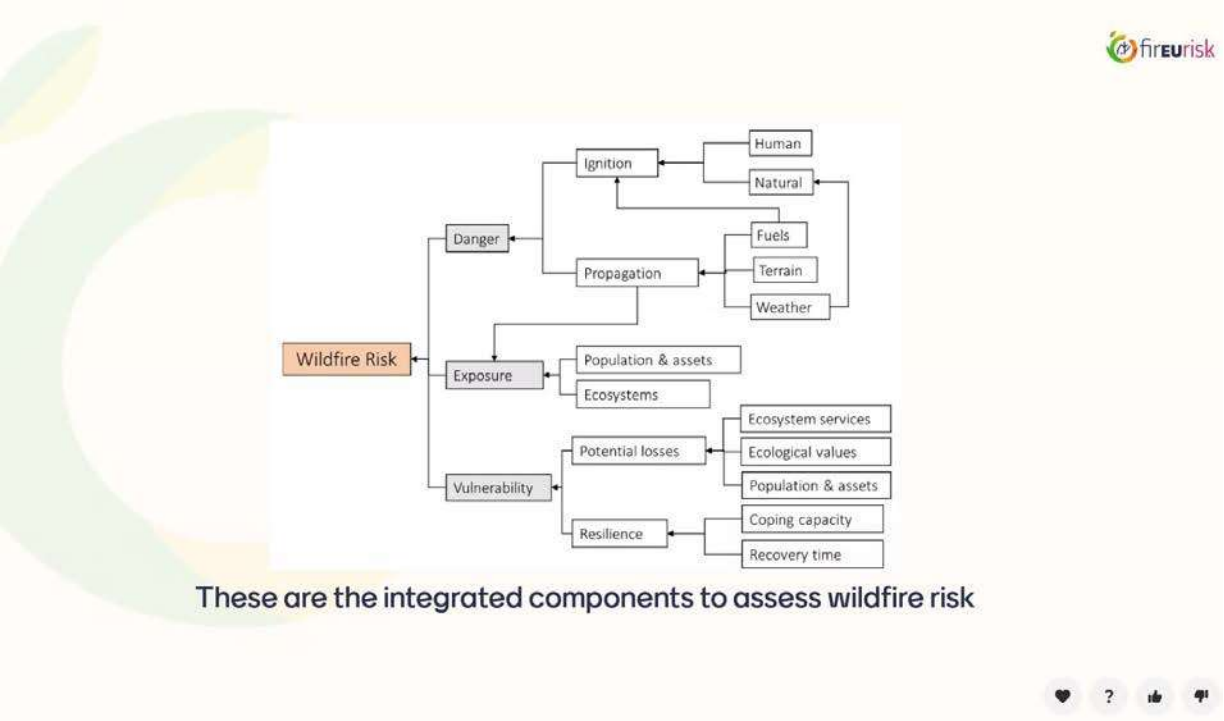
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rt 1: Products on risk assessment, reduction and adaptation





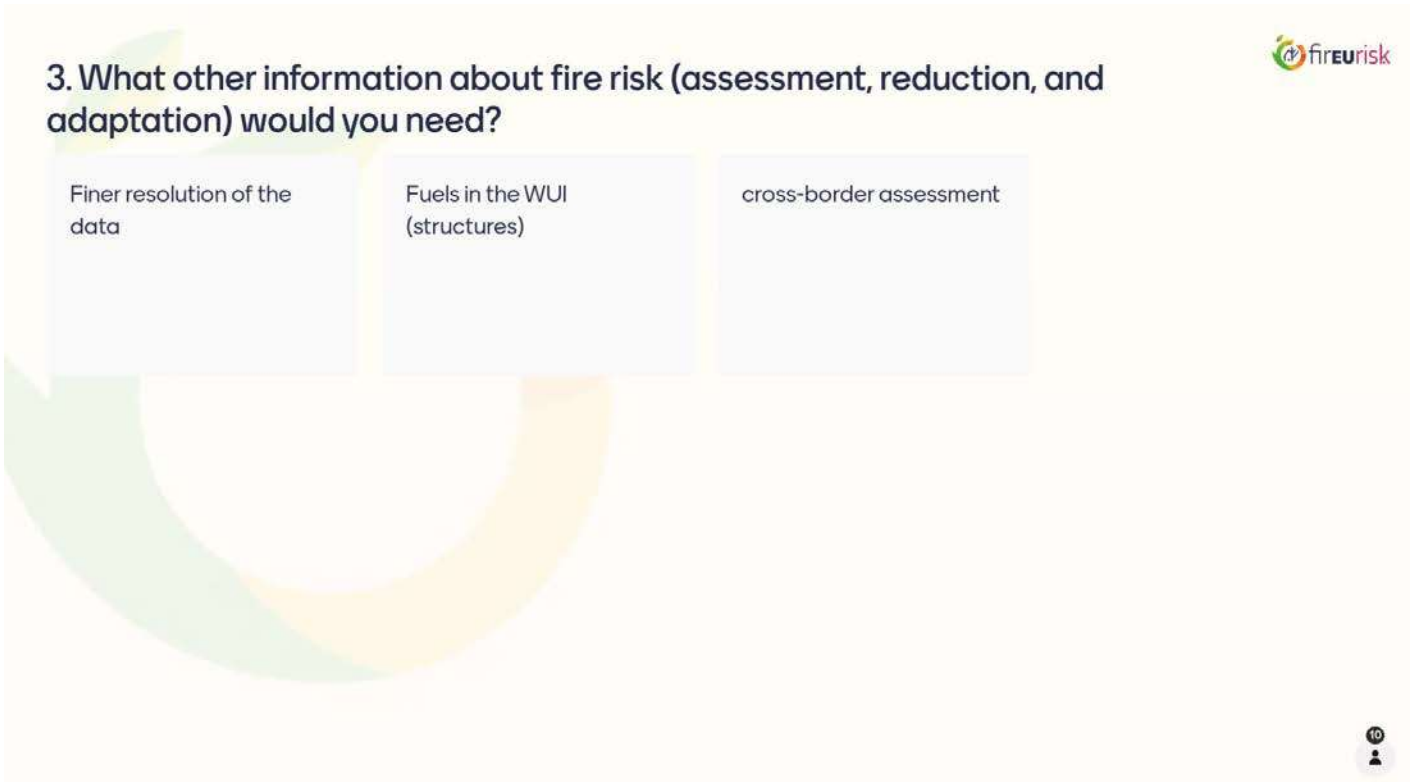
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4. Is the approach of fire risk prevention products comprehensive?



16

5. How interesting and usable are these products?



20

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Part 2: products on risk assessment, reduction and adaptation





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2.How suitable are these fire risk products for your territory?



11

3. What other information for fire risk (assessment, reduction, and adaptation) would you need?

- Integration of them all
- detailed fuel maps for fighting fires
- recommendations concrete fuel management measures according to the forest type
- Efficient awareness campaigns
- presence of people, type of construction of houses and buildings,
- Risk perception

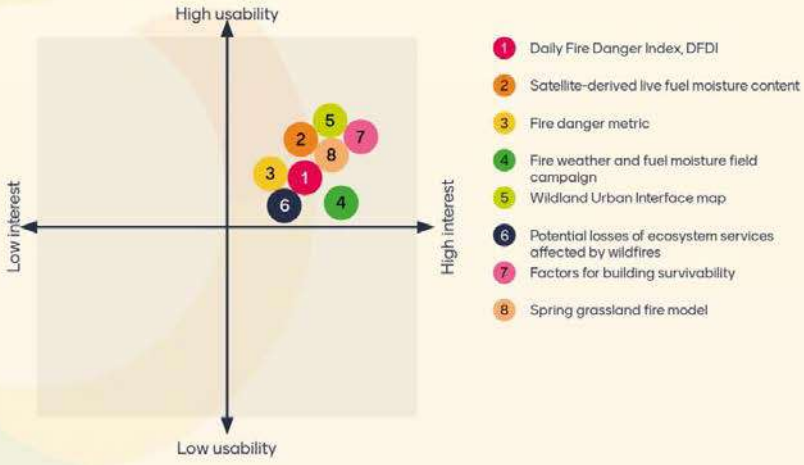
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4. Is the approach to fire risk products comprehensive?



5. How interesting and usable are these products?

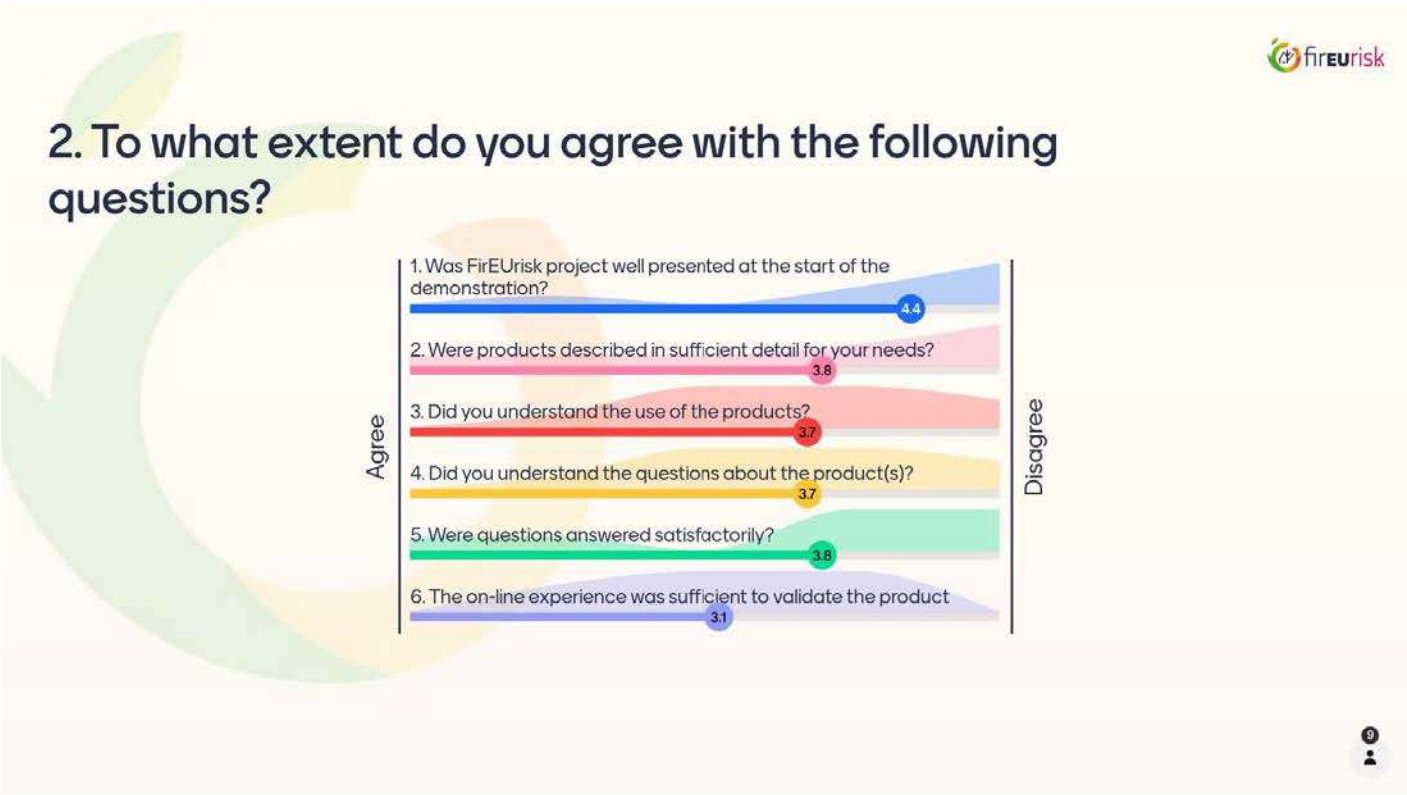


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Part 3: Evaluation and validation of the FirEURisk event



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10 Annex B: PS2 Demonstration Event Presentations.

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Central Europe Pilot Site Demonstration Event

FirEURisk Project

Developing a Holistic Risk-wise Strategy for Wildfire Management



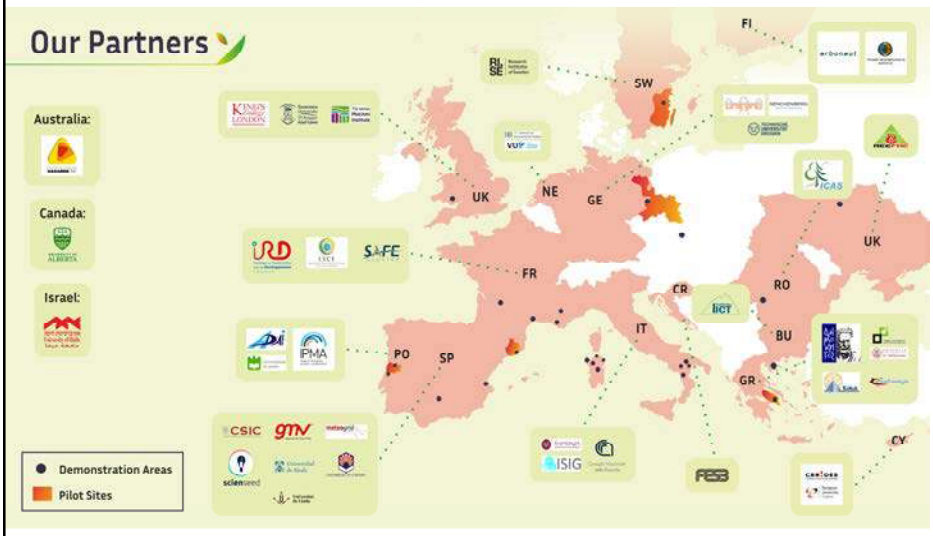
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003890

2

Project Demo Event in Central Europe

- Welcome to this Demo Event of FirEURisk Project results and products to be applied in the Central Europe.
- The first Demo event was held in Barcelona and the second one in the Central Region of Portugal, in past July and November.
- The FirEURisk is in its 34th month (of 48) we have already produced an important number of results that are materialized in products that can be applied and used operationally by Wild Fire Risk Managers in different countries and even at the European scale.
- Being research products not all of them are already fully developed and all of them can be improved with your suggestions and proposals.

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme



- 38 partners.
- 18 countries
- 21 research institutions
- 12 Operational agencies
- 5 Enterprises
- Interdisciplinary:
  - Mechanical engineers.
  - Forest engineers.
  - Social scientists
  - Ecologists / env. scientists.
  - Geographers.
  - Climatologists
  - …

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme

4 Objectives

- Develop, test and disseminate an Integrated a Science-Based Strategy for wildfire risk management in Europe.
  - 1) expand the capabilities of existing wildfire **risk assessment** systems
  - 2) use risk-assessment to drive wildfire management and **reduce current fire risk conditions**, and
  - 3) **adapt fire management strategies** to expected future climate and socio-economic changes.
- In close collaboration between researchers, practitioners, policymakers and citizens.



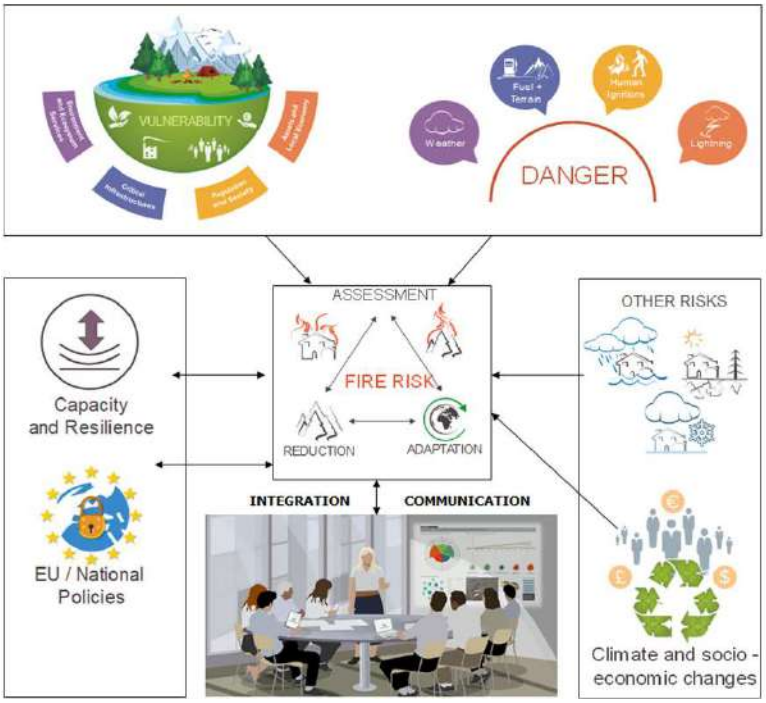
This project has been granted funding from the European Union's Horizon 2020 research and innovation programme

26/01/2024 Central Europe PS Demonstration Event

Shift towards managing the risk

FirEURisk framework



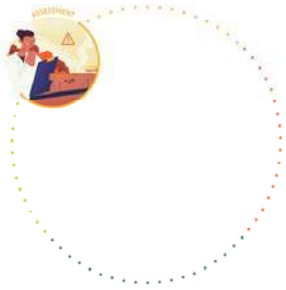


This project has been granted funding from the European Union's Horizon 2020 research and innovation programme

6

Wildfire risk **ASSESSMENT**

- Go beyond fire danger as base of fire management
- Assess risk conditions and potential (vulnerability and impact)
- Include social & ecological aspects of risks (holistic approach)
- Focus to managing fire risk conditions in WUI areas
- Involve local population in fire management aspects (citizen-science).



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme

7 Wildfire risk **REDUCTION**

- Test different fire reduction strategies
- Reduce ignitions caused by human activity
- Increase socio-ecological resilience (capacity building)
- Capitalize on the experience from previous extreme events
- Improve training and preparedness of all stakeholders (citizens and volunteers, forest and fire managers, decision and policy makers)



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme

8 Wildfire risk **ADAPTATION**

- Generate and elaborate fire regime scenarios linked to changes due to the future climate conditions
- Integrate risk-change drivers into future scenarios
- Support adaptation plans in new fire-prone regions (higher altitude and northern areas)
- Improve resilience of WUI areas to extreme fire behavior



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26/01/2024 Central Europe PS Demonstration Event

9

Integration and **Communication**

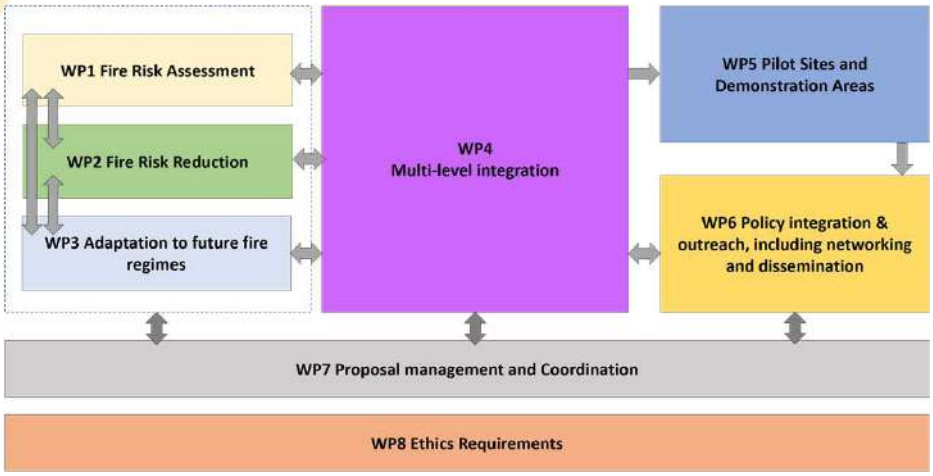
- Integration of results into existing risk systems (e.g., EFFIS)
- Integrate existing platforms and satellites services (e.g., Copernicus)
- Two-way communication with citizens living in fire-prone areas (e.g., WUI)
- Consider potential cascading effects related to wildfires
- Networking with the international wildfire research community (Boards & FEU Observatory)
- Capitalization of results using Knowledge Management platforms such as DRMKC/JRC including a Repository of the fuel management tools & apps



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme

10

WP structure



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26/01/2024 Central Europe PS Demonstration Event

11 Steering Committee

- General Coordinator

Domingos Xavier Viegas

ADAI/UC-Portugal



- Technical Coordinator

George Eftychidis

AUTH - Greece



- Scientific Coordinator

Emilio Chuvieco Salinero

UAH-Spain



- Data Manager

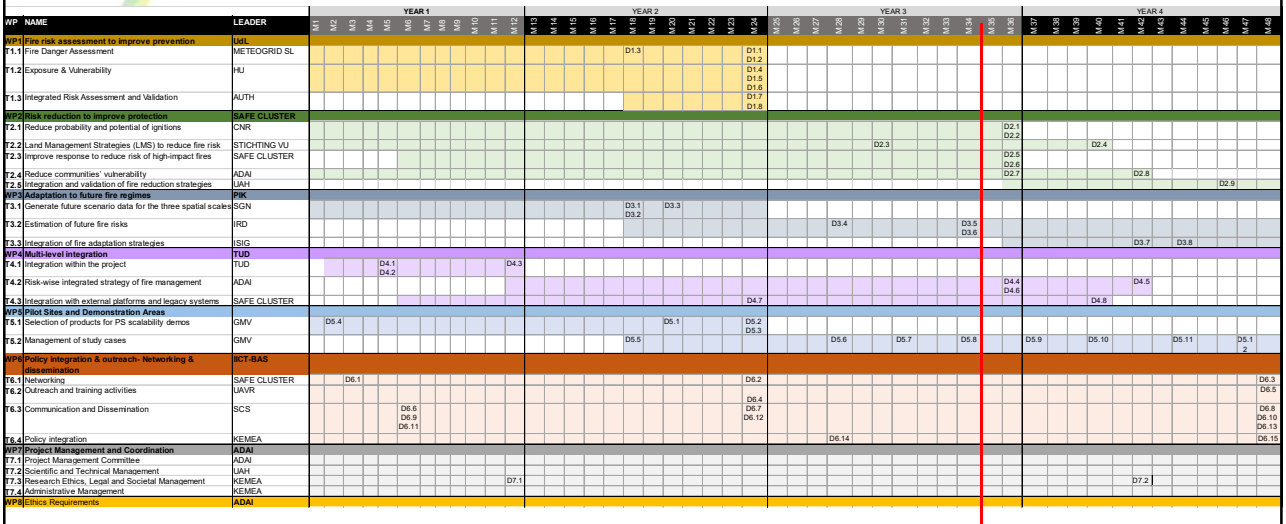
Ioannis Gitas

AUTH - Greece



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1. Gantt Chart

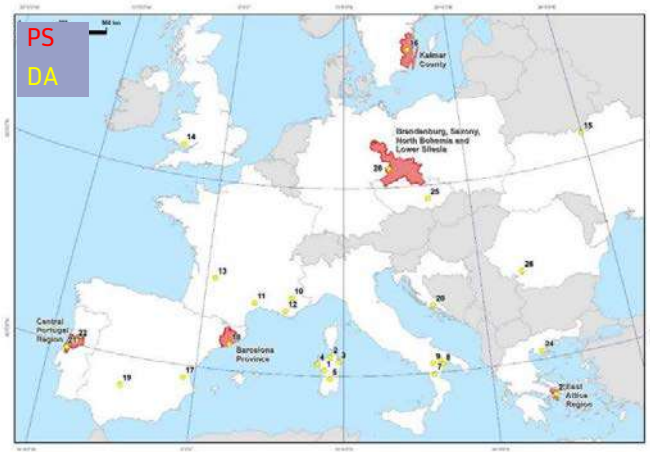


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Demonstration plan

13

- 26 Demonstration Areas (DA) (NUT-3)
  - Field data collection campaigns for modelling and testing purposes
- 5 Pilot Sites (PS)
  - Portugal, Spain, Greece, Germany, Sweden (field tests)
- EU scale
  - Projection of fire regime and wildfire risk for 2050 and 2100



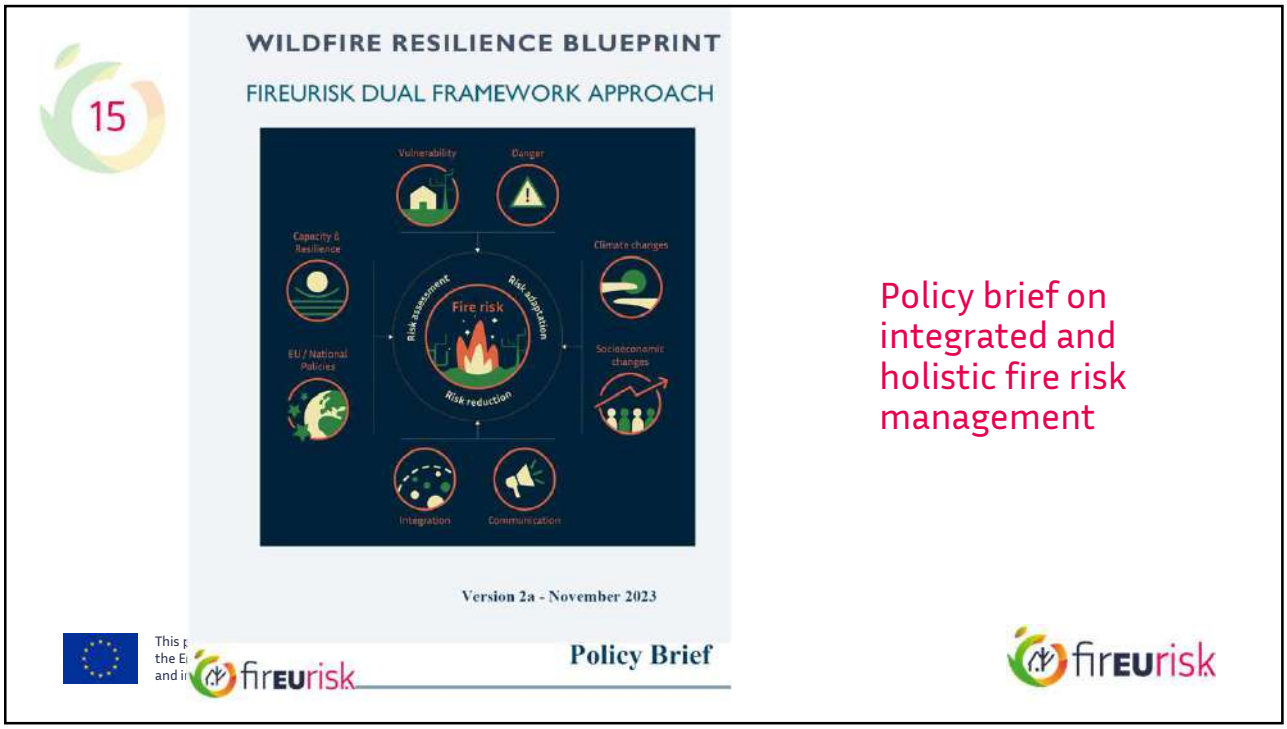
This project has been granted funding from the European Union's Horizon 2020 research and innovation programme



- Report on the fires of 2021 published by JRC.
- The report on the fires of 2022 is ready and that of 2023 is in preparation.

Abstract

This report presents an overview of the 2021 wildfire season in the Mediterranean region on the basis of the data that are available in the European Forest Fire Information System (EFFIS [1]) which is complemented with a specific analysis of some of the most damaging fires during this campaign, performed by the FirEUrisk [2] project. For the analysis of these fires, information on the pre-fire conditions is provided to determine wildfire danger at the time of ignition. Furthermore, evolution and damage of each of the fires is described with as much detail as possible, looking into the possibility of learning from the experience gathered from these fires for the management of future critical wildfire events. It is foreseen that this report is repeated for the forthcoming fire seasons as a collaboration between the FirEUrisk project and the EFFIS team at the Joint Research Centre.



Policy brief on integrated and holistic fire risk management




fireurisk
Many thanks

Scientific overview of FirEURisk

Emilio Chuvieco, University of Alcalá (Spain)
FirEURisk science leader

25/1/2024 | Demonstration Event (Central Europe)

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

2 Objectives

1. Expand the capabilities of existing wildfire **risk assessment** systems.
2. Use risk-assessment to drive wildfire management and **reduce current fire risk conditions**.
3. **Adapt fire management strategies** to expected future climate and socio-economic changes.
4. **Integrate** all fire management phases and activities.



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme

3

FirEURisk proposal structure



WP1



WP2 WP3

WP4



WP4 WP6 WP6 WP3

WP5: Demonstration

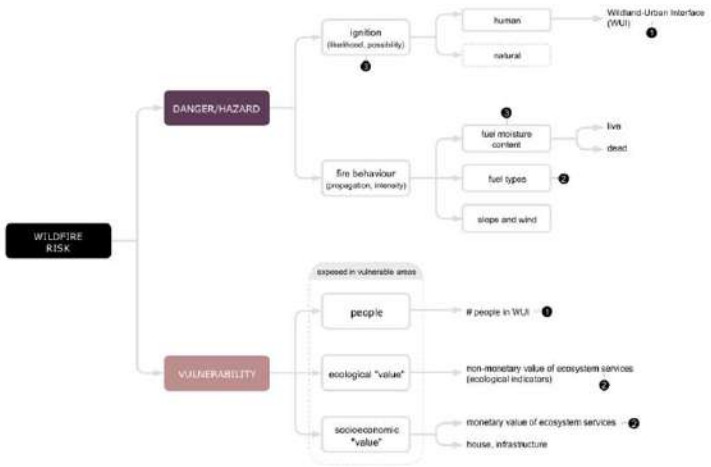
4

A wildfire risk assessment system should be:

- Comprehensive risk:
  - Include the three dimensions of risk, danger, exposure and vulnerability.
  - And all relevant risk variables
- Flexible: applicable to a wide range of spatial and temporal conditions.
- Coherent: internally logical.
- Consistent: same terms in all dimensions.
- Replicable: based on transparent methods

5

EFFIS integration scheme



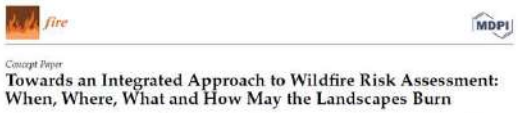


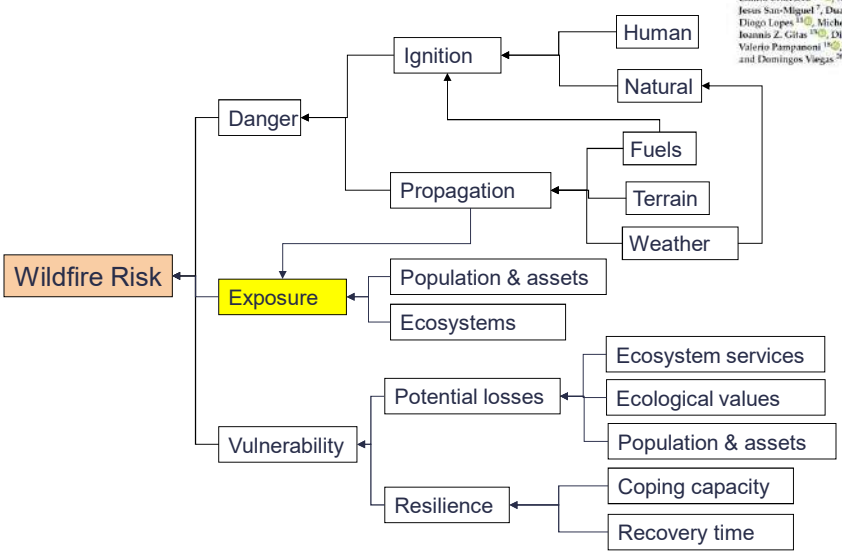
Oom, D., et al. 2022. Pan-European wildfire risk assessment, EUR 31160 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-55137-9. doi:10.2760/9429, JRC130136

and innovation programme

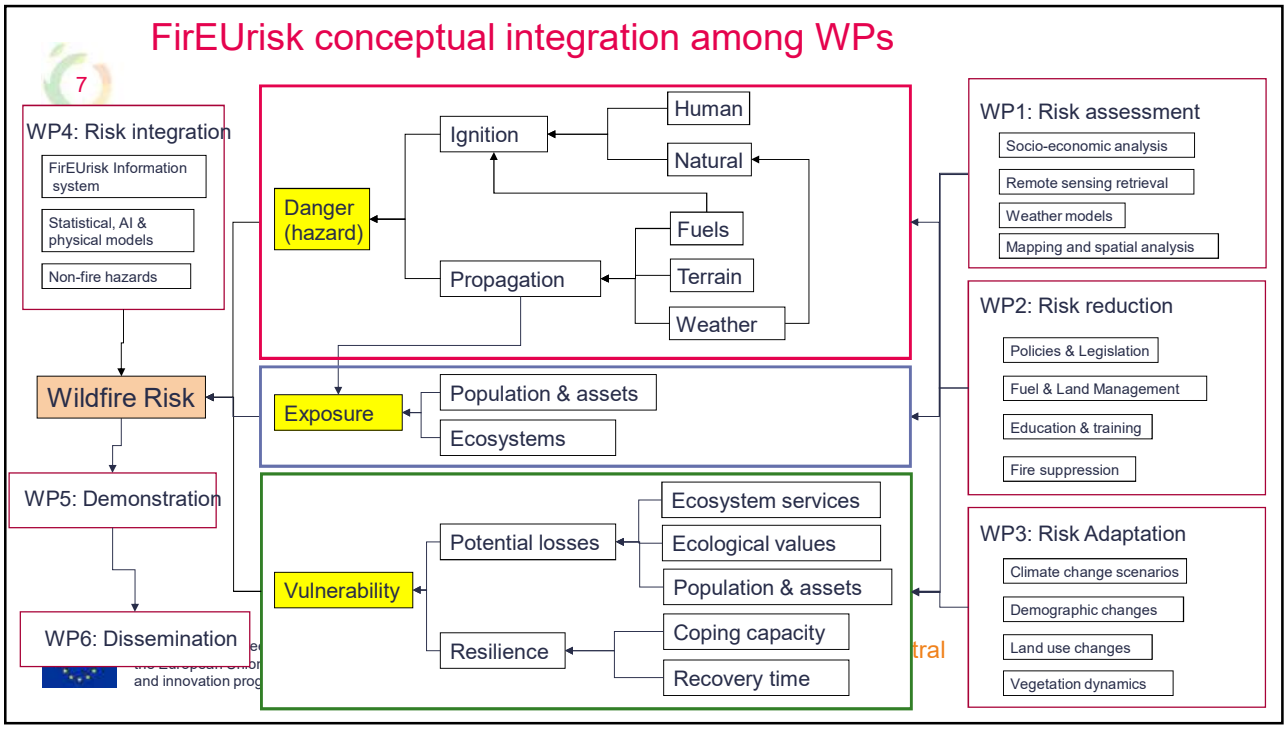
6

FirEUrisk Integration Scheme: Risk Assessment





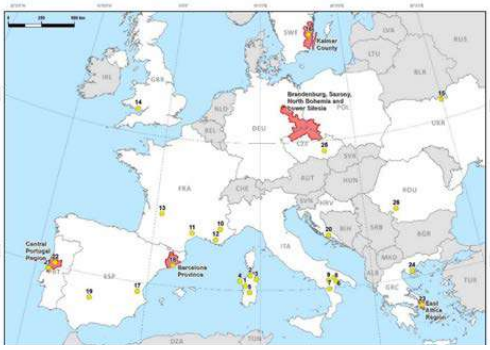
FirEUrisk conceptual integration among WPs



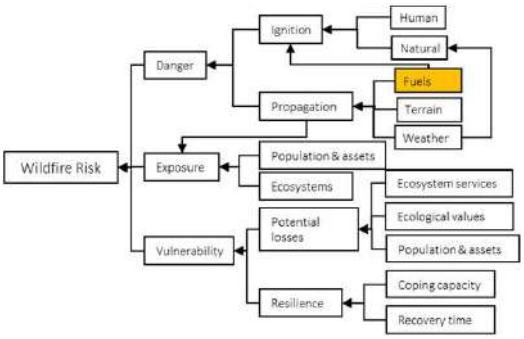
FirEUrisk Spatial Integration

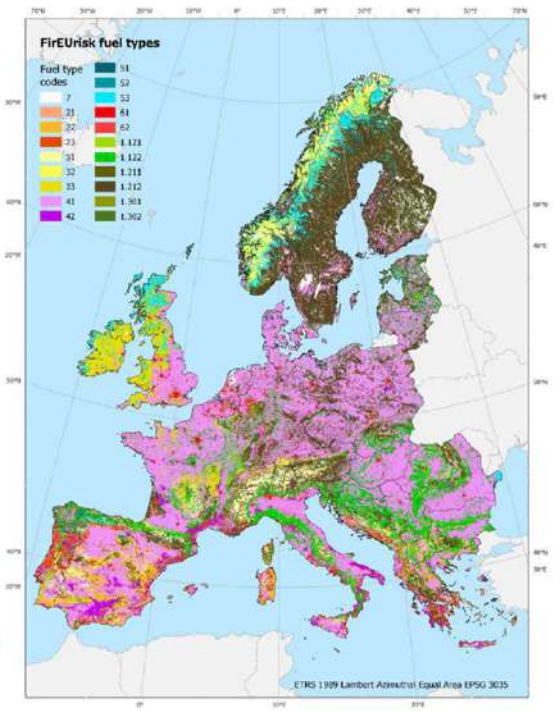
- Spatial resolution: ET: 1 km; PS: 1 ha (↑). WP3 9x9 km.
- Same cartographic projection: ET (LAEA); PS (UTM) (↑↓). Some geographical.



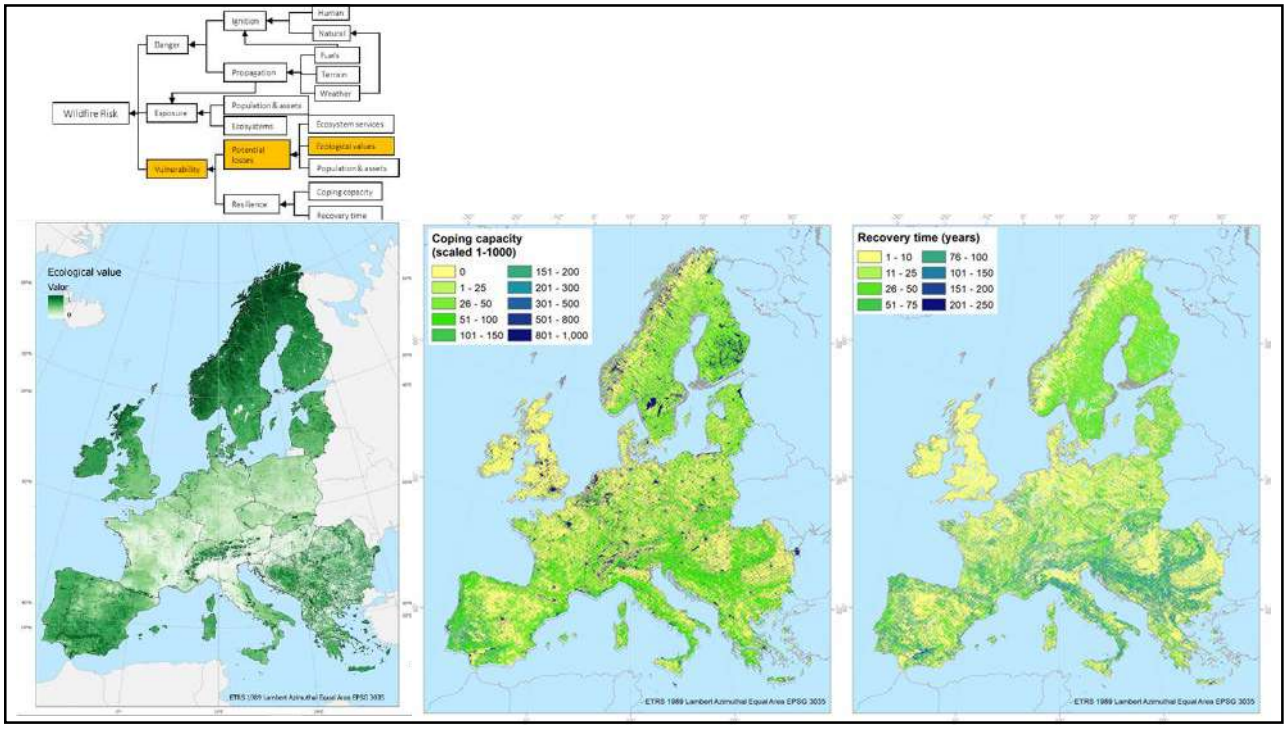


26 DA → WP 1-4
5 PS → WP 5: Sweden, Central Europe [Germany, Poland, Czech Republic], Portugal, Spain, Greece.





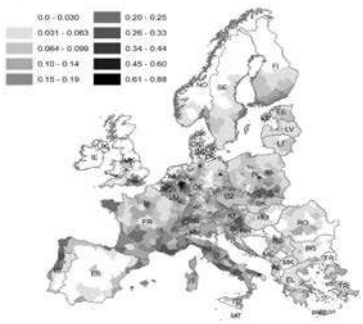
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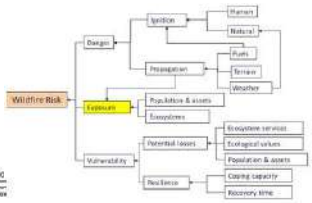


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Exposure: WUI (2020)



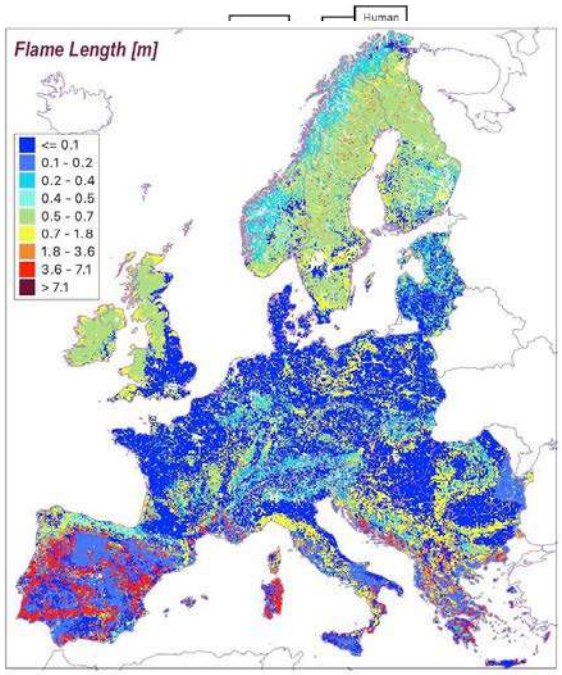




Proportion of total WUI in NUTS-3

Bar Massada et al. 2022

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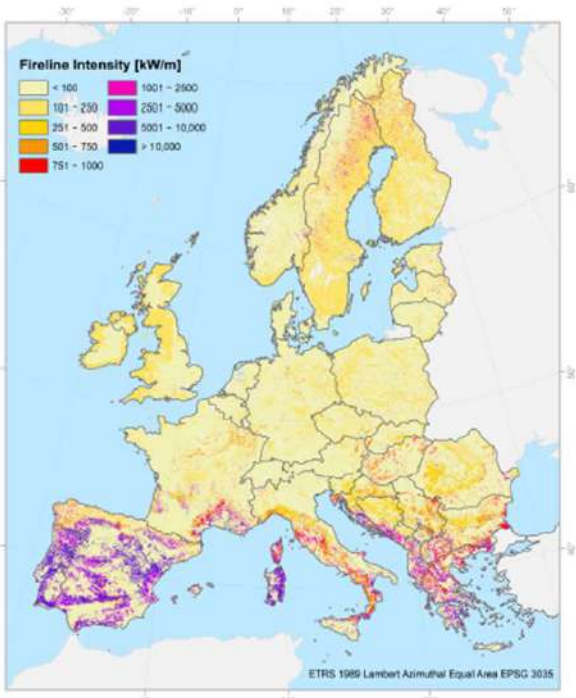
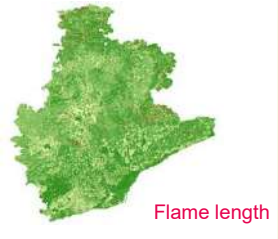


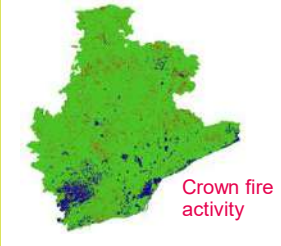
Figure 20: Map of Flame Length (FL) [m] for extreme 95th percentile wind speed and 5th percentile fuel moisture

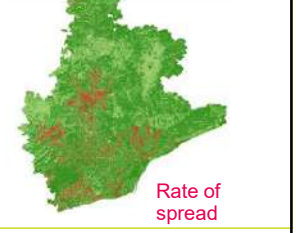
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Propagation potential: reliminary results for Barcelona PS





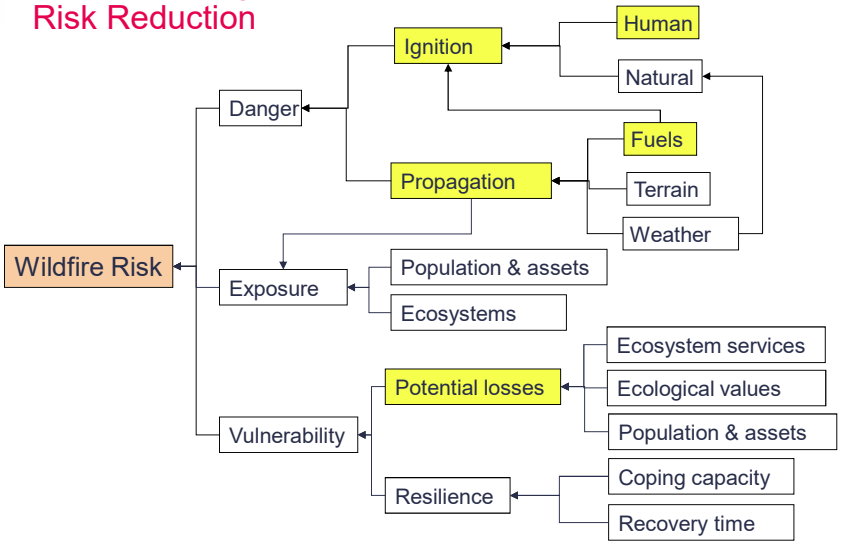




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14

FirEUrisk Integration Scheme: Risk Reduction



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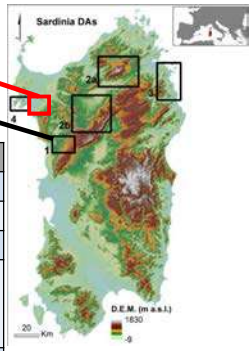
25/1/2024 | Demonstration Event (Central Europe)

15

Reducing citizen-driven fire ignitions (CNR – Bachisio Arca)

Surigheddu (Alghero)

Suni (Oristano)



Area	Surigheddu	Suni
Property	Public	Private
Month	Late May-Jun	Late Aug-Sep
Years	2021-2022	2021-2023
Goal	**Training professionals**	**Support local community needs**
Main fuels	Herb. Past.	Herb. Past., shrubs (incl. Rubus) & oaks
Sardinia Inst.	Sardinia Forest Service	Sardinia Forest Service



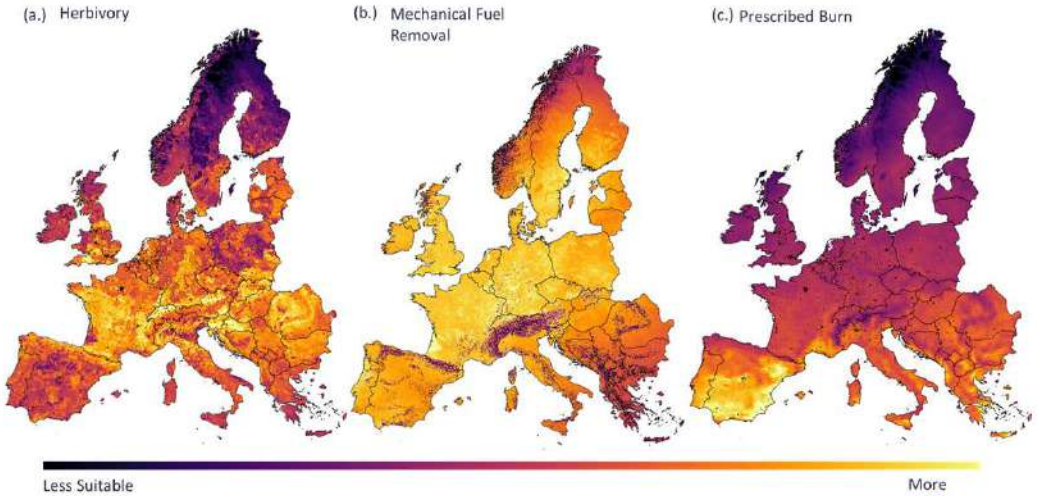
Professional teams applying prescribed burnings and pastoral uses of fire

- Professional teams
- Pastoral use
- Losses in the traditional use of fire; difficulty to support restoration

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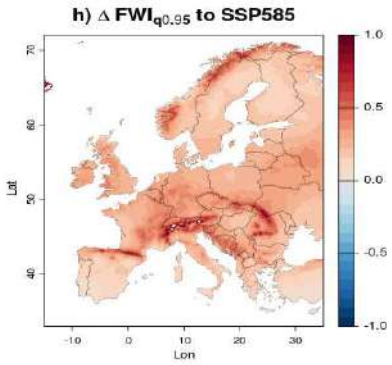
Fire Reduction: Land Management Strategies (LMS)



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17

Fire risk adaptation Hotspots of change



	Area	FWI_{q95} Historical	FWI_{q95} SSP126	FWI_{q95} SSP245	FWI_{q95} SSP370	FWI_{q95} SSP585
Nordic mountains	392,008 km^2	3.26	3.68 (+13%)	3.82 (+17%)	3.88 (+19%)	4.04 (+24%)
British Isles	71,329 km^2	4.23	4.93 (+16%)	5.14 (+21%)	5.49 (+3%)	5.7 (+35%)
Alps	192784 km^2	6.7	8.98 (+34%)	8.86 (+32%)	9.63 (+44%)	9.85 (+47%)
Central European middle mountains 2 (CZ , AT, GE)	45,331 km^2	7.81	10.24 (+31%)	10.15 (+30%)	11.05 (+41%)	11.68 (+50%)
Central European middle mountains 1 (BE, GE)	38288 km^2	8.93	11.7 (+31%)	11.52 (+29%)	13 (+46%)	13.39 (+50%)
Carpathians	161000 km^2	9.66	12.74 (+32%)	12.86 (+33%)	14.25 (+48%)	15.11 (+56
French/Swiss middle mountains	81714 km^2	12.3	16.68 (+36%)	16.77 (+36%)	18.18 (+48%)	18.68 (+52%)
Pyrenees	55056 km^2	15.43	20.28 (+31%)	20.81 (+35%)	22.01 (+43%)	22.4 (+45%)
Balkans/Southeast Europe	314851 km^2	22.04	26.95 (+22%)	26.96 (+22%)	28.78 (+31%)	29.71 (+35%)
Apennines	111392 km^2	24.79	29.29 (+18%)	29.71 (+20%)	30.82 (+24%)	31.21 (+26%)
Western Mediterranean islands	23678 km^2	30.73	34.64 (+13%)	35.05 (+14%)	35.5 (+16%)	36.06 (+17%)
Iberian mountains	262409 km^2	33.7	38.4 (+14%)	39.18 (+16%)	39.85 (+18%)	40.83 (+21%)
Eastern Mediterranean islands	15713 km^2	39.8	41.87 (+5%)	41.95 (+5%)	42.29 (+6%)	42.38 (+6%)
Turkey	597204 km^2	41.12	44.89 (+9%)	45.58 (+11%)	46.48 (+13%)	47.14 (+15%)

Risk classes	
FWI < 5.2	very low
5.2 ≤ FWI < 11.2	low
11.2 ≤ FWI < 21.3	moderate
21.3 ≤ FWI < 38	high
38.0 ≤ FWI < 50	very high
50 ≤ FWI	extreme

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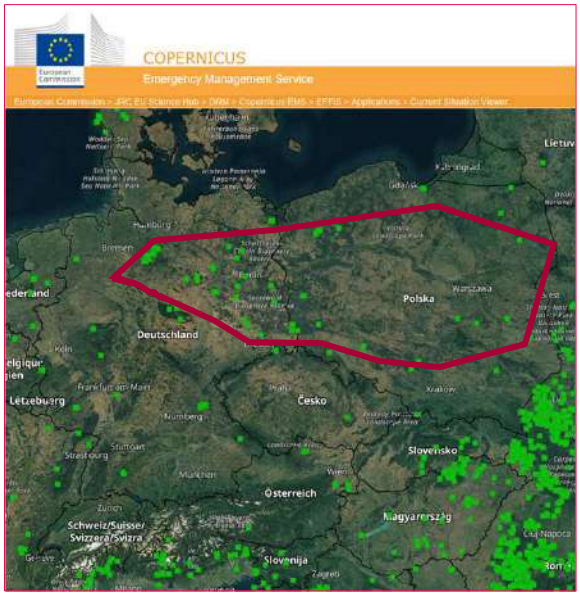
Past and new fire risks in Central Europe

Matthias Forkel, TU Dresden

25/01/2024 | Central Europe Pilot Site Demonstration

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

Forest fires in Central Europe

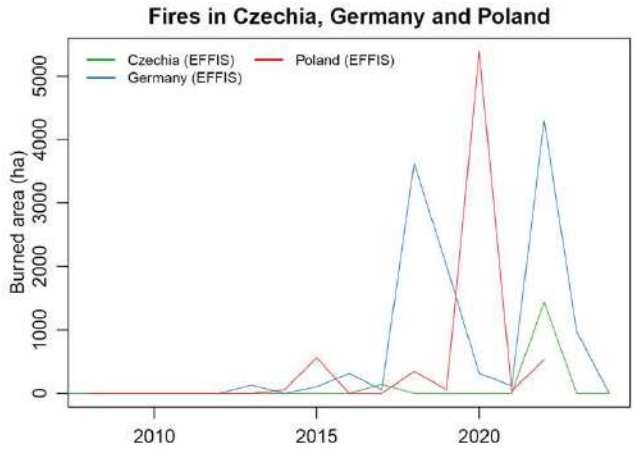


EFFIS: Burned areas in 2022
https://effis.jrc.ec.europa.eu/apps/effis_current_situation/

- Forest fires are rare in Central Europe in comparison to southern and eastern Europe
- Most fires occur in pine-dominated lowland forests in NE-Germany and Poland

2

Forest fires in Central Europe



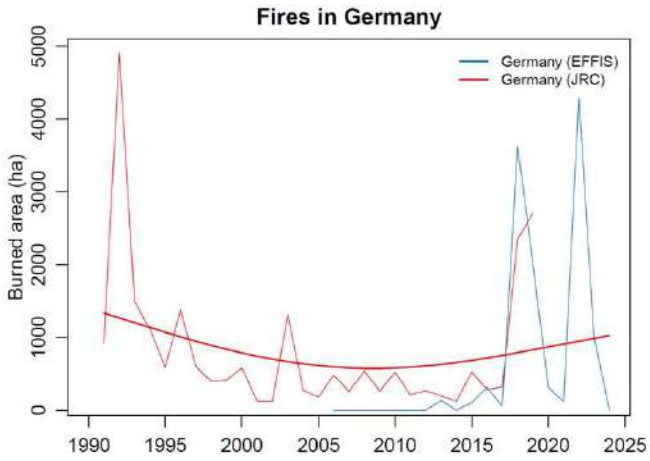
Large fires in Central Europe in the last years:

- 2018 – Germany
- 2019 – Germany
- 2020 – Poland
- 2022 – Germany and Czechia

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3

Forest fires in Central Europe

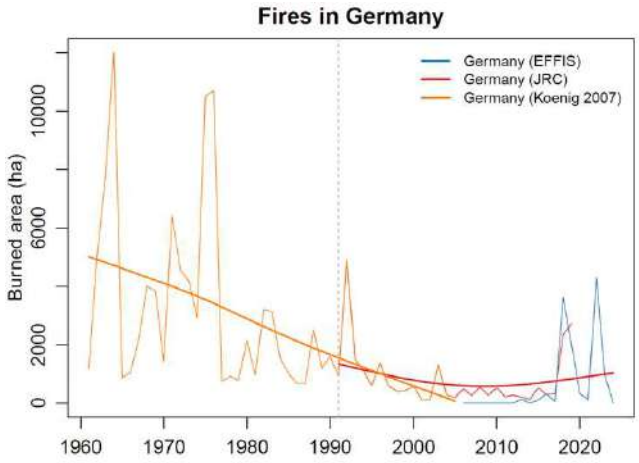


- The 2022 fires in Germany are the largest for 30 years.

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Forest fires in Central Europe

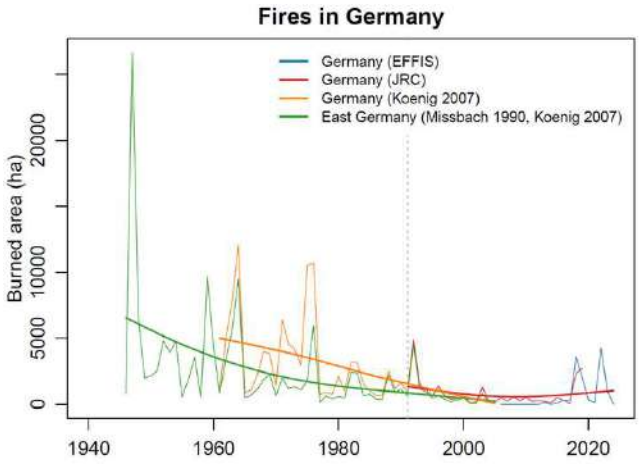


- The number of fires and burned area declined in Germany since the 1960.
- However, the years 2018-2022 are comparable to the 1960s and 1970s.

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5

Forest fires in Central Europe



- For Eastern German states/former GDR, the fire statistics date back to 1946 *(but this excludes military-used forests → add 20-50 %)*
- Many and large forest fires occurred in the 1940s

(König 2007, Mißbach 1990)

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Forest fires in Central Europe



< 30 year pine forest without thinning
→ Risk of high spread rate and flame length



Old pine forest with natural regeneration in understorey
→ Risk of high spread rate and flame length



> 30 year pine forest with thinning
→ Low-intensity surface fires

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Forest fire protection in northern Germany



Thinning

Fire breaks

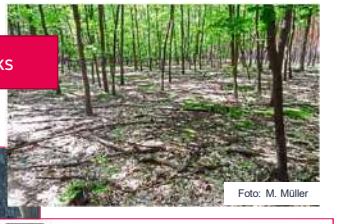


Foto: M. Müller



>1900: Fire watch towers





>1998: FireWatch

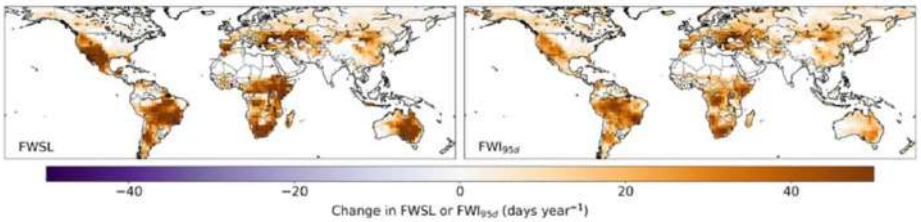


>1968: Forest fire index and danger levels

(König 2007)

8

Changes in fire weather



- 14 days/year with fire weather in Germany
- Global increase in length of fire season by 14 days 1979-2019
- Strongest increase in Europe: 67%
- Increase by 12 days in extreme fire weather in Germany

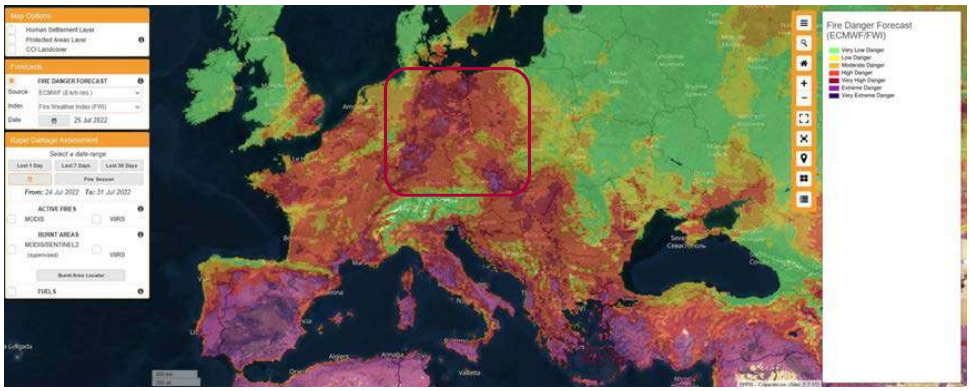
(Jones et al. 2022)

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New fire weather conditions

Fire Weather Index (25.07.2022) (EFFIS) https://effis.jrc.ec.europa.eu/

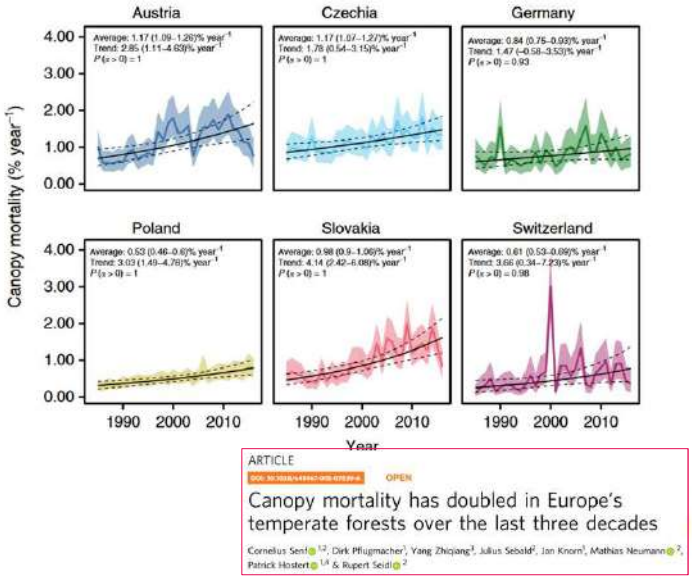


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10

Forest Mortality in Central Europe





ARTICLE

OPEN

Canopy mortality has doubled in Europe's temperate forests over the last three decades

Cornelius Senf[1,2], Dirk Pflugmacher[1], Yang Zhiqiang[1], Julius Sebald[2], Jan Knorn[1], Mathias Neumann[2], Patrick Hostert[1,4] & Rupert Seidl[2]



fireurisk

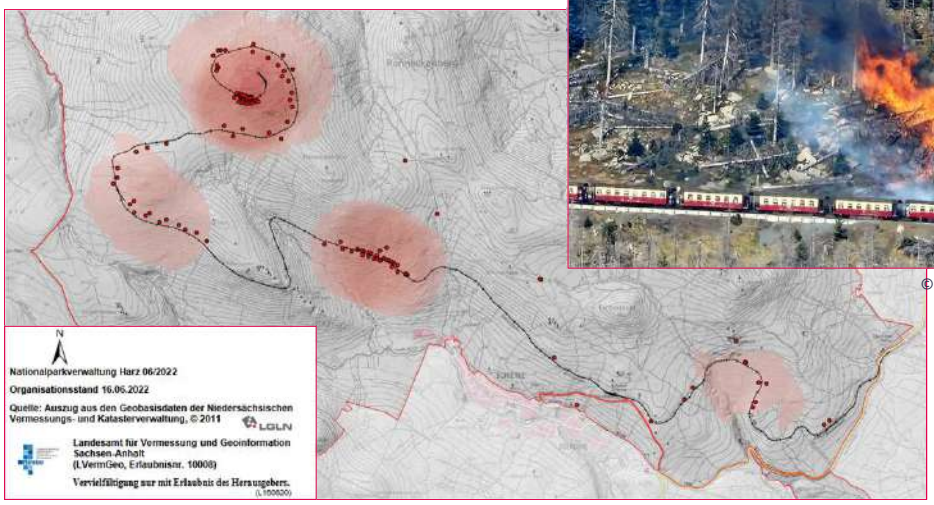
Effects of forest mortality on fire risks?

- Accumulation of surface fuels
- Creation of ladder fuels
- Regrowth of flammable vegetation
- Increased drying of surface fuels

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Unadapted systems

Forest fires in Harz Nationalpark 1994-2022



© HK-Archiv | Marcus Rothhaupt

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Challenges in Central Europe

- Increasing drought and heat events
- Massive change of forest structures
- Increased fire danger
- Mountain regions are not yet well adapted to forest fires
  - Vegetation / fuel structure is changing rapidly
  - Many potential ignition sources (tourism)
  - No monitoring systems
  - Difficult accessibility
  - Difficult cooperation (> 8 countries, languages, policies, organisations ...)

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Central Europe Pilot site January 202

WP2: Curriculum to fight extreme fires and fires in the WUI

Sébastien LAHAYE – SAFE



This project has received funding from the European Union 's Horizon 2020 research and innovation programme under grant agreement No 101003890

Curriculum to fight extreme fires and fires in the WUI

Operational Context: the procedures of Response agencies (forest & fire services) are currently lead by:

- **National standards**
- **Local knowledge of fires**

Research context: Scientific institutes (e.g. ADAI, UAVR, RISE…) develop advanced understanding on fire behaviour, smoke, safety…

Objective: Produce a handbook aggregating updated scientific outcomes to help firefighters face to:

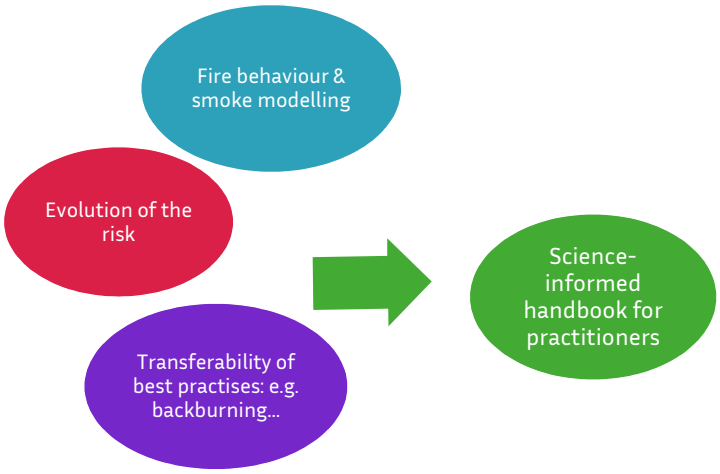
1. **Extreme fire behaviours and extreme fires**
2. **Fires in the Wildland-Urban Interfaces**

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme

Curriculum to fight extreme fires and fires in the WUI

3

Working plan:

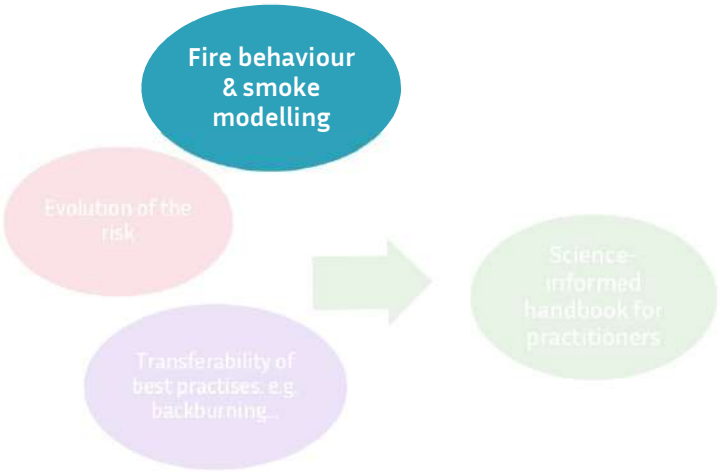


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Curriculum to fight extreme fires and fires in the WUI

4

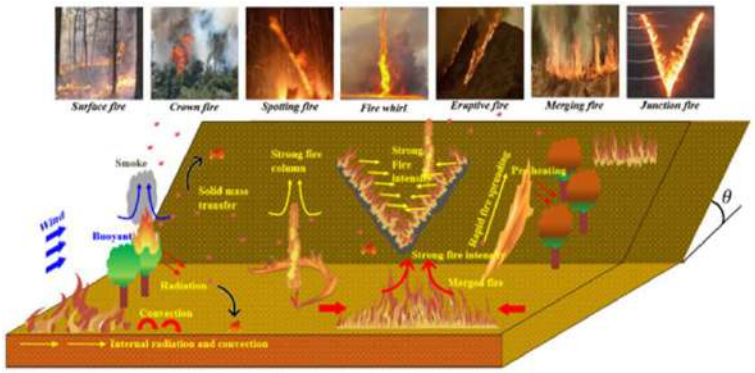
Working plan:



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme

5 Extreme Fire modelling

- Crown fires
- Spot fires
- Fire whirls
- Peat fires
- Eruptive fires
- Junction fires
- Oscillatory fire behaviour
- Acceleration and deceleration of a fire.

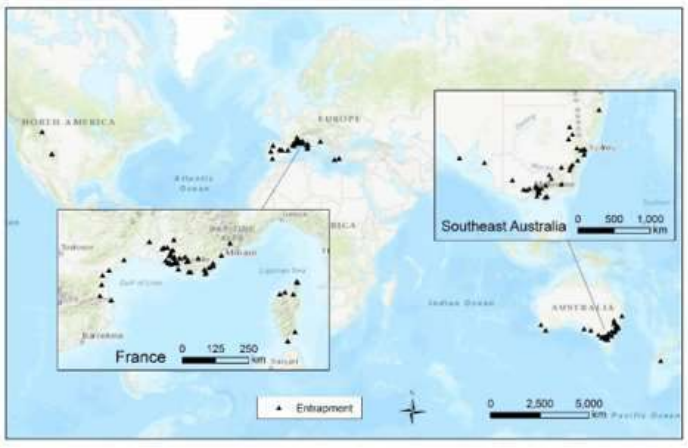


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6 Integrating feedback from past fires and entrapments

Investigating the topography / weather / fuel related with >100 entrapments worldwide

-> flame attachment on slope > 20°
-> Vorticity-driven lateral spread
-> changes in wind direction
-> pyroconvection effect



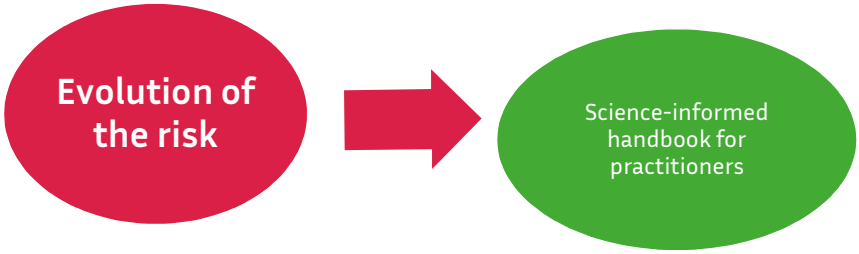
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Curriculum to fight extreme fires and fires in the WUI

7

Working plan:



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Evolution of the risk

8

With climate change, fire extension is expected:

- ✓ In higher latitudes (Northern Europe)
  - ➢ peatfires
  - ➢ boreal fires with forest continuities ...
- ✓ In higher altitudes (mountains)
  - ➢ access difficulties
  - ➢ topography fires with flame attachment on slopes...

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Curriculum to fight extreme fires and fires in the WUI

9

Working plan:



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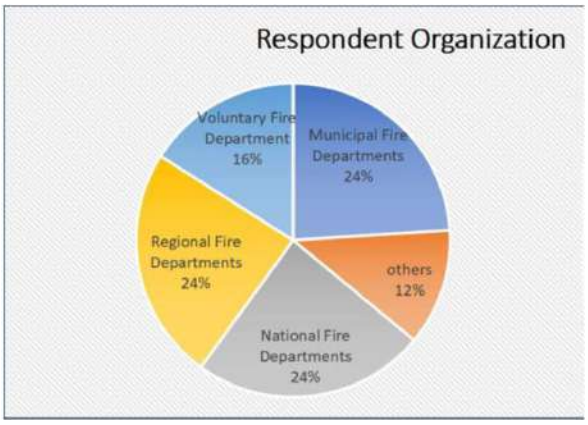
Survey and interview of FF

10

April-May 2023. Survey and interviews focusing on:

- Initial attack to keep starting fires as small as possible
- Fighting extreme fires
- Fighting fires in the WUI

The survey received responses from **27 firefighters** across **10 countries**: Spain, Portugal, Italy, Croatia, France, Greece, Ireland, Russia, Germany, and South Africa.



Then interviews were conducted with four experts: two from Portugal's National Authority for Emergency and Civil Protection (informants 1 and 2), one from the Fire and Rescue of the Bouches du Rhone Department in France (informant 3), and one from the Forest Fire service of Castilla La Mancha in Spain

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collection of words related to fire suppression strategy and techniques used in Europe



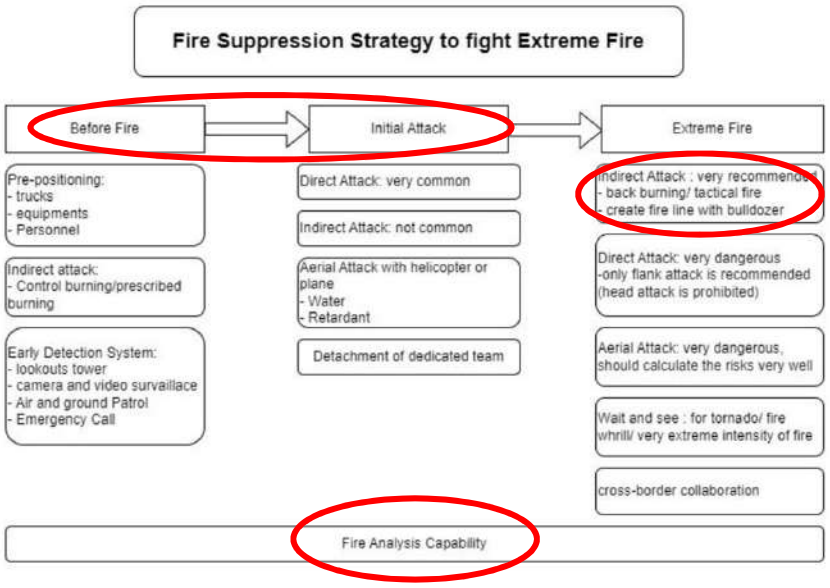
Initial attack

- Portable pumps (->swiming pools)
- Backpack sprayers
- Light vehicles
- Mobile teams
- Shelter in place

Fighting fire in WUI

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D2.6 : Handbook with guidelines for fire fighters to face to extreme fires, fires in WUI and fires in high latitudes/ altitudes

1. Introduction
2. Fundamentals of fire behaviour
3. Extreme fire behaviour
4. Pyroconvective phenomena
5. Fire safety
6. Firefighting methodologies
7. Case studies

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fireurisk

fireurisk

Wildfire Spread and Behaviour Outputs “Basic Mode”

Propagation Potential for Central European Pilot Site

Marin Bugaric, FESB University of Split, Croatia

marin.bugaric@fesb.hr

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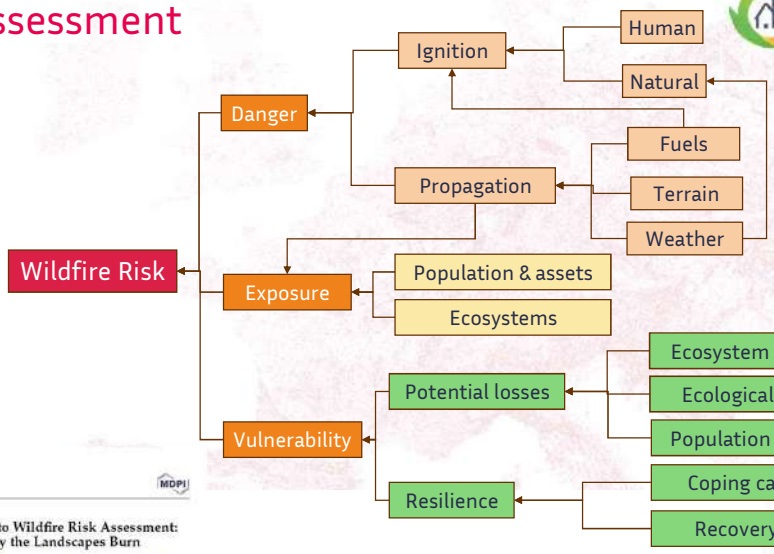
Propagation potential

What is propagation potential?

- Propagation potential refers to the probability of wildfire spread in a given area, influenced by factors such as the type of vegetation present, prevailing weather conditions, and the area's topography.
- Calculating propagation potential allows for the generation of important maps useful for prevention and preparedness planning.

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FirEUrisk Integration Scheme: Risk Assessment




Concept Paper
Towards an Integrated Approach to Wildfire Risk Assessment: When, Where, What and How May the Landscapes Burn

3

Propagation potential calculation

inputs

Topography
Vegetation
Meteorology

FlamMap

FlamMap incorporates the following fire behaviour models:

- Rothermel's (1972) surface fire spread model,
- Van Wagner's (1977) crown fire initiation model,
- Rothermel's (1991) crown fire spread model,
- Albini's (1979) spotting model,
- Finney's (1998) or Scott and Reinhardt's (2001) crown fire calculation method, and
- Nelson's (2000) dead fuel moisture model. This allows conditioning of dead fuels in each pixel based on slope, shading, elevation, aspect, and weather.

primary outputs
- Rate of spread
- Fireline intensity
- Flame lenght

secondary outputs
- Spotting
- Crown fires
- Probability of ignition
- Height of dead crown

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Propagation potential calculation

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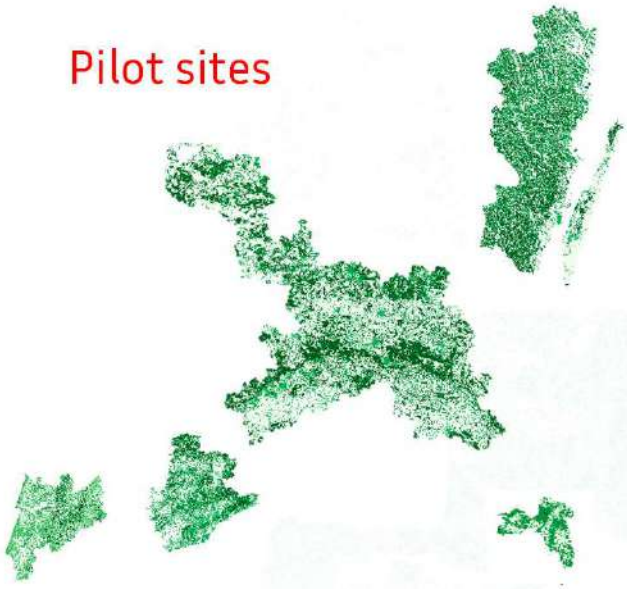
INPUTS

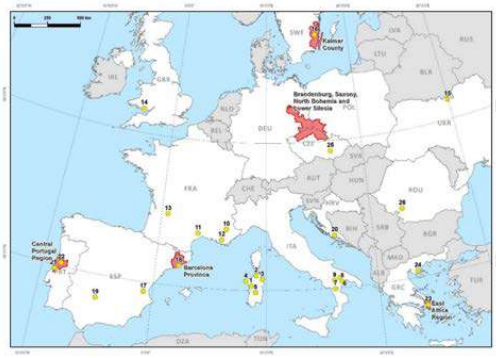


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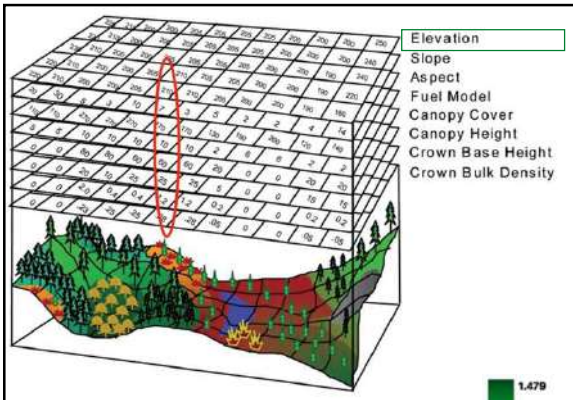
Pilot sites

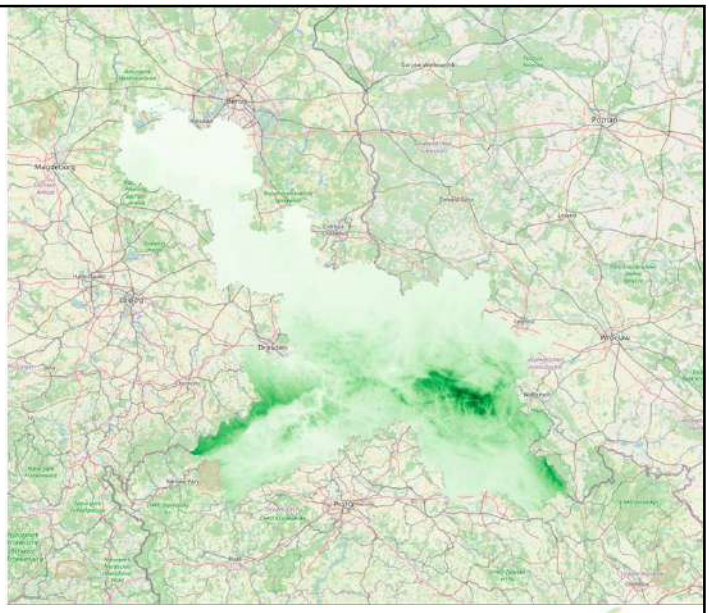
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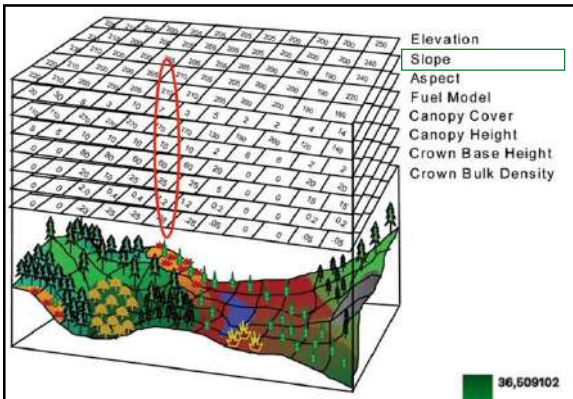
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elevation

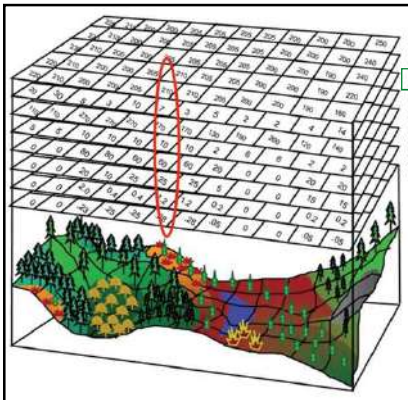
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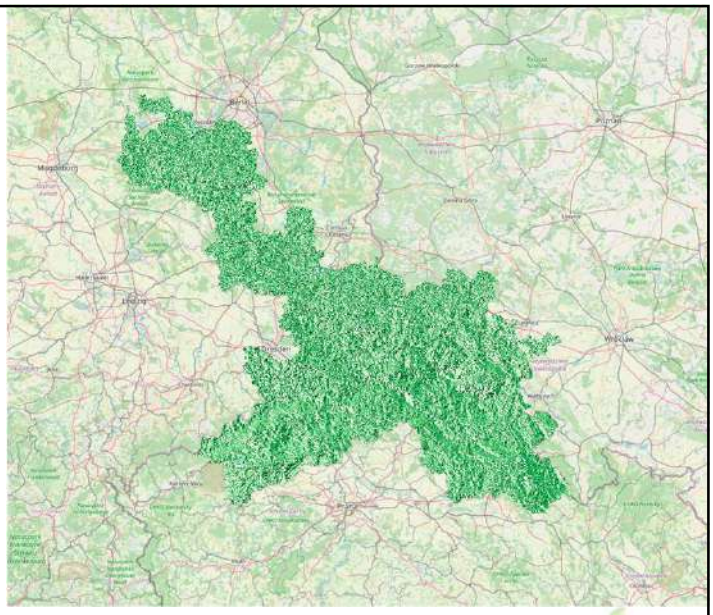




slope

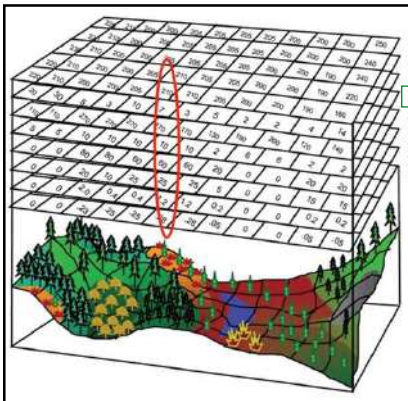
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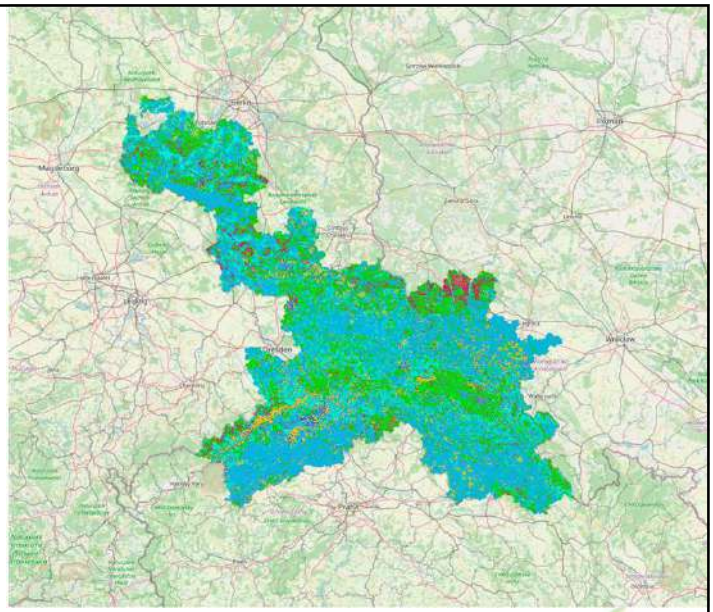




aspect

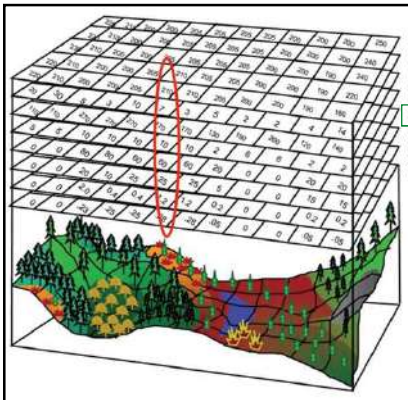
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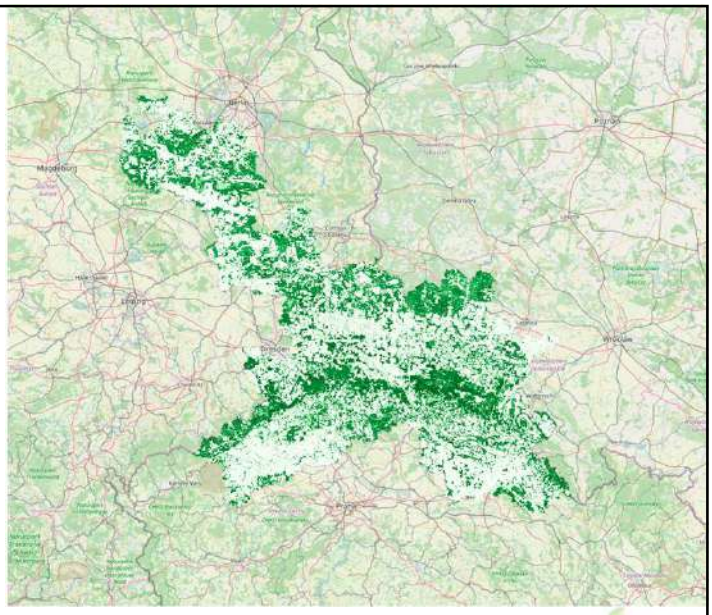




fuel model

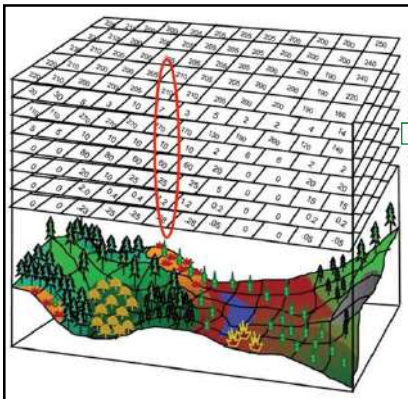
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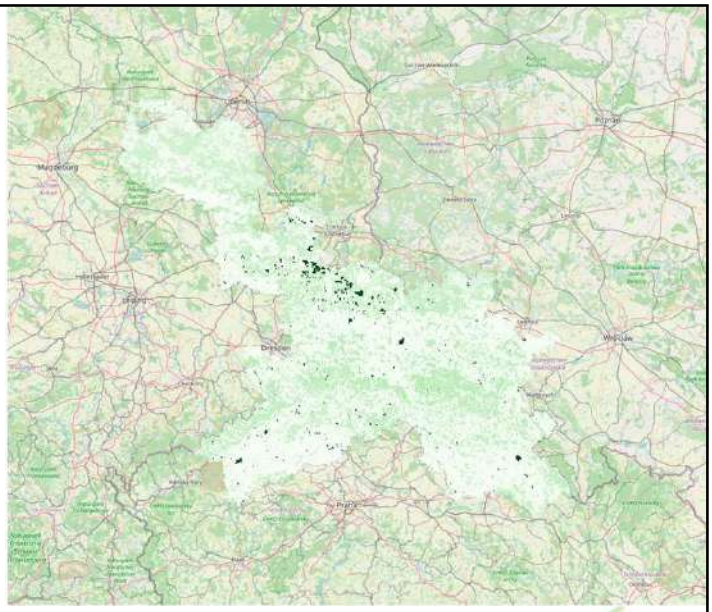


canopy cover

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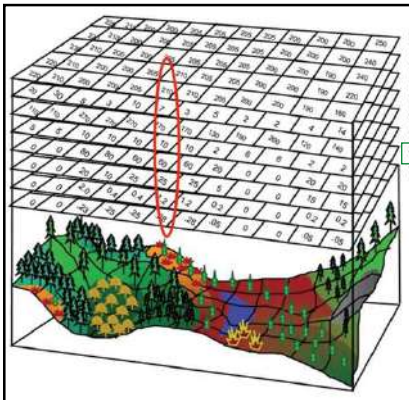


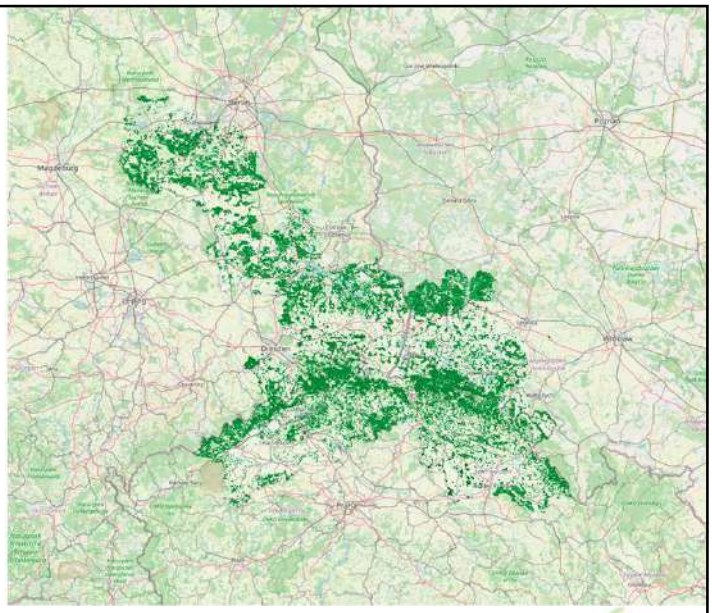




canopy height

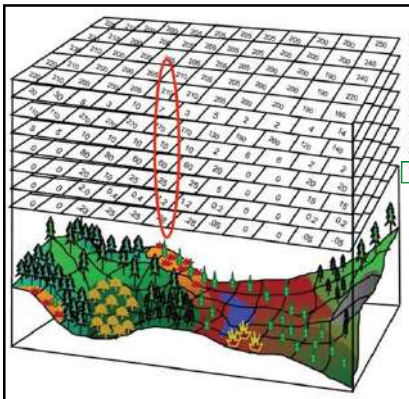
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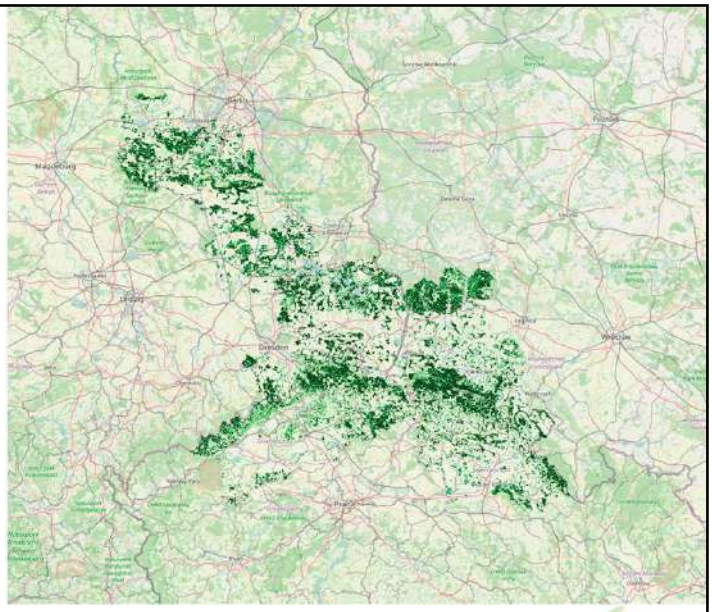




crown base height

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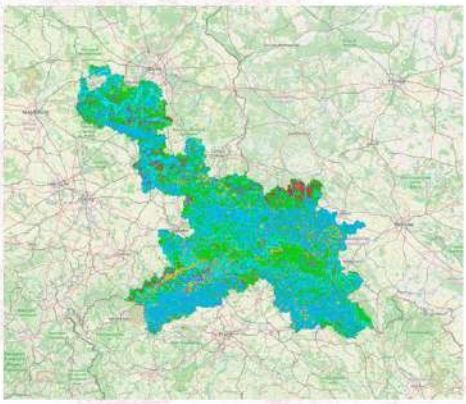
crown bulk density

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Fuel model

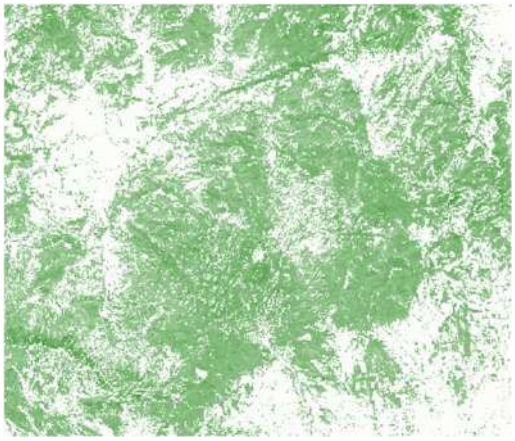
Fuel Code	Fuel Description	Crosswalk A*	Crosswalk H*
1111	Open broadleaf ev. forest	SH7	SH8
1112	Closed broadleaf ev. forest	TU1	TU2
1121	Open broadleaf dec. forest	SH5	SH9
1122	Closed broadleaf dec. forest	TU5	TU3
1211	Open needleleaf ev. forest	SH7	SH8
1212	Closed needleleaf ev. forest	TU1	TU2
1221	Open needleleaf dec. forest	SH5	SH9
1222	Closed needleleaf dec. forest	TU5	TL3
1301	Open mixed forest	SH7	SH8
1302	Closed mixed forest	TU5	TL3
21	Low shrubland	SH2	SH3
22	Medium shrubland	SH7	SH8

Fuel Code	Fuel Description	Crosswalk A*	Crosswalk H*
23	High shrubland	SH5	SH9
31	Low grassland	GR2	GR6
32	Medium grassland	GR4	GR8
33	High grassland	GR7	GR9
41	Herbaceous cropland	GR4	GR6
42	Woody cropland	GR2	GR6
51	Tree wet & peatland	SH7	SH8
52	Shrubland wet & peatland	SH5	SH9
53	Grassland wet & peatland	GR7	GR9
61	Urban continuous fabric	NB	NB
62	Urban discontinuous fabric	SH2	SH3
7	Nonfuel	NB	NB



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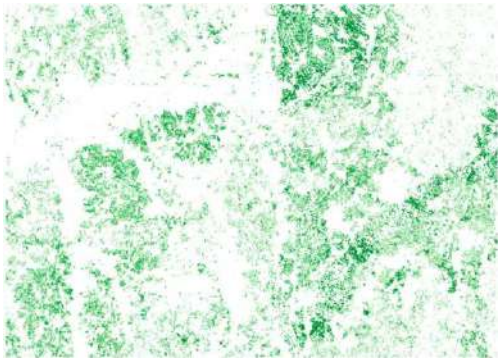
Canopy data



- **canopy cover** – Copernicus 2018 Tree Cover Density
- **canopy height** – combination of Global Forest Canopy Height, 2019 and Simard data (for Sweden and boreal regions)

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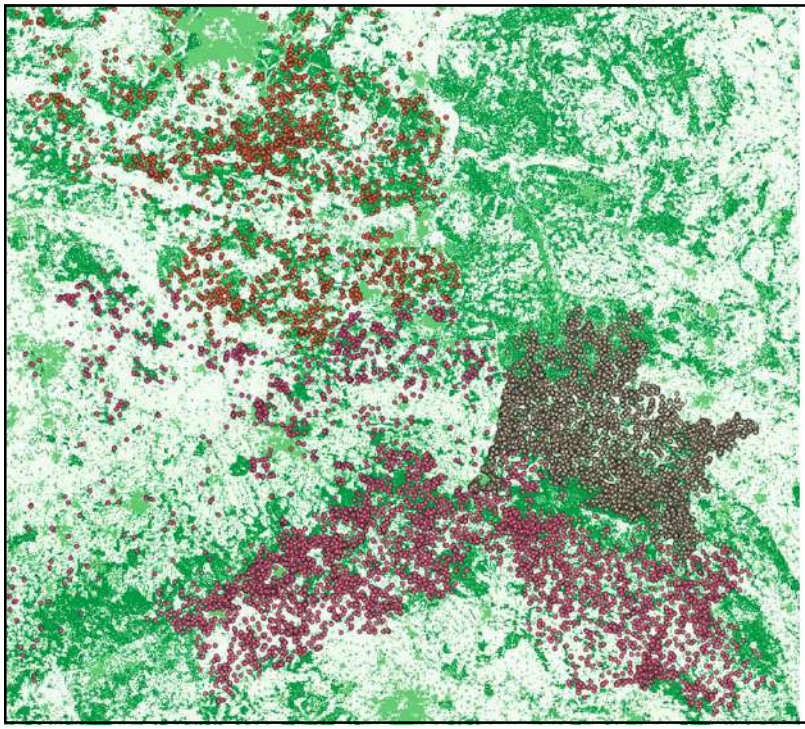
Canopy data



- **canopy base height**
- **canopy bulk density**

- generated a table with average CBH and CBD values for different CC intervals
- different tables for conifer, broadleaf evergreen, and broadleaved deciduous forest fuel types
- the values were extracted using randomly distributed 300,000 points from LiDAR-derived PREVINCAT

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Propagation potential historical data

- Historical fire records (20 years) was collected

Propagation potential

Weather scenarios

For every fire record (historical fire) larger than 1ha, we obtained:

- *burned area*
- *wind direction*
- *wind speed*
- *wind gust speed*
- *2m_temperature*
- *relative humidity*
- *VPD*
- *precipitation*
- *1h dead fuel moisture*
- *10h dead fuel moisture*
- *100h dead fuel moisture*
- *live woody fuel moisture*
- *live herbaceous fuel moisture*

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Propagation potential

Weather scenarios

Historical fire record (20 years) was collected

Fire No.	Date	Coordinates of the ignition[1]	Source[2]	Burned area (m²)	Wind direction (deg)	Wind speed (average) at noon that day (m/s)	Wind speed (gust) at noon that day (m/s)	Live woody fuel moisture (%)	Dead 1h fuel moisture[3] (%)
1	2001-01-01 12:00:00	43.564321 N 17.34567 E	RE	10000	300	5	15	80	3
2	...			...	...	...	...	...	...

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Propagation potential

Weather scenarios

1. North (337.5-22.5)
2. Northeast (22.5-67.5)
3. East (67.5-112.5)
4. Southeast (112.5-157.5)
5. South (157.5-202.5)
6. Southwest (202.5-247.5)
7. West (247.5-292.5)
8. Northwest (292.5-337.5)

	Wind direction scenario	Wind speed (gust) (m/s)	Live woody fuel moisture (%)	Dead 1h fuel moisture (%)
95-percentile:	North (337.5-22.5)	15	100	3
50-percentile:		7	110	4
95-percentile:	Northeast (22.5-67.5)	10	105	2
50-percentile:		4	106	3
	...	...	...	...

50 percentile scenario represents average conditions per weather scenario

95 percentile scenario represents extreme conditions per weather scenario

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Propagation potential

Weather scenarios

Wind direction scenario	no# fires	Percentage	Total burned area (m^2)
North (337.5-22.5)	100	60%	1000000000
...	...		...

Burned area was assigned to specific weather scenario based on 72.5 percentile values of 1h dead fuel moisture

Scenarios that influence <10% overall burned area were ignored

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Propagation potential

Summary table

scenario	percentile	wind speed (gust)	live woody fuel moisture	1h dead fuel moisture	1h dfmc (72.5p)	burned area (sum)	burned area (percentage)	number of fires	average fire size	fire size stdev
east	95 percentile	13.00866699921875	-9999.0	7.126091371611988	11.781585026065862	971.4200000000001	9.28	140	6.94	22.88
east	50 percentile	8.581618309020996	-9999.0	15.101324192703864	11.781585026065862	1024.9100000000003	9.79	401	2.56	4.65
south	95 percentile	13.46990156173706	-9999.0	7.3891280288267644	12.592961236267858	2263.9130999999998	21.63	198	11.43	63.51
south	50 percentile	8.360235691070557	-9999.0	15.703340744910511	12.592961236267858	1569.8799999999999	15.0	558	2.81	10.84
southwest	95 percentile	13.695022010803225	-9999.0	7.978876244001514	11.98503687889402	1195.83	11.42	158	7.57	34.47
southwest	50 percentile	8.569026947021484	-9999.0	16.029643500424772	11.98503687889402	1031.0049999999999	9.85	451	2.29	2.19
west	95 percentile	16.648635864257812	-9999.0	8.201917119412414	13.070544630538151	1483.3154999999997	14.17	170	8.73	30.21
west	50 percentile	9.592805862426758	-9999.0	17.52028045039452	13.070544630538151	928.268	8.87	403	2.3	4.05

Scenarios that influence <10% overall burned area were ignored

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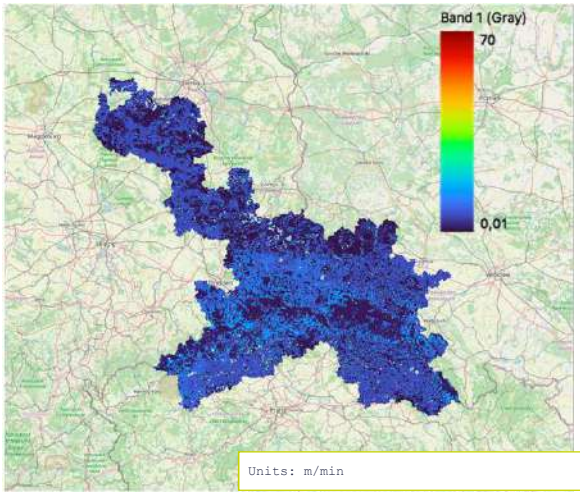
FlamMap outputs

Basic run

- Fireline intensity
- Rate of spread
- Flame length
- Heat / Unit area
- Midflame wind speed
- Crown fire activity
- Crown fraction burned

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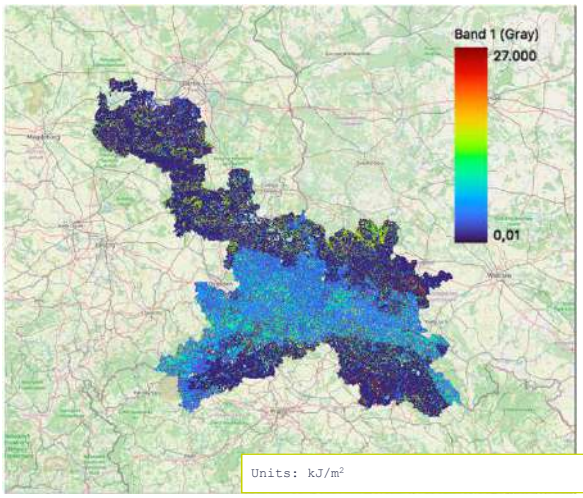
Rate of spread



- The linear rate of advance of a flaming front into unburned fuel in the direction perpendicular to the fire front
- ROS:
  - contributes to how large the wildfire can become during a specified period of time,
  - is a significant factor affecting fireline intensity and flame size, which are important for determining fire effects

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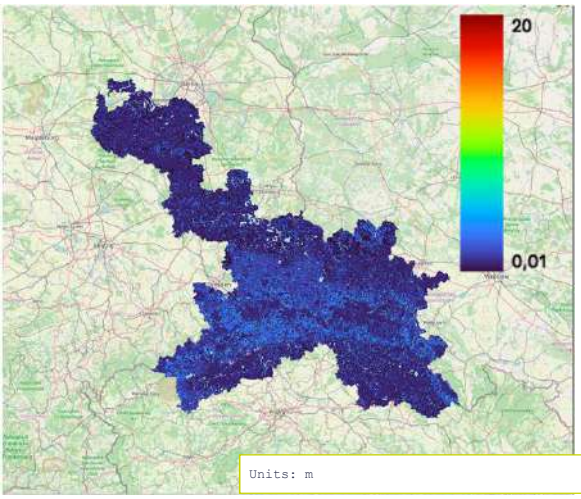
Heat per unit area



- is the amount of heat released per unit area during the short period of continuous flaming
- Heat per Unit Area is not affected by wind speed, slope, or direction of spread.

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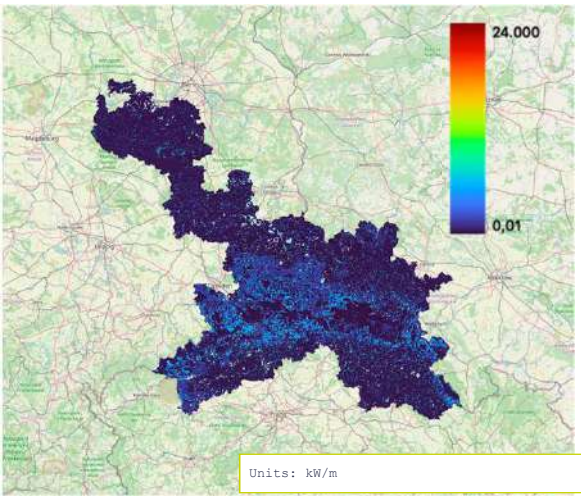
Flame length



- measured from midway in the active flaming combustion zone to the average tip of the flames
- indicator of fireline intensity

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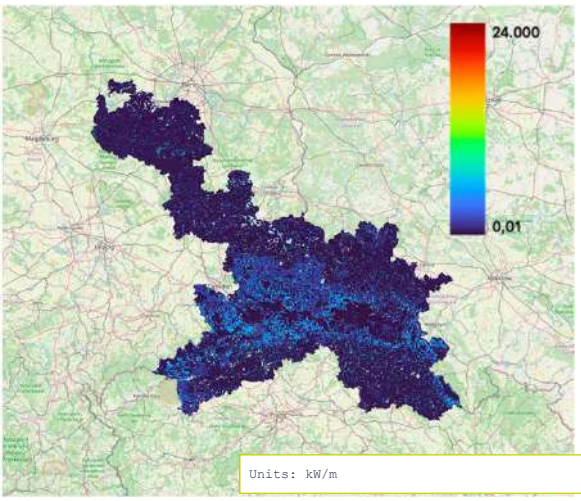
Fireline intensity

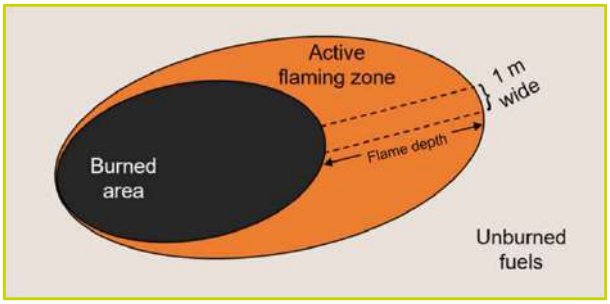


- also called Byram's fire intensity
- fundamental fire characteristic
- Heat energy released per unit time from a one-meter-wide section of the fuel bed extending from the front to the rear of the flaming zone.
- Fireline intensity is a function of rate of spread and heat per unit area, and is directly related to flame length.

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Fireline intensity

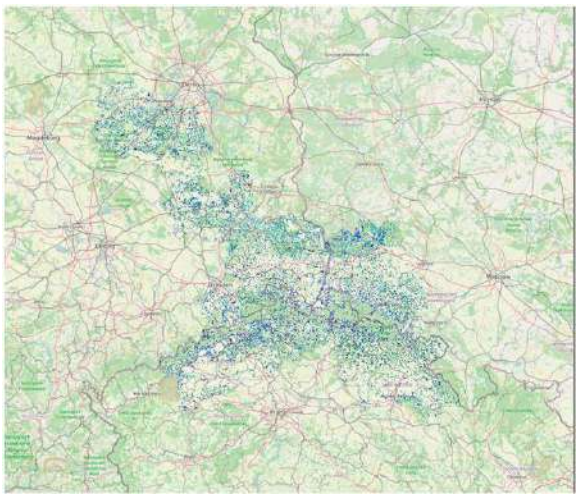




"about as much information about a fire's behavior as can be crammed into one number"

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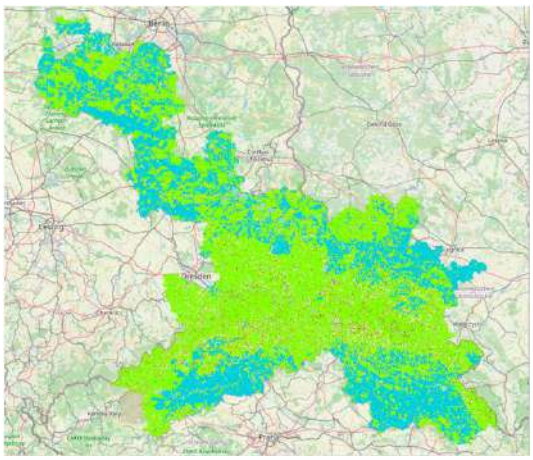
Crown fraction burned

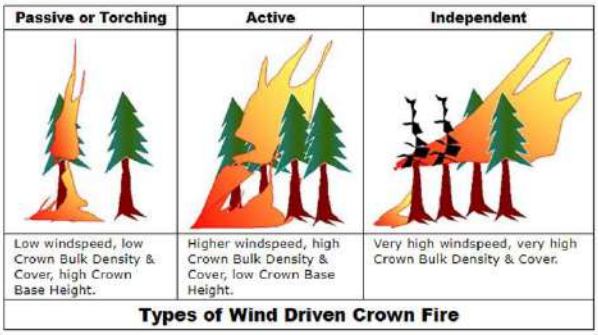


- A fraction between 0 and 1 indicating the severity of a crown fire

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Crown fire activity





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FlamMap MTT runs

Dynamic mode

- Next step was to saturate Pilot Site landscape with thousands of fire simulations to calculate burn probability map
- Calibration stage was required to determine "simulated fire durations" for each weather scenario

- FlamMap limits?
- Pilot Site area size?
- Time to run simulations?

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FlamMap MTT runs

Dynamic mode

> 320.000 fire simulations

Outputs:

- burn probability
- conditional flame length

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FlamMap MTT runs

Burn probability

- The fraction of the number of fires that encountered each node
- Gives an estimation of the probability of a cell burning due to a random fire, according to the set of static inputs
- The bigger the fires in the region, the higher the probability

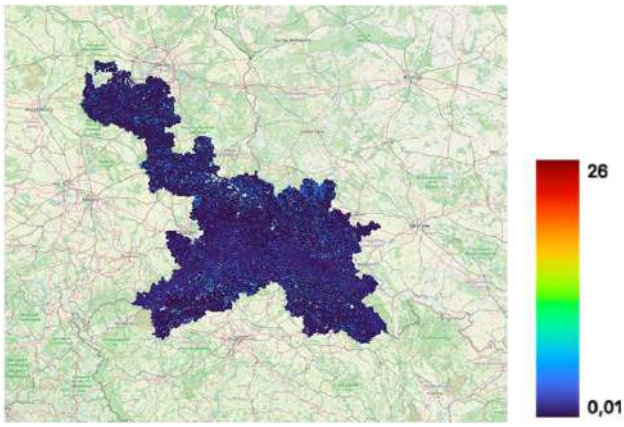
Low values for Central Europe Pilot site

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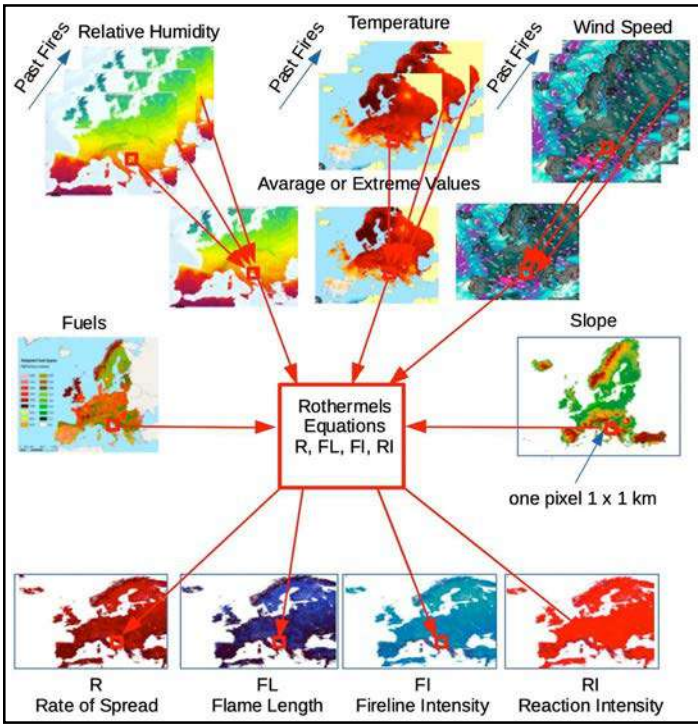
FlamMap MTT runs

Conditional flame length

- Represents the most likely flame length at a given location if a fire occures
- Average measure of expected wildfire intensity

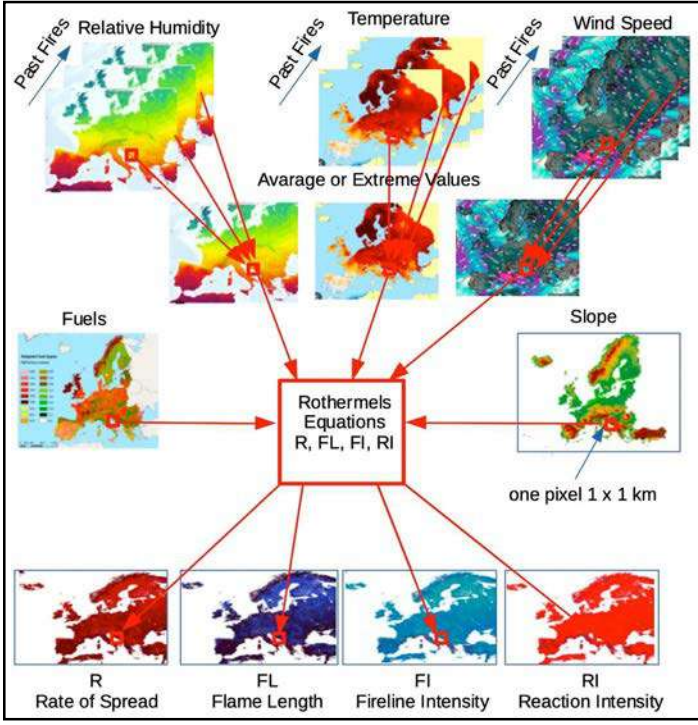


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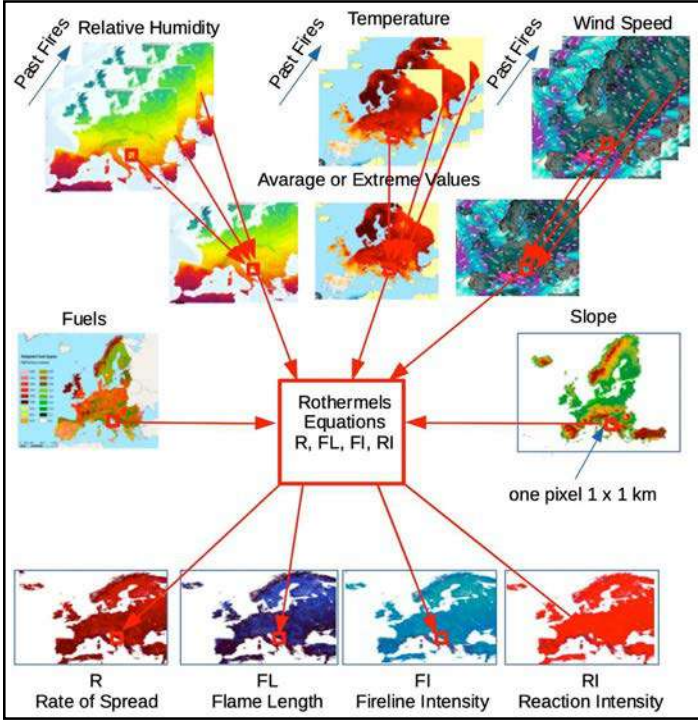


Propagation potential calculation for European Territory (ET)

METHODOLOGY



- Propagation potential for EU territory was calculated in 1 km resolution, based on **custom implementation of Rothermel's model** (in Python) **for cell-based wildland landscape fire growth simulations**.
- From the list of past fires on EU territory from Jan, 1st 2001 to Dec, 31st 2019, fires larger then 2000 ha were selected. There were 403 such fires.



- **10h Fuel Moisture Content** and **wind speed** were calculated for each date, based on two weather scenarios:
  - average weather conditions (50th percentile) and
  - extreme weather conditions (5th percentile for fuel moisture and 95th percentile for wind speed).

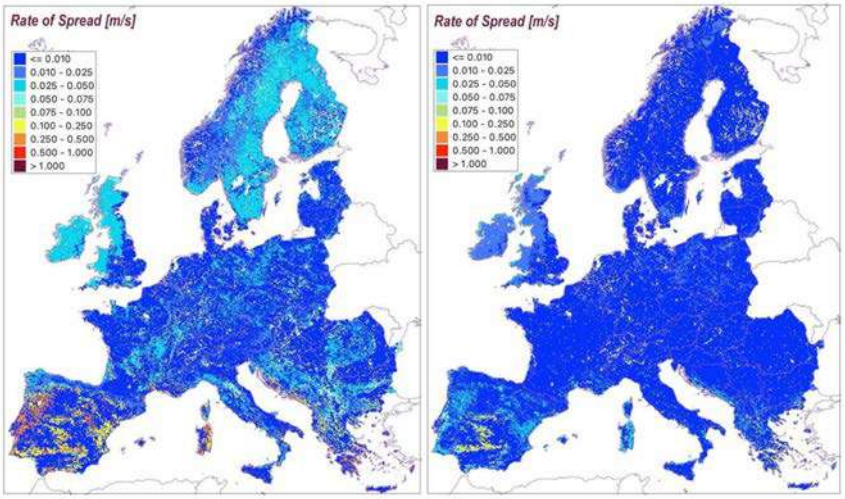


Figure 25: Comparison of Rate of Spread (ROS) [m/s] for extreme and average wind speed and fuel moisture (left – extreme, right – average)

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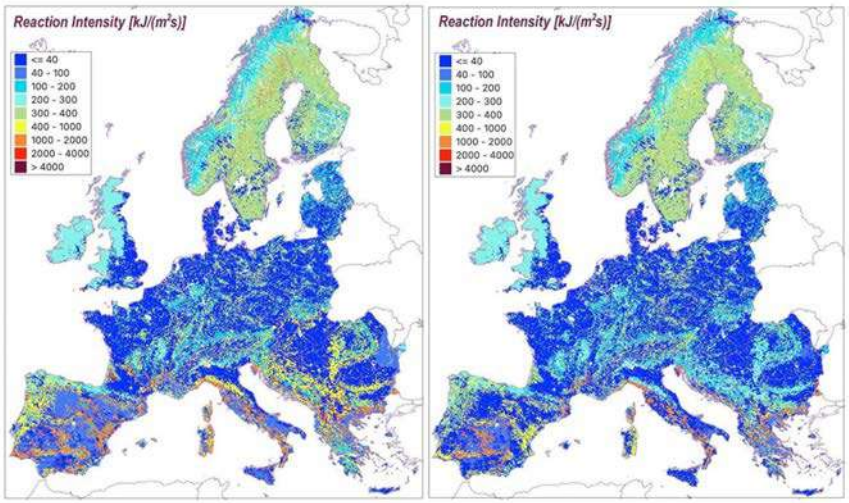


Figure 26: Comparison of Reaction Intensity (RI) [kJ/(m² s)] for extreme and average wind speed and fuel moisture (left – extreme, right – average)

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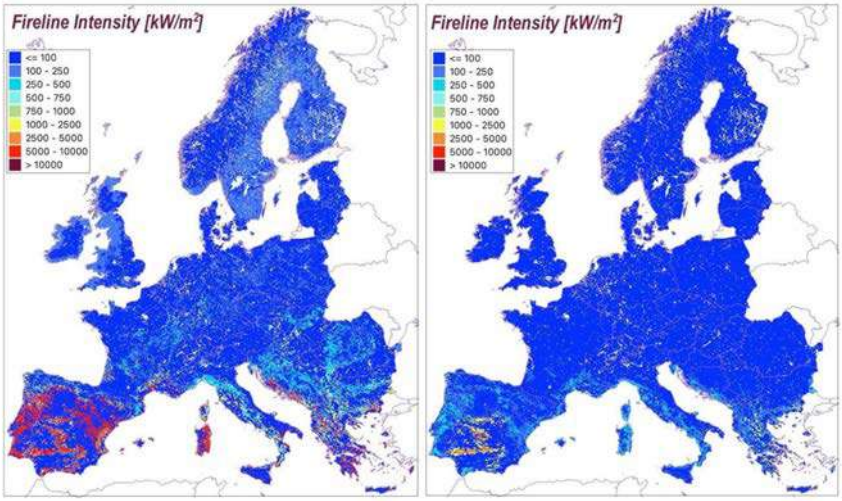


Figure 27: Comparison of Fireline Intensity (FI) [kW/m²)] for extreme and average wind speed and fuel moisture(left – extreme, right – average)

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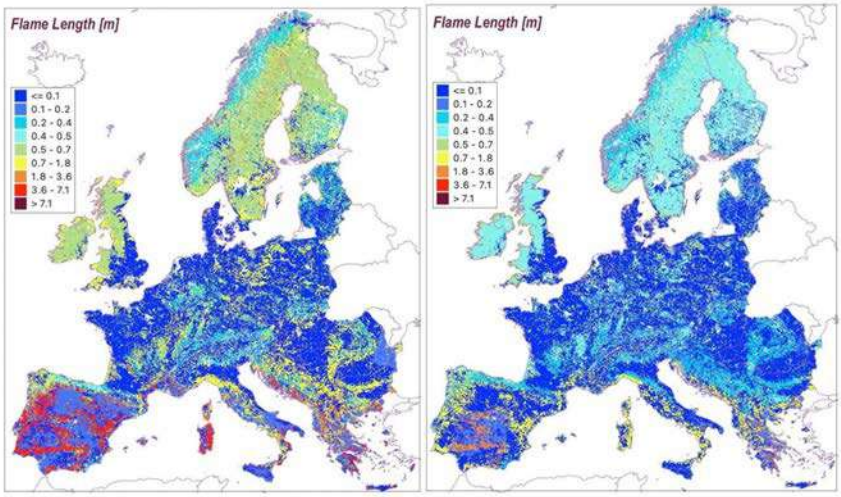


Figure 28: Comparison of Flame Length (FL) [m] for extreme and average wind speed and fuel moisture (left – extreme, right – average)

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Thank You

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Suppression Difficulty Index Evaluation

Prof. Juan Ramón Molina, University of Cordoba

26/1/24 | PS2 Demonstration Event

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Suppression Difficulty Index (SDI)

This index combines variables related to fire behaviour and variables related to suppression operations

For a given level of potential fire behaviour, greater control opportunities reduce the overall suppression difficulty





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2

Suppression Difficulty Index (SDI)

$$SDI = \left[\frac{\sum(I_{ce})}{\sum(S_{oi})}\right] = \left[\frac{\sum(I_{ce})}{\sum(I_a + I_m + I_p + I_{ar} + I_c)}\right]$$

SDI = **Energy behaviour** / Suppression opportunities



Flame length and heat per unit area



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3

Suppression Difficulty Index (SDI)

$$SDI = \left[\frac{\sum(I_{ce})}{\sum(S_{oi})}\right] = \left[\frac{\sum(I_{ce})}{\sum(I_a + I_m + I_p + I_{ar} + I_c)}\right]$$

SDI = Energy behaviour / **Suppression opportunities**



Accessibility, mobility, penetrability, fire-line opening

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4

Suppression Difficulty Index (SDI)

CSIRO PUBLISHING
International Journal of Wildland Fire
https://doi.org/10.1071/WF19042

Modelling suppression difficulty: current and future applications

Francisco Rodríguez y Silva[A,D], Christopher D. O'Connor[B], Matthew P. Thompson[C], Juan Ramón Molina Martínez[A] and David E. Calkin[B]



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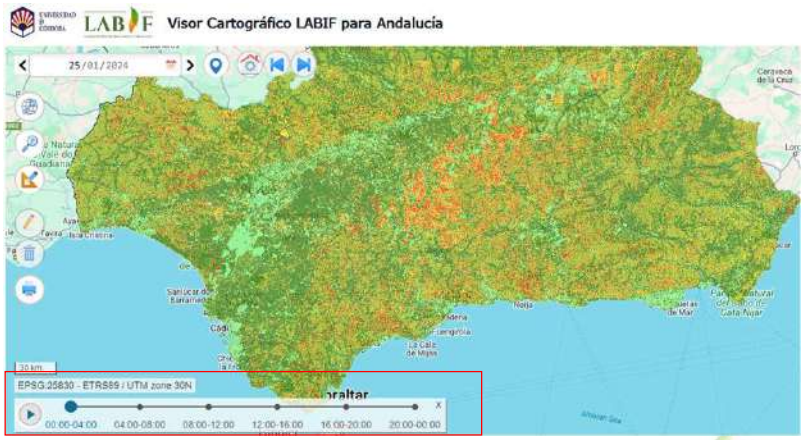
5

Suppression Difficulty Index (SDI)

CSIRO PUBLISHING
International Journal of Wildland Fire
https://doi.org/10.1071/WF19042

Modelling suppression difficulty: current and future applications

Francisco Rodríguez y Silva[A,D], Christopher D. O'Connor[B], Matthew P. Thompson[C], Juan Ramón Molina Martínez[A] and David E. Calkin[B]



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Suppression Difficulty Index (SDI)

Saxony and Bohemian Switzterland National Parks



Accessibility

Fuel models opportunities

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7

Suppression Difficulty Index (SDI)

Saxony and Bohemian Switzterland National Parks



Canyons

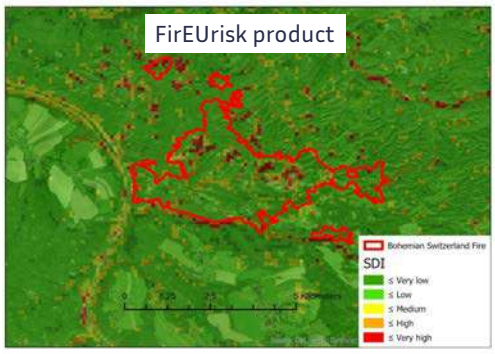
Higher fuel continuity

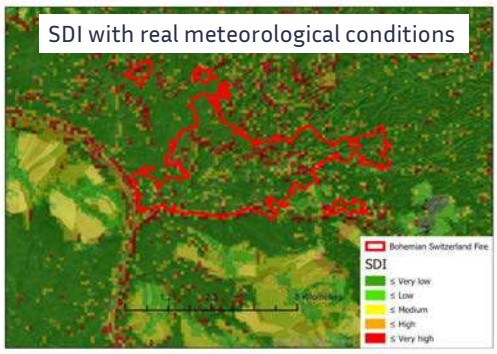
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8

Suppression Difficulty Index (SDI)

Saxony and Bohemian Switzterland National Parks





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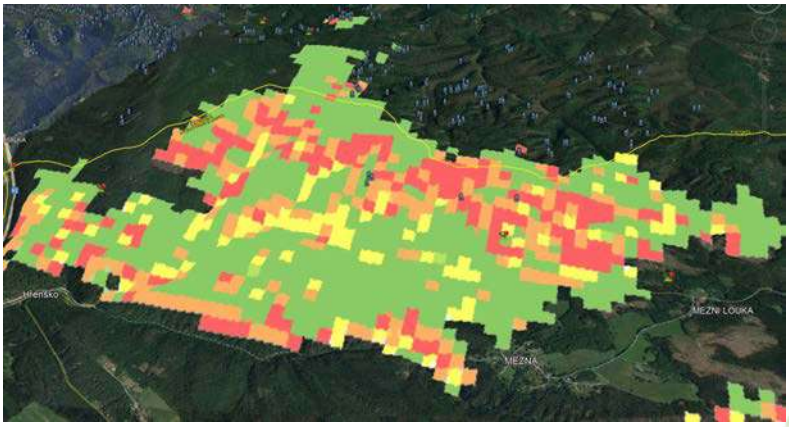
9

Suppression Difficulty Index (SDI)

Saxony and Bohemian Switzterland National Parks

Fire 1 evaluation

88.30% of the control line (perimeter) is in Very or Low SDI

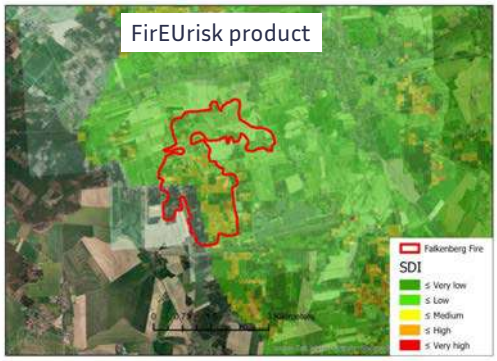


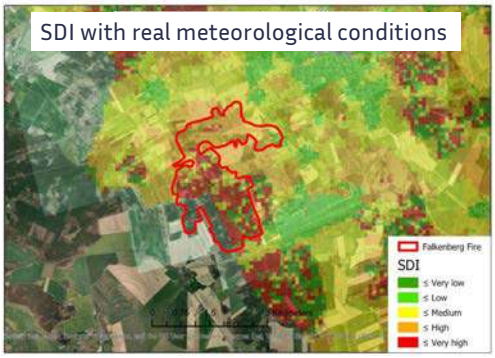
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10

Suppression Difficulty Index (SDI)

Frankenberg/Elster





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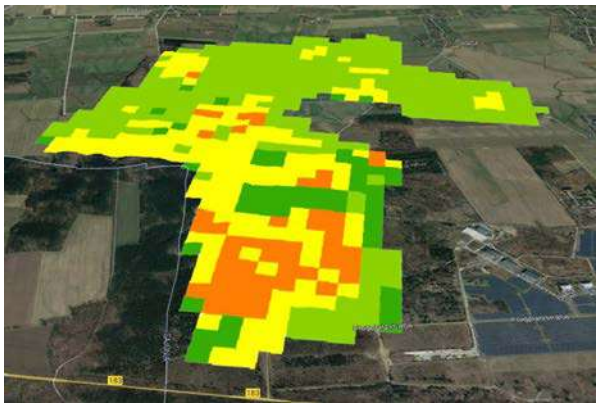
11

Suppression Difficulty Index (SDI)

Frankenberg/Elster

Fire 2 evaluation

89.98% of the control line (perimeter) is in Very or Low SDI

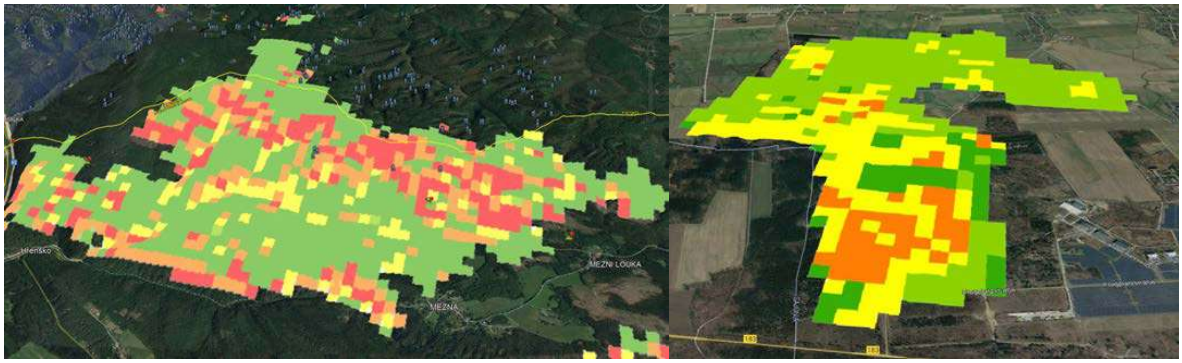


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Suppression Difficulty Index (SDI)

SDI results in Central Europe have ben quite promising (higher than 88% of the control line). However, testing with a greater number of fires and meteorological conditions is required.



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Thank you!

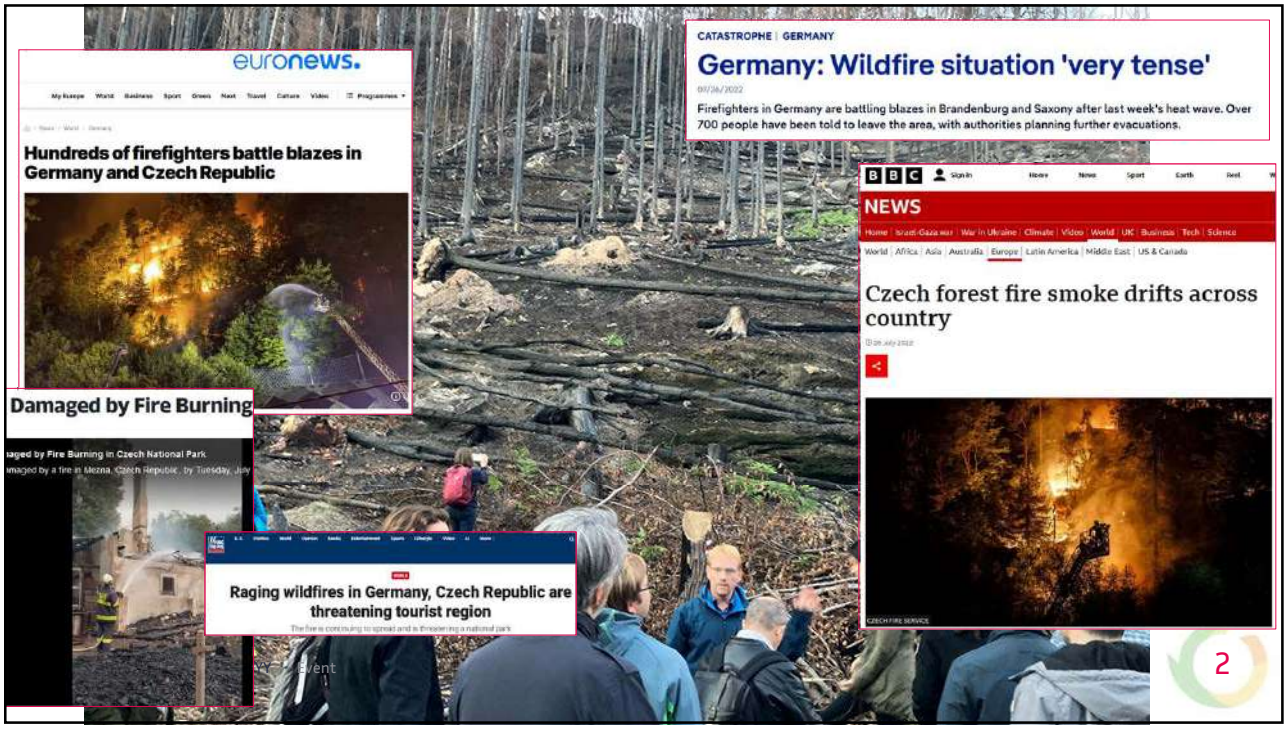
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Fuel mapping and fire severity for the Bohemian-Saxon Switzerland NP 2022

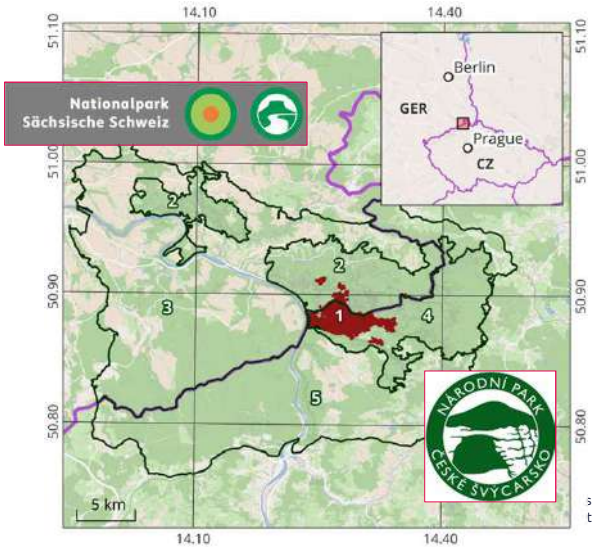
Matthias Forkel, TU Dresden

Kristina Beetz, Annika Busse, Markéta Poděbradská, Daniel Kinalczyk, Johanna Kranz, Christopher Marrs

25/01/2024 | Central Europe Pilot Site Demonstration



Fire in Bohemian-Saxon Switzerland

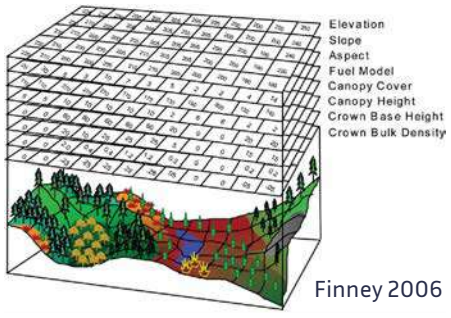


- Fire started in the night from the 24th to 25th July 2022
- Main spread until 29th July
- End of fire fighting operations end of August
- 1,060 ha in CZ
- 113 ha in DE
- Largest fire in the Czech Republic
- ~11 Mio € for fire fighting operations in Germany

3

Fuel mapping and fire modelling

- *Fuel types* describe the kind of plant material that will likely burn during a fire
- *Fuel models* are used operationally in many countries to estimate potential fire behaviour with fire models
- *Fuel types/models* were recently mapped for Europe at 1 km resolution (Aragoneses et al. 2023)
- Higher resolution required for mountain regions

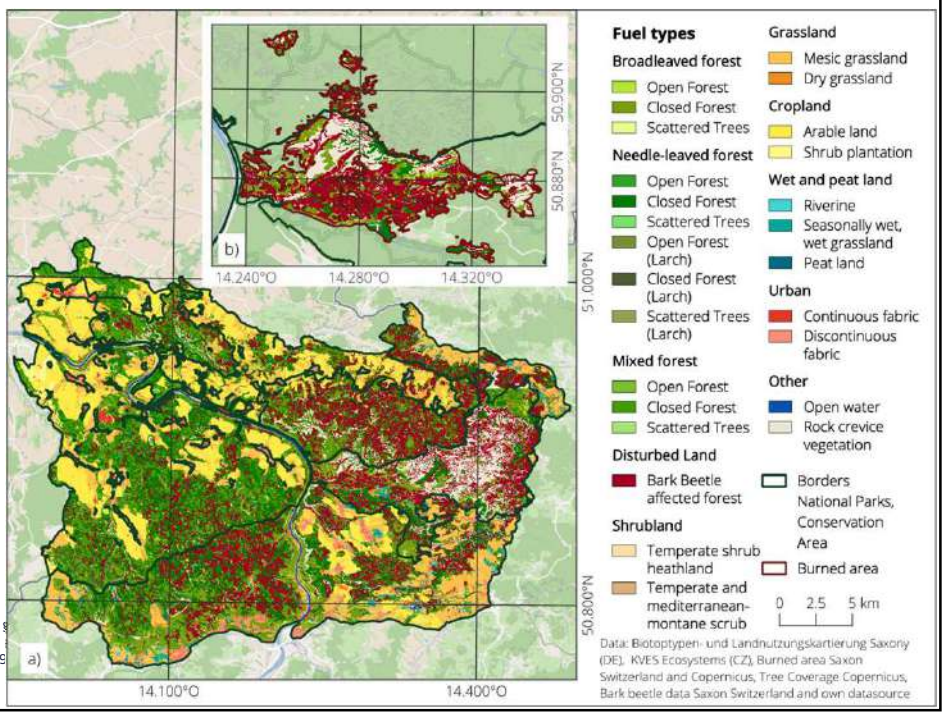


Finney 2006



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Fuel types in the Bohemian-Saxon Switzerland (2022)

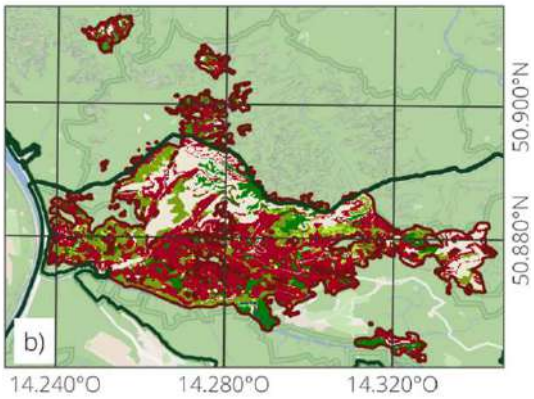


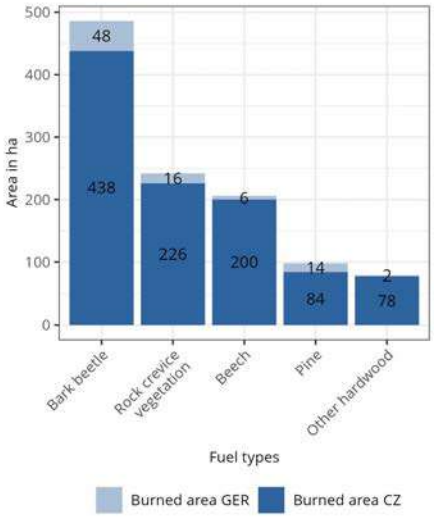
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Horizon 2020 research
Agreement no. 10100389

Field survey of fuel types (2023, 83 sites)



Fuel types affected by the fire 2022

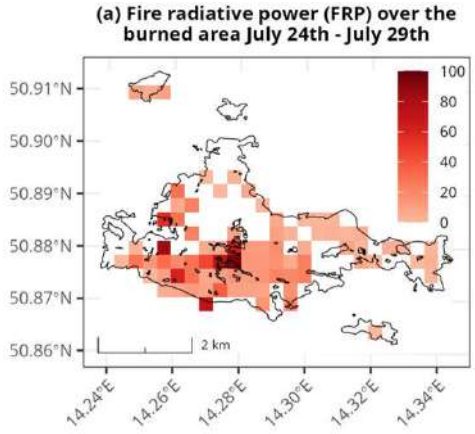


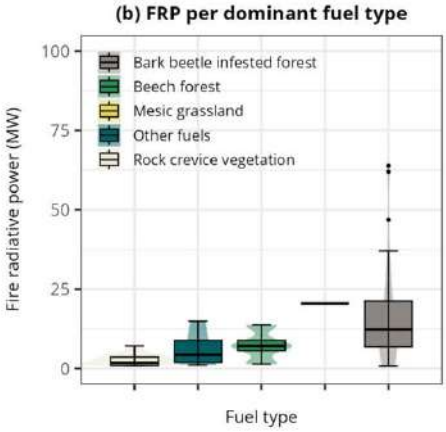


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7

Fire intensity (fire radiative power)



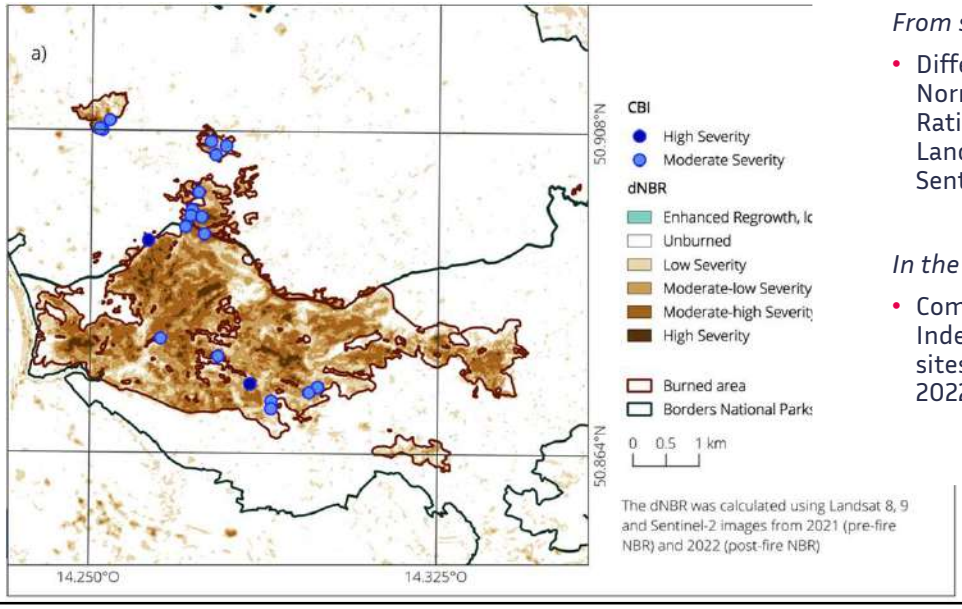


FRP from VIIRS sensors, 375 m x 375 m

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8

Fire severity



From satellites:

- Difference Normalized Burn Ratio (dNBR) from Landsat-8 and Sentinel-2 imagery

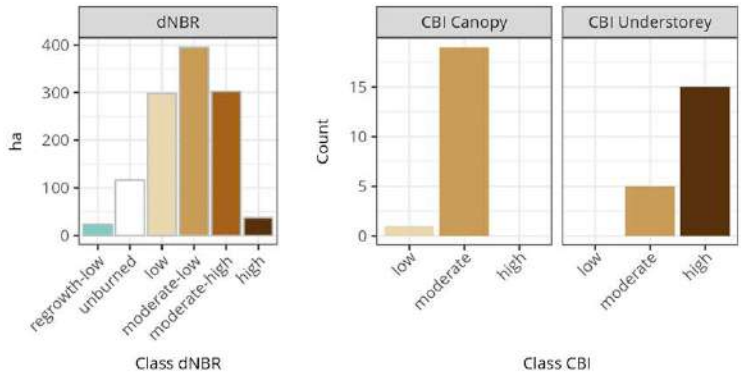
In the field:

- Composite Burn Index (CBI) at 21 sites in September 2022

9

Fire severity





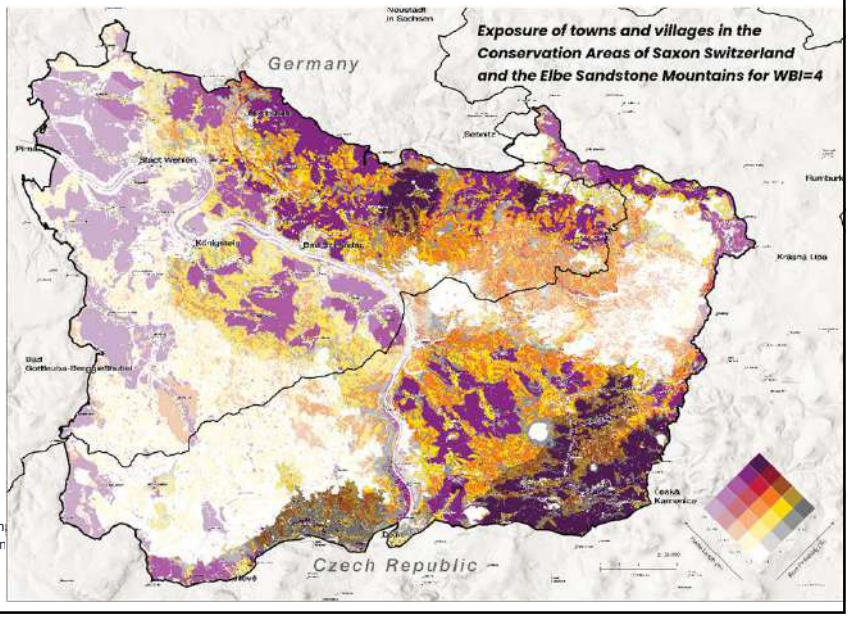
10

Fire behaviour



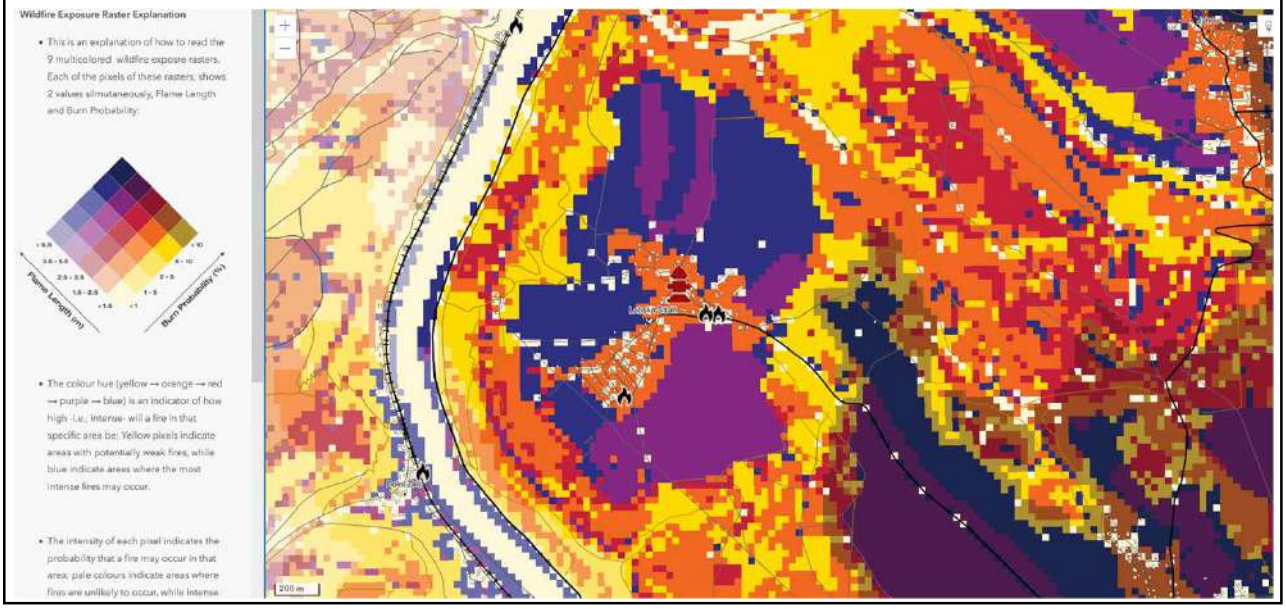
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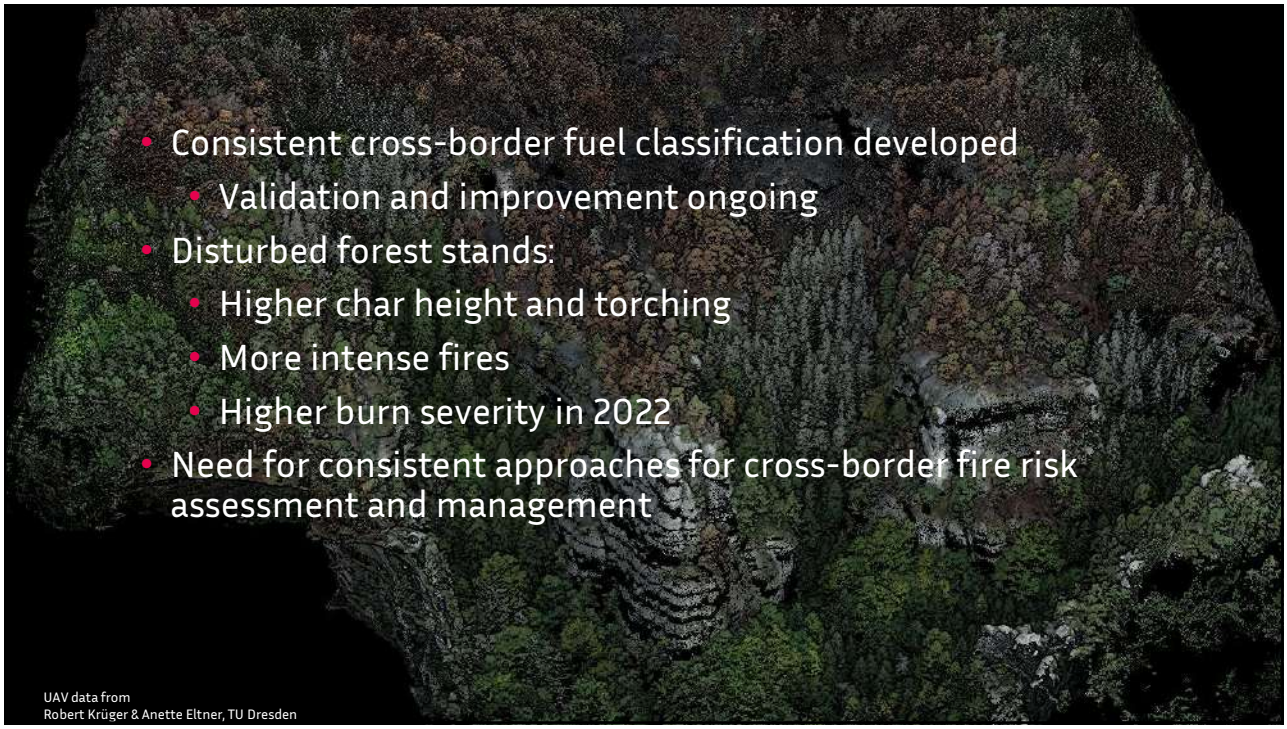
Potential fire risk



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Potential forest fire risk







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Probability of human-caused ignitions in Central Europe

Pere Gelabert
University of Lleida
perejoan.gelabert@udl.cat

03/11/23 | Demo Event – Central Europe

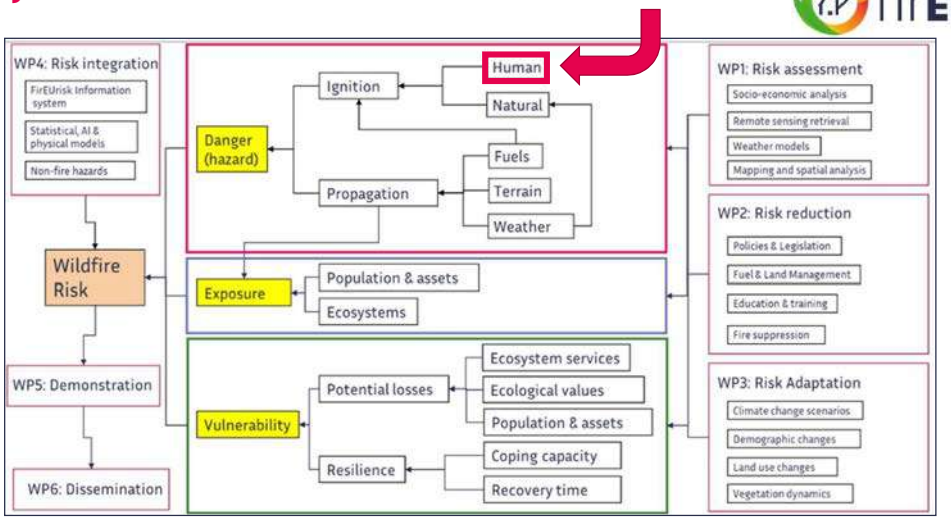
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3. Modeling strategy
4. Model performance
5. **PRODUCT: HUMAN-CAUSED IGNITION PROBABILITY MAP**

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Project context



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Data sources and input variables

- Fire data – 1636 recorded ignitions provided by different FirEUrisk institutions

Variable	Year	Source
Population density	2020	SEDAC
Distance to roads	2005–2014	Global Roads Inventory Project (model GLOBIO)
Percent Elder people (>65yo)	2011	EUROSTAT at municipality level
Distance to interfaces (WAI, WUI y WGI)	2018	Corine Land Cover
Percent cover (urban, crop and forest)	2018	Corine Land Cover
Fuel types	2020	FirEUrisk product

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Modeling strategy

- We calibrated Random Forest (machine learning) binary classification models:
  - Presence vs absence of fires
  - We calibrated 100 model realizations to account for the variability in absence fire location
- Comparison of conditions (input variables)
- **Result**: Raster layer (.tif format) with the probability of human-caused fire occurrence

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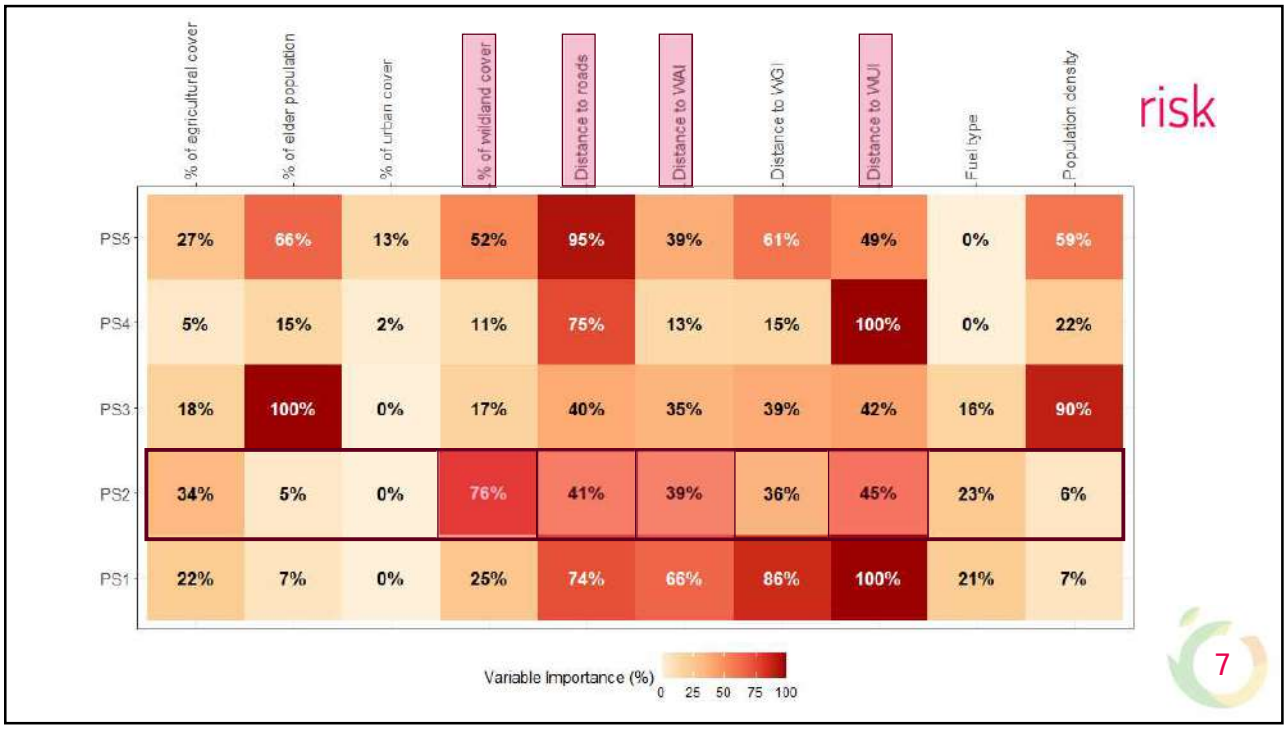
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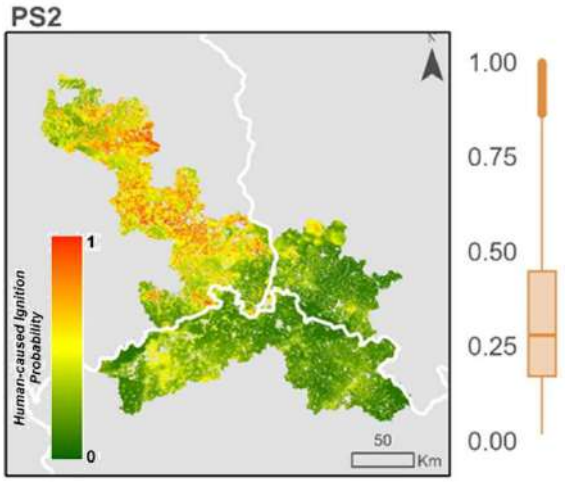
Model performance

Pilot site	AUC	Top four fire drivers
PS1 – Northern Europe	0.87	Distance to WUI, WGI, roads and WAI
PS2 - Central Europe	**0.84**	**% of Wildland, distance to WUI, roads and WAI**
PS3 - Barcelona	0.85	% of elder population, population density, distance to WUI and roads
PS4- Central Portugal	0.89	Distance to WUI, roads, population density and % of elder population
PS5 - Attica region	0.69	Distance to roads, % of elder population, distance to WGI, population density

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HUMAN-CAUSED IGNITION PROBABILITY MAP

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Thanks for your attention

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Future fire regimes

Simulations of future fire regimes and vegetation under climate and land-use change

Dr. Kirsten Thonicke, on behalf of WP3

26/01/2024 | Central European Demonstration Event

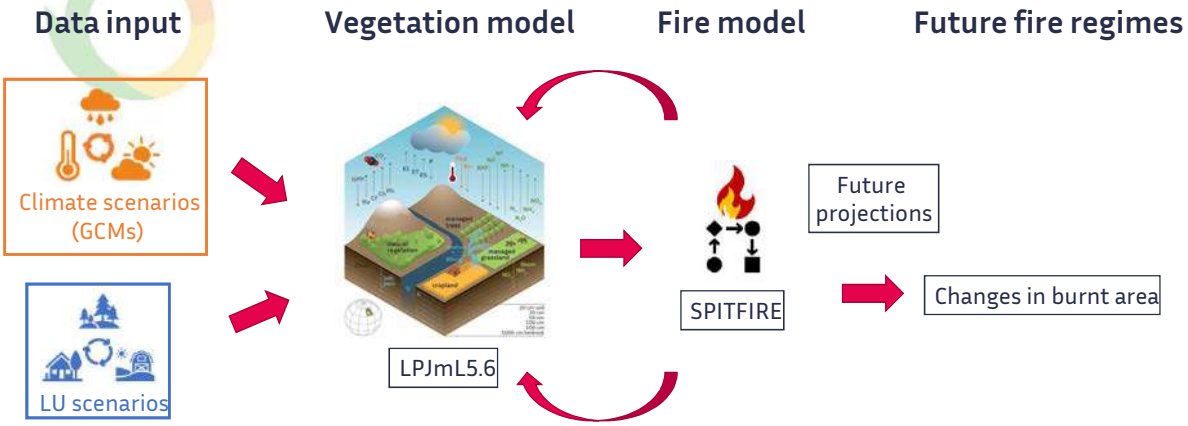
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Overview

1. Methods used to simulate changes in future vegetation and fire under climate change
   - Climate change in Central-European PS
2. Possible changes in vegetation and fire in Central-European Pilote site
   - Fire weather
   - Burned area
   - Vegetation changes
3. Changes at the European scale

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What was our task?



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1. From IPCC climate model archive (CMIP6) to high-resolution scenario data

Climate scenarios (GCMs)



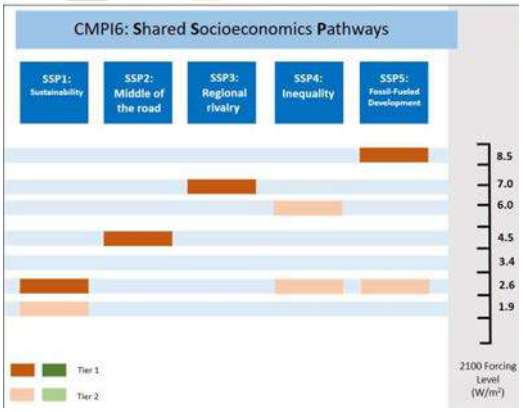
1. Climate scenarios are
   - **Bias corrected using ERA5-Land reanalysis climate data**
   - **Statistical downscaling method applied daily values & 9x9 km spatial resolution**
   - **Produced for FirEUrisk European region (map) and Pilote sites**

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Climate scenarios (GCMs)

From IPCC climate model archive (CMIP6) to high-resolution scenario data

meteogrid



2. Selection of climate scenarios

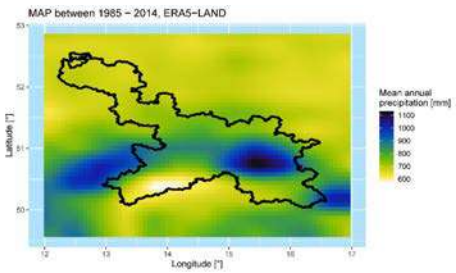
- **Sustainable pathway (Paris Accord achieved): RCP2.6 (climate) and SSP1 (land-use, economic and policy trajectory)**
- **Regional rivalry (In a 3 to 4°C warmer world): RCP7.0 and SSP3**
- **Each climate model has different model outcome, we selected the scenarios according to their ranking using the FWI**

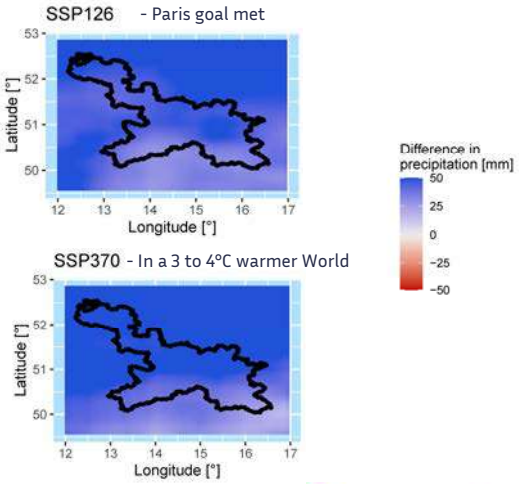
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1. Future climate conditions - Precipitation



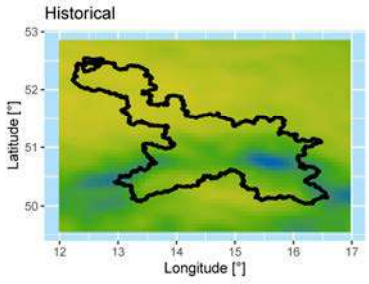


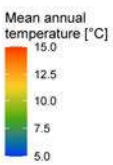
- Historical (1985 – 2014) reconstructed precipitation (ERA-5 Land)
- Future scenarios: averaged over 5 climate models, differences to present shown
- Increase in precipitation under climate change (2070-2099)

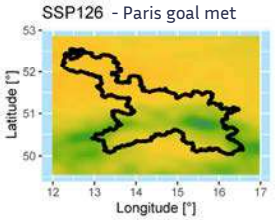
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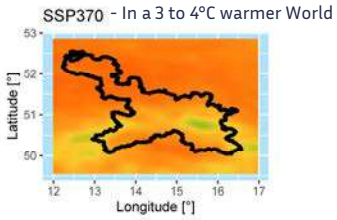
1. Future climate conditions – Air temperature







- Future climate: averaged over 5 climate models
- Cool climate in mountains disappears, warming in lowlands (2070-2099)



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1. Future changes in fire weather

- Applying the Canadian Fire Weather Index

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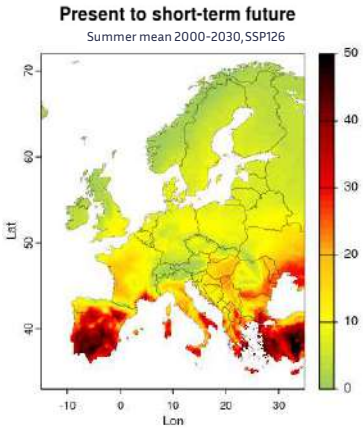
9

1. Future fire weather

- Simulated FWI using future climate scenarios

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Danger classes	
FWI < 5.2	very low
5.2 ≤ FWI < 11.2	low
11.2 ≤ FWI < 21.3	moderate
21.3 ≤ FWI < 38	high
38.0 ≤ FWI < 50	very high
50 ≤ FWI	extreme

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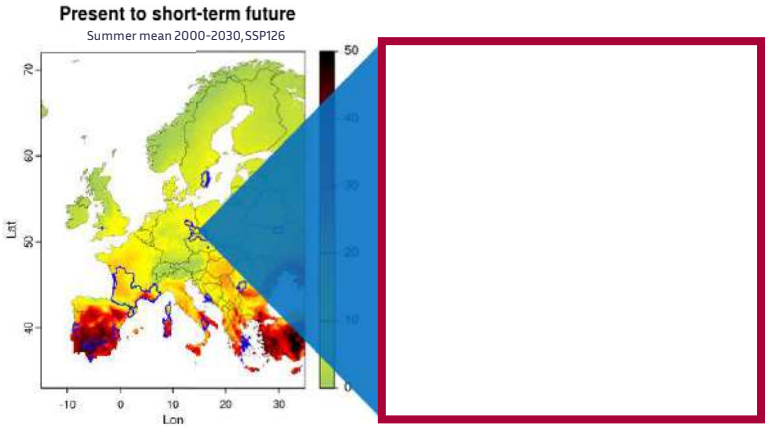
10

1. Future fire weather

- Simulated

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Danger classes	
FWI < 5.2	very low
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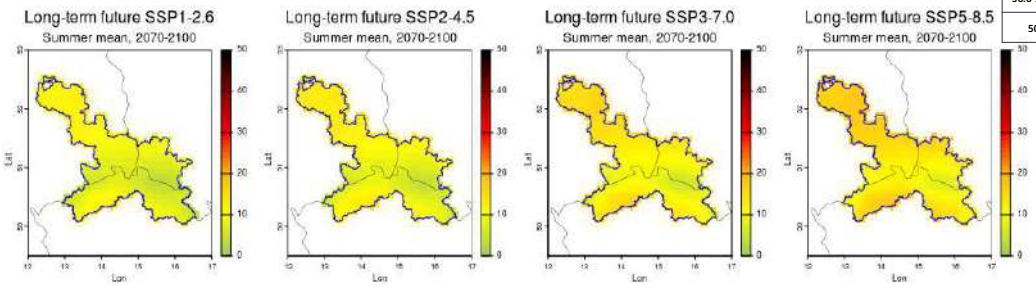
FWI at the end of the century (2070-2100)

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Danger classes	
FWI < 5.2	very low
5.2 ≤ FWI < 11.2	low
11.2 ≤ FWI < 21.3	moderate
21.3 ≤ FWI < 38	high
38.0 ≤ FWI < 50	very high
50 ≤ FWI	extreme

Difference seems low compared to the general European change, however the absolute change is marked see following pages



More CO_2 in the atmosphere

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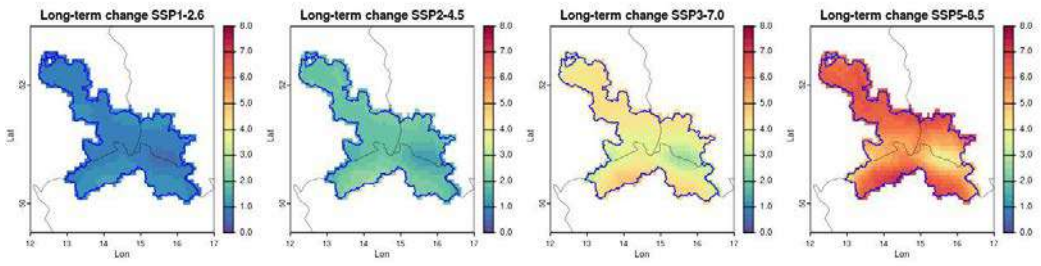
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Absolute change in FWI until the end of the century (2070-2100)

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More CO_2 in the atmosphere

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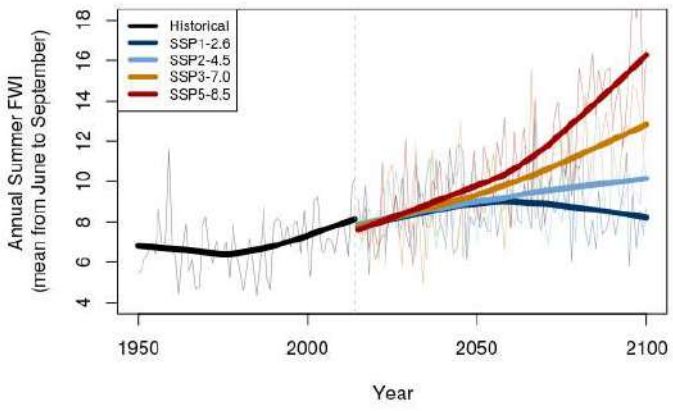
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Summer FWI per year for different climate scenarios over Central European Pilote site

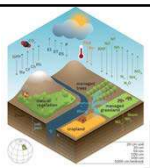
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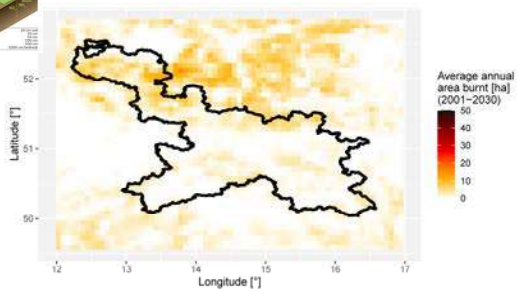
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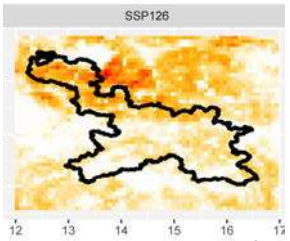


2. Changes in area burnt – Central Europe

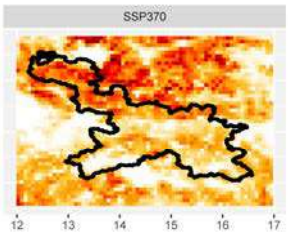
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Potsdam Institute for Climate Impact Research PIK





- Paris goal met

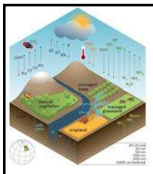


- In a 3 to 4°C warmer World

- Simulated by fire-enabled DGVM LPJmL-SPITFIRE: vegetation and fire are simulated process-based and interact
- Model forced with scenarios for land-use and climate change, vegetation changes in response to that and affects fire simulation
- Overall increase in average area burnt (ha), much more in lowland areas

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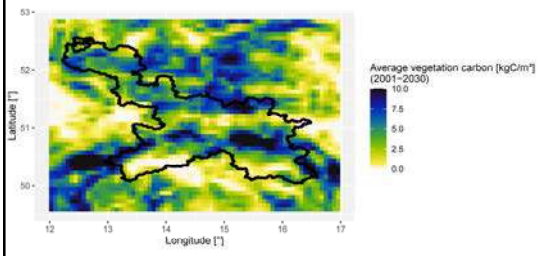
fireurisk



3. Biomass: Combined effects of climate change, CO_2-Effect and land-use change

© Maik Billing, Kirsten Thonicke

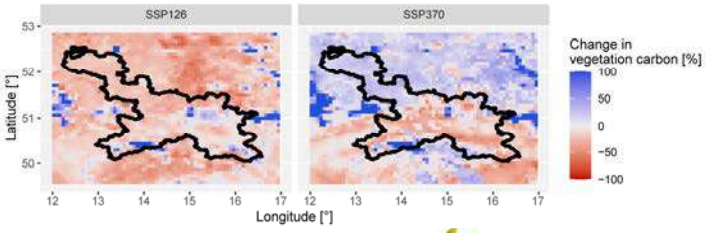
- Simulated biomass in forests within 9x9 km grid cell
- Low in areas with high proportion of land-use, incl. urban areas



Change in biomass

Effects of temperature increase, but also precipitation projected to increase

Increase in atmospheric CO_2 concentration increases water-use efficiency in the tree, less drought stress in **potential natural vegetation (no spruce or pine monocultures, nor bark beetle simulated)**



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme

4. The European scale

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

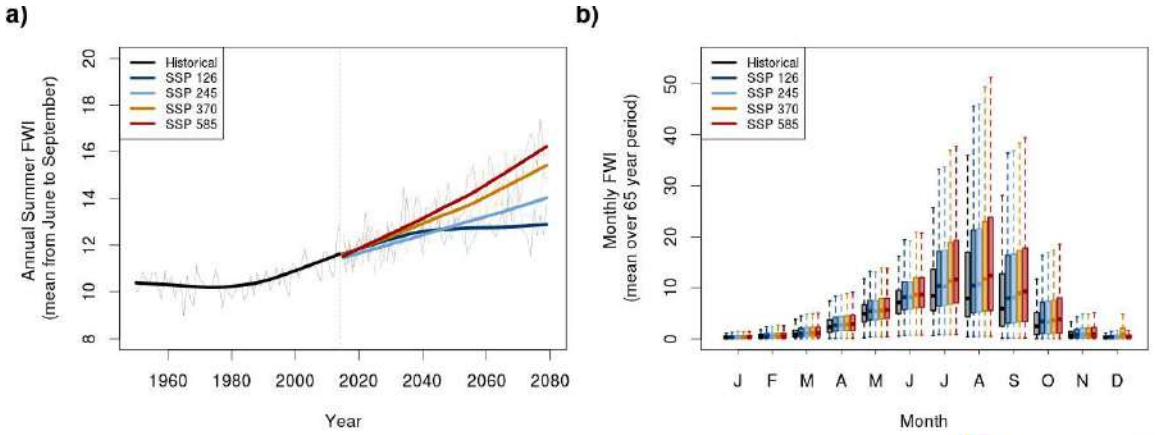
17

1. Future fire weather

© Jessica Hetzer, Matthew Forrest
SENCKENBERG
world of biodiversity

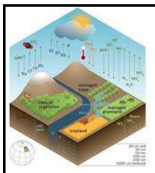
- Long-term trends in Europe

Changes in seasonality



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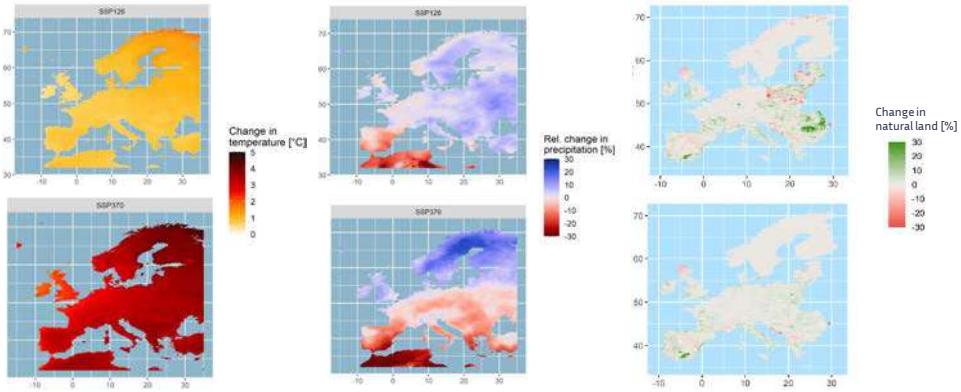
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4. Projections into the future: input data

© Maik Billing, Kirsten Thonicke
Potsdam Institute for Climate Impact Research
PIK

Temperature | Precipitation | Land-use change



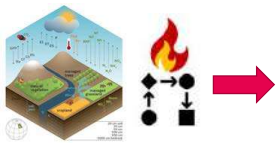
SSP126

- sustainable
- low warming

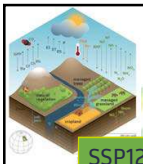
SSP370

- not so sustainable
- medium warming

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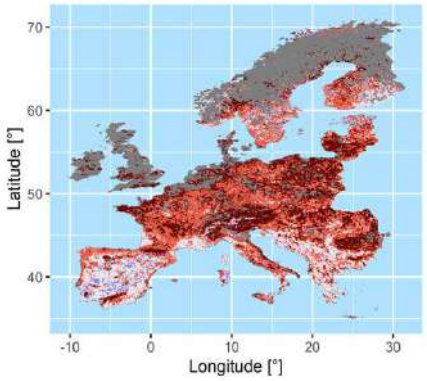
Changes in vegetation & burnt area



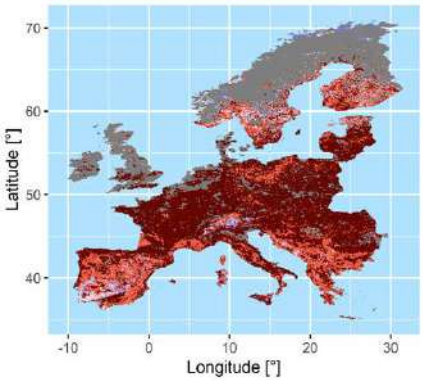
4. Relative change in area burnt (2000 – 2030 to 2070 – 2100)

© Maik Billing, Kirsten Thonicke

SSP126 – Paris goal met



SSP370 - in a 3 to 4°C warmer world



- Be prepared in central and northern EU!
- More Fires in Southern EU under SSP3

Change in area burnt
- much more (> 300%)
- more (+50% to +300%)
- rather same (-50% to +50%)
- less (-300% to -50%)
- much less (< -300%)
- no fires

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5. Conclusion

- Future fire situation in Europe will depend on success of global climate policy
- Pathways "Paris goal met" OR "in a 3 to 4°C warmer world" decide about intensity of changes in vegetation and fire in the future fire
  - Europe: Future fire weather will increase, the fire season expand and become more extreme
  - Central Europe: Future area burned is a result of multiple changes happening at the same time
    - Rising temperatures and atmospheric CO2, wetter conditions enhance vegetation growth, nevertheless fire weather and potential burned area increases
    - Less land-use additionally increases forest cover that could bur
- Next step: investigate opportunities & limitations of fire adaptation through land management (fuel removal, fire fighting) in managed forests

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

Thank you for your attention!

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

CENTRAL EUROPE DEMONSTRATION EVENT

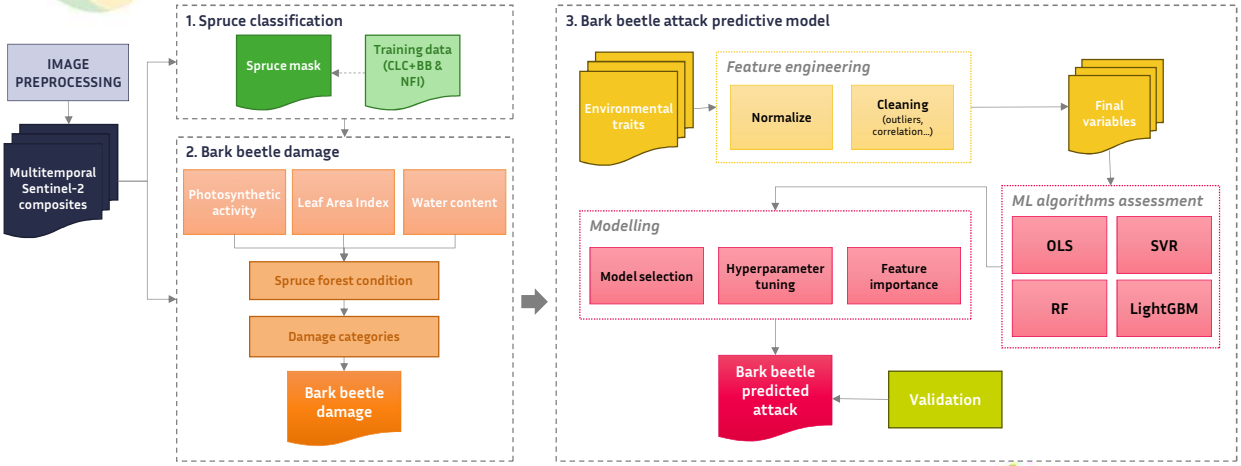
Forest Condition: Biotic Damages
Bark beetle attack predictive model in Central Europe

Ángel Fernández-Carrillo, Antonio Franco-Nieto, Julia Yagüe-Ballester, Marta Gómez-Giménez
GMV

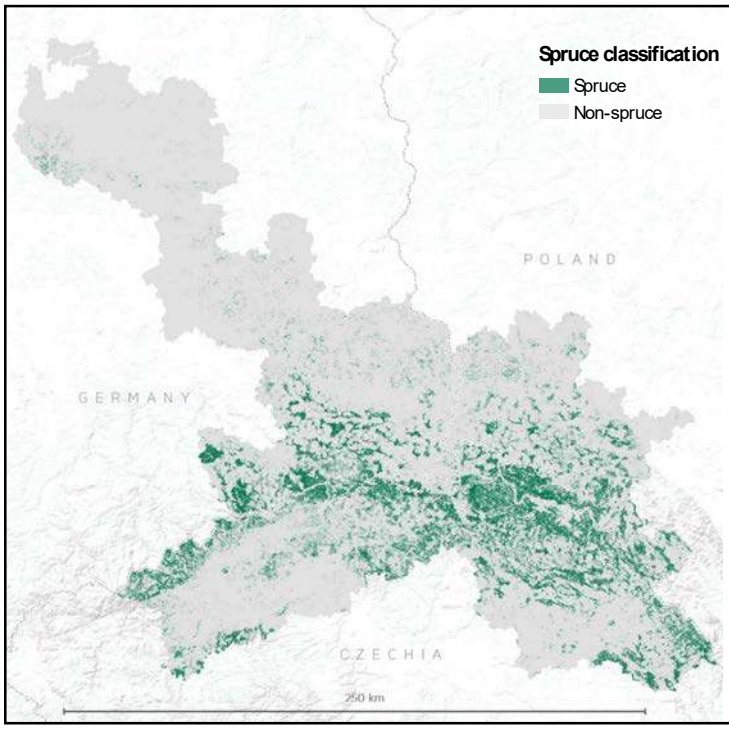


This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003890

2 Workflow



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme



1. Spruce classification

- Inputs: Sentinel-2 composites, NFI 2021 and CLC+ Backbone
- **Most suited spectral indices to discriminate *Picea abies***: EVI, MBI, MSAVI2 and NDVI
- Main algorithm: **Random Forest**

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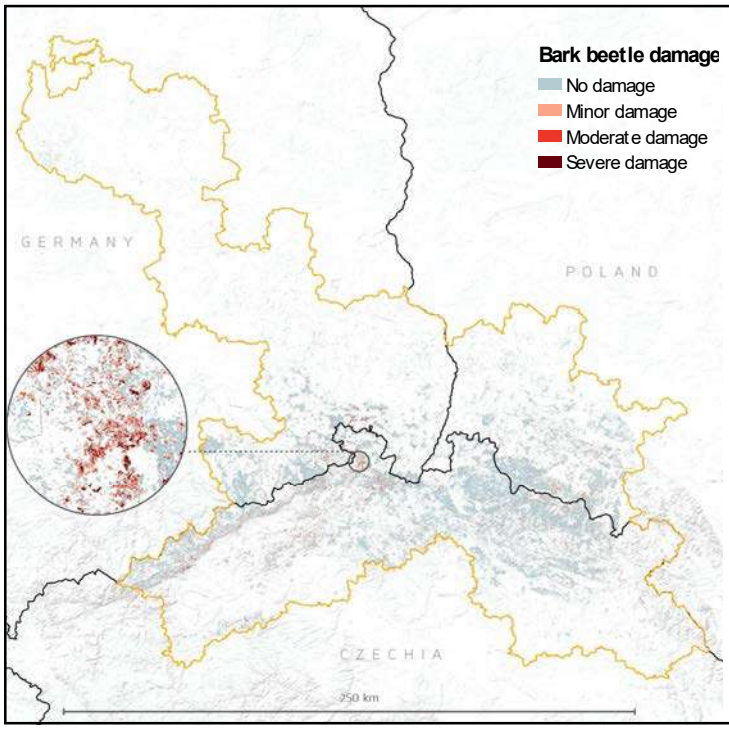
1. Spruce classification



Metric	Value (%)
Overall accuracy	91
Precision	79
Recall	94
F1-score	86
Commission error	3
Omission error	21
Relative bias	-16



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2. Bark beetle damage

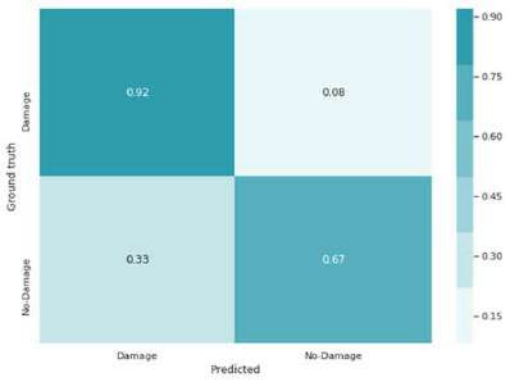
- Detects the concurrence of a bark beetle outbreak and estimates the **forest loss** and the **area affected**
- Spruce forest condition:
  - **Photosynthetic activity**: NDVI
  - **Leaf Area Index**: LAI_{green}
  - **Water content**: NDMI
- Main algorithm: **OLS Regression**

remote sensing
MDPI
Article

Monitoring Bark Beetle Forest Damage in Central Europe. A Remote Sensing Approach Validated with Field Data

Angel Fernandez-Carrillo [1,*], Zdeněk Patočka [2], Lumír Dobrovolný [3], Antonio Franco-Nieto [1] and Beatriz Revilla-Romero [1]

2. Bark beetle damage



Metric	Value (%)
Overall accuracy	81.7
Precision	79.5
Recall	92.3
F1-score	85.4
Commission error	20.5
Omission error	7.7
Relative bias	16.1



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3. Bark beetle attack predictive model

Bark beetle parametrization: Environmental traits

Environmental traits

- **Stand characteristics:** Forest types + Forest age
- **Site characteristics:** DEM + Soil moisture
- **Previous Damage:** Wind & Snow damage, wildfires
- **Climate:** Temperature & Precipitation
- **Pest occurrence:** Bark beetle damage

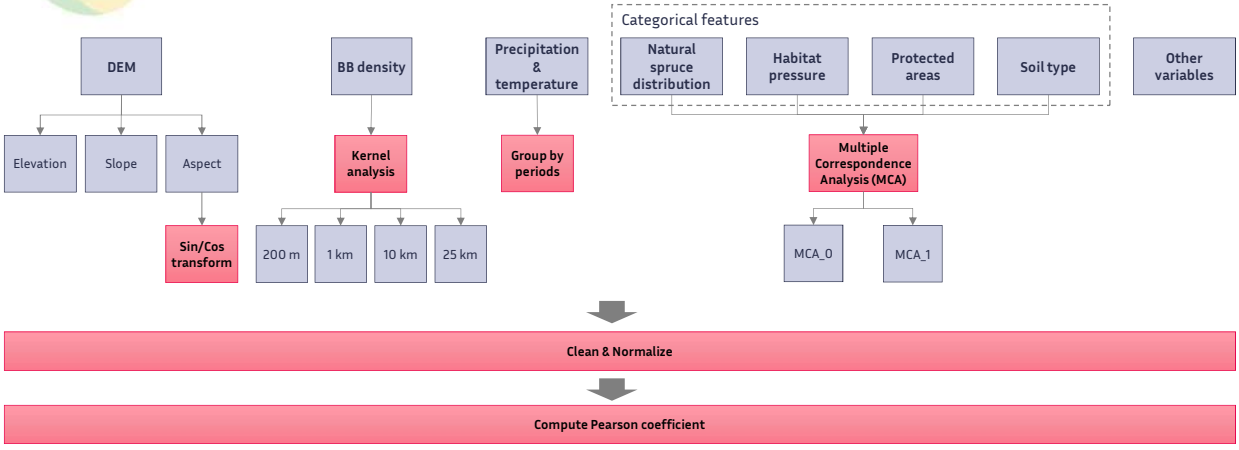
Variables	Sources	Variables	Sources
Spruce density (2020)	EO-derived	Soil type	European Soil Database
Stand density (2020)	EO-derived	Previous drought (2020)	European Drought Observatory
Natural spruce distribution	EUFORGEN	Temperature (2020-21)	ERA5
Habitat pressure	EEA	Precipitation (2020-21)	ERA5
Protected areas	EEA	Wind speed (2020-21)	ERA5
DEM	EU-DEM	Bark beetle attack density (2020)	EO-derived
Solar Irradiation (2020-21)	DEM-derived	Bark beetle attack distance (2020)	EO-derived

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3. Bark beetle attack predictive model

Feature engineering



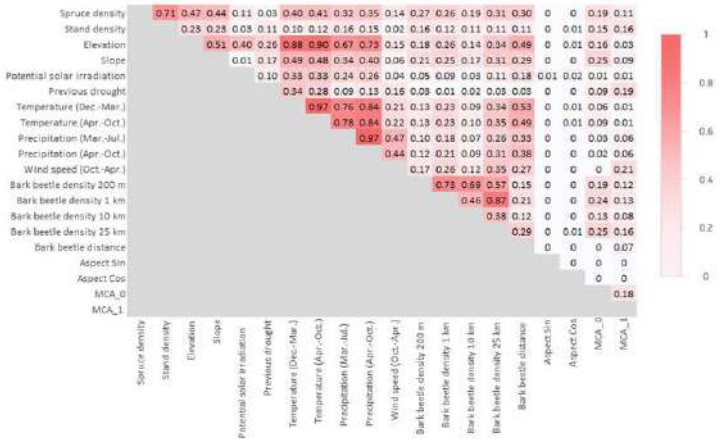
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3. Bark beetle attack predictive model

Final variables

- Spruce density
- Stand density
- Elevation
- Slope
- Aspect Sin
- Aspect Cos
- Potential solar irradiation
- Previous drought
- Temperature: Dec.-Mar. & Apr.-Oct.
- Precipitation: Mar.-Jul. & Apr.-Oct.
- Wind speed Oct.-Apr.)
- Bark beetle density 200 m, 1 km, 10 km & 25 km
- Bark beetle distance
- MCA_0
- MCA_1



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3. Bark beetle attack predictive model

Model selection & tuning

- **ML regression model comparison:**
  - Ordinary Least Squares (OLS)
  - Random Forest (RF)
  - Support Vector Regression (SVR)
  - XGBoost
  - LightGBM
- **Best model**: Random Forest with tuned hyperparameters

Model selection	OLS	RF	SVR	XGBoost	LightGBM
Train r^2	0.25	**0.54**	0.41	0.47	0.48
Test r^2	0.23	**0.55**	0.39	0.47	0.49
Test RMSE	0.46	**0.03**	0.15	0.05	0.03
Test MAE	0.71	**0.10**	0.29	0.14	0.12

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26/01/2024 | Central Europe Demonstration Event

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3. Bark beetle attack predictive model

Feature importance

Gini impurity	Variable	Importance (%)
1	Spruce density	19.94
2	Stand density	15.63
3	Elevation	7.73
4	Bark beetle density 25 km	6.93
5	Bark beetle density 10 km	6.34
6	Slope	4.93
7	Bark beetle density 1 km	4.90
8	Bark beetle distance	4.73
9	Temperature (Dec.-Mar.)	4.63
10	Potential solar irradiation	4.39
11	Aspect Sin	3.32
12	Aspect Cos	3.30
13	Wind speed (Oct.-Apr.)	2.83
14	Previous drought	2.36
15	Precipitation (Mar.-Jul.)	2.33
16	MCA0	2.12
17	MCA1	1.94
18	Bark beetle density 200 m	1.64

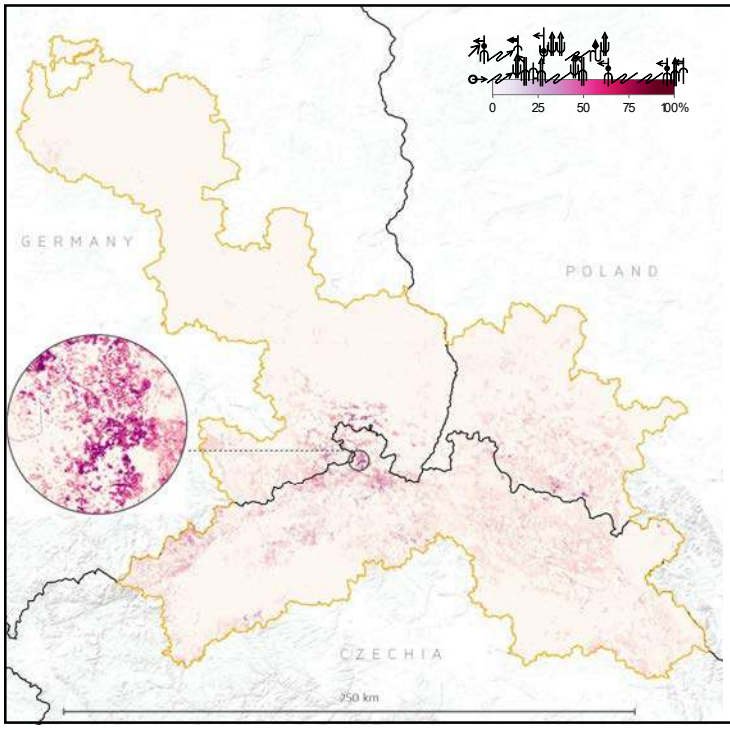
Bark beetle attack

- Forest structure = 35 %
- Previous attacks = 25 %
- Topography = 25 %
- Climate = 10 %
- Other = 5 %

Some important variables were not considered (e.g., **Forest age**)

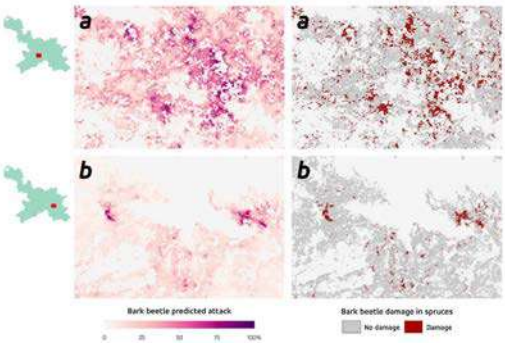
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3. Bark beetle attack predictive model



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3. Bark beetle attack predictive model

Validation

Attack threshold	10%	25%	30%	35%	40%	45%	50%	60%	75%	90%
Accuracy	83.0	92.7	93.9	**94.4**	94.3	94.1	93.6	92.6	90.8	89.4
F1-score	89.6	95.9	96.6	**96.8**	96.8	96.8	96.5	96.0	95.1	94.4
Commission error	18.2	5.5	3.4	**2.0**	1.2	0.7	0.4	0.1	0.0	0.0
Omission error	1.0	2.7	3.5	**4.2**	5.0	5.7	6.4	7.7	9.3	10.6
Relative bias	-17.4	-2.9	0.0	**2.3**	4.0	5.4	6.5	8.2	10.3	11.9

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Conclusions

- Bark beetle attack can be predicted using freely available data
- Semi-automatic pipeline
- Good performance metrics (F1 = 96.8%)
- Low errors (< 5%) and bias
- Feature importance revealed some outbreak triggering factors

- Limitations
  - Some environmental traits should be included (**forest age**)
  - Lack of standard validation data
  - Low resolution of some datasets (climate)

This project has been granted func
the European Union's Horizon 202
and innovation programme

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Thank you for your attention

aafernandez@gmv.com

The Daily Fire Danger Index

A Prototype of a Scalable Fire Danger Index for Europe

Valerio Pampanoni, Giovanni Laneve

School of Aerospace Engineering, Sapienza University, Rome, Italy

26/01/24 | Central European Pilot Site Demonstration Event

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

What is Fire Danger?

- With the term **"Fire Danger"** we refer to the likelihood of fire **ignition and propagation** in a given area at a specific time
- It depends on a number of factors such **as weather conditions**, **fuel status**, **topography…**

Conceptual Fire Risk Integration Scheme

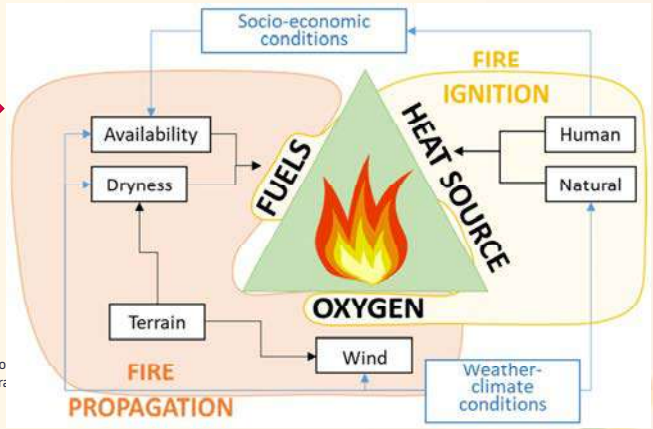


fire — MDPI

Concept Paper

Towards an Integrated Approach to Wildfire Risk Assessment: When, Where, What and How May the Landscapes Burn

Emilio Chuvieco, Marta Yebra, Simone Martino, Kirsten Thonicke, Marta Gómez-Giménez, Jesus San-Miguel, Duarte Oom, Ramona Velea, Florent Mouillot, Juan R. Molina, Ana I. Miranda, Diogo Lopes, Michele Salis, Marin Bugaric, Mikhail Sofiev, Evgeny Kadantsev, Ioannis Z. Gitas, Dimitris Stavrakoudis, George Effychidis, Avi Bar-Massada, Alex Neidermeier, Valerio Pampanoni, M. Lucrecia Pettinari, Fatima Arrogante-Funes, Clara Ochoa, Bruno Moreira and Domingos Viegas



What is Fire Danger?

- With the term **"Fire Danger"** we refer to the likelihood of fire **ignition and propagation** in a given area at a specific time



High Fire Danger → Fire more likely to ignite and propagate

Low Fire Danger → Even if ignited, fire less likely to propagate

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

Why Develop a New Fire Danger Index?

- The **European Forest Fire Information System (EFFIS)** uses a custom version of the Canadian Fire Weather Index (CFWI) as its Fire Danger index of choice
- The CFWI can be calculated using **only weather data**, and consequently it is a **coarse resolution** product
- **The current product is provided at 0.1x0.1 degree resolution (~11 km)**
  - ➢ Reliable, time-tested product
  - ➢ Easy to calculate at large spatial scales
  - ➢ Level of detail insufficient at smaller scales

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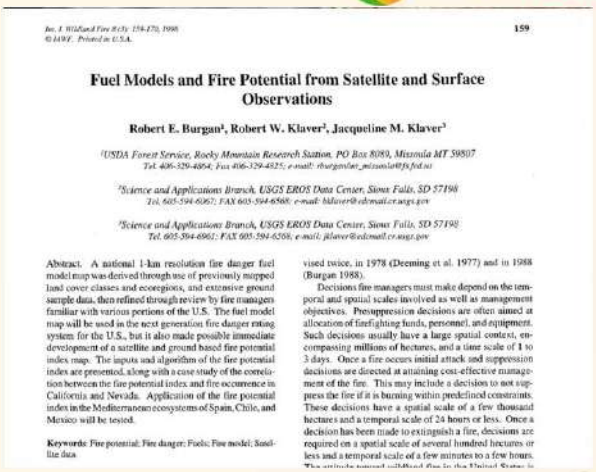
Why a Satellite-Based Danger Index?

A **Satellite-based** Fire Danger Index has many advantages:

- ❑ Global applicability
- ❑ Can incorporate weather data
- ❑ High spatial resolution
- ❑ High update frequency

But pose also some challenges:

- Not trivial to **design**
- Not trivial to **validate**



Int. J. Wildland Fire 8(3): 159-170, 1998 159
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Fuel Models and Fire Potential from Satellite and Surface Observations

Robert E. Burgan[1], Robert W. Klaver[2], Jacqueline M. Klaver[3]

[1]USDA Forest Service, Rocky Mountain Research Station, PO Box 8089, Missoula MT 59807
Tel. 406-329-4854; Fax 406-329-4925; e-mail: rburgan/at_missoula@fs.fed.us

[2]Science and Applications Branch, USGS EROS Data Center, Sioux Falls, SD 57198
Tel. 605-594-6067; FAX 605-594-6589; e-mail: hklaver@edcmail.cr.usgs.gov

[3]Science and Applications Branch, USGS EROS Data Center, Sioux Falls, SD 57198
Tel. 605-594-6961; FAX 605-594-6589; e-mail: jklaver@edcmail.cr.usgs.gov

Abstract. A national 1-km resolution fire danger fuel model map was derived through use of previously mapped land cover classes and ecoregions, and extensive ground sample data, then refined through review by fire managers familiar with various portions of the U.S. The fuel model map will be used in the next generation fire danger rating system for the U.S., but it also made possible immediate development of a satellite and ground based fire potential index map. The inputs and algorithm of the fire potential index are presented, along with a case study of the correlation between the fire potential index and fire occurrence in California and Nevada. Application of the fire potential index in the Mediterranean ecosystems of Spain, Chile, and Mexico will be tested.

Keywords: Fire potential; Fire danger; Fuels; Fire model; Satellite data

vised twice, in 1978 (Deeming et al. 1977) and in 1988 (Burgan 1988).

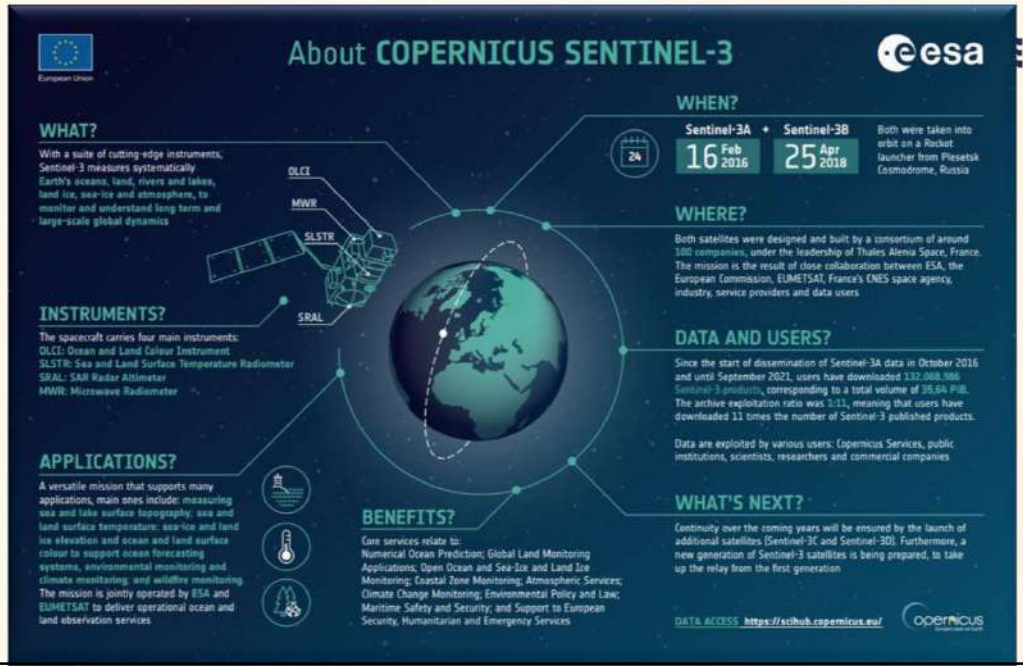
Decisions fire managers must make depend on the temporal and spatial scales involved as well as management objectives. Presuppression decisions are often aimed at allocation of firefighting funds, personnel, and equipment. Such decisions usually have a large spatial context, encompassing millions of hectares, and a time scale of 1 to 3 days. Once a fire occurs initial attack and suppression decisions are directed at attaining cost-effective management of the fire. This may include a decision to not suppress the fire if it is burning within predefined constraints. These decisions have a spatial scale of a few thousand hectares and a temporal scale of 24 hours or less. Once a decision has been made to extinguish a fire, decisions are required on a spatial scale of several hundred hectares or less and a temporal scale of a few minutes to a few hours.

Burgan, et al. 1994

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

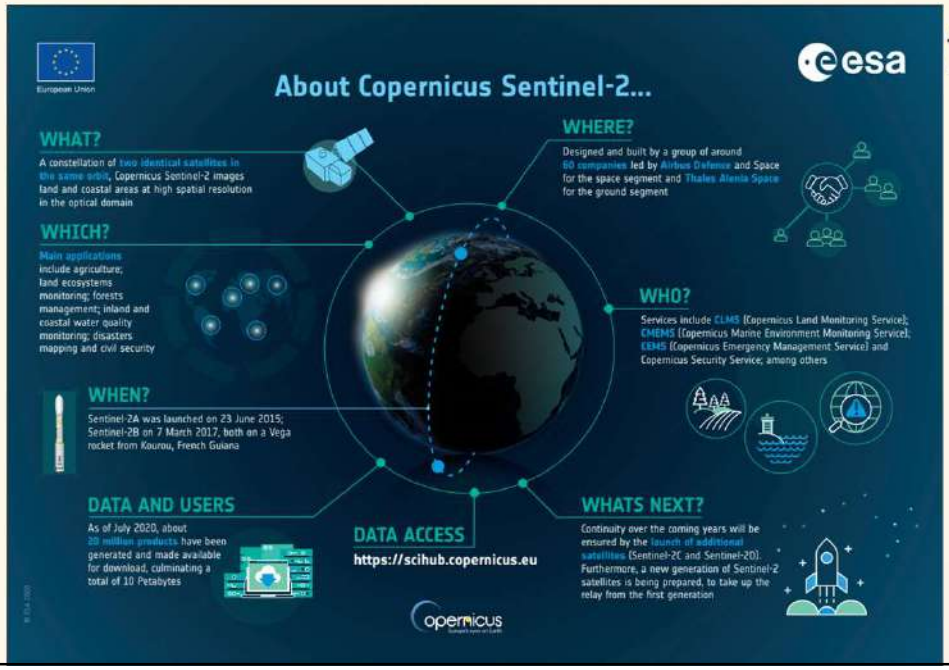
5

Sentinel-2 and Sentinel-3



6

Sentinel-2 and Sentinel-3



7

The DFDI Components

FIRE DANGER VARIABLES

- STATIC
  - TERRAIN VARIABLES: ELEVATION, SLOPE, ASPECT
  - VEGETATION CHARACTERISTICS: LAND COVER MAP, FUEL MAP
- DYNAMIC
  - VEGETATION STATUS AND STRESS: VEGETATION GREENNESS, DEAD FUEL MOISTURE, LIVE FUEL MOISTURE, EVAPOTRANSPIRATION
  - WEATHER VARIABLES: AIR TEMPERATURE, RELATIVE HUMIDITY, WIND SPEED, PRECIPITATION

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

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The Variables of Fire Danger: Vegetation Greenness

- Measures the **amount** and the health of the vegetation in a given pixel using long timeseries of satellite observations

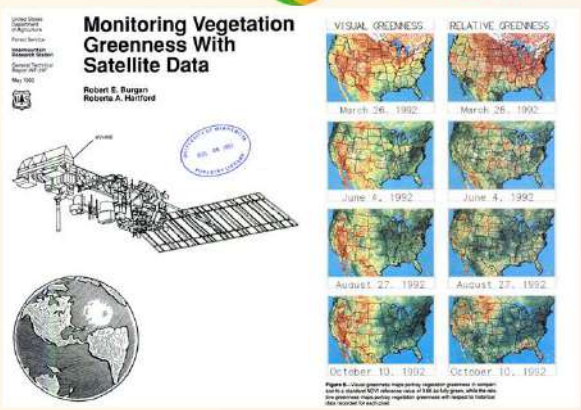
Low Vegetation Greenness

↓

More fuel for the fire to burn

↓

High Fire Danger



Burgan, Hartford 1993

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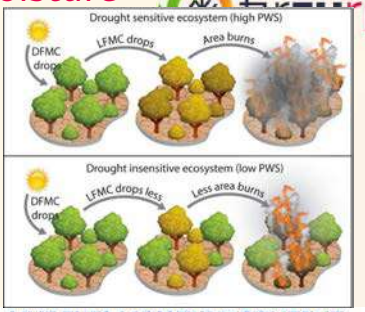
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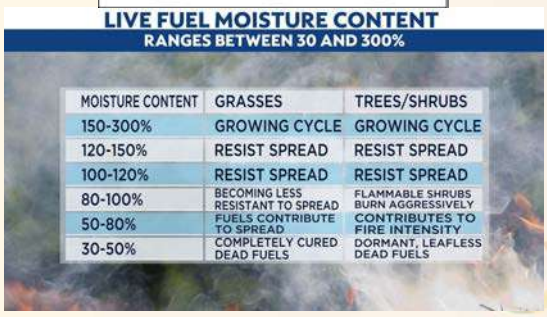
The Variables of Fire Danger: Live Fuel Moisture

Live Fuel Moisture Content has an important role in determining the nature of the interaction of fire with live fuels:

- Fire **Ignition** (will the fire start?)
- Fire **Severity** (how strong will the fire be?)
- Fire **Spread** (how fast will the fire spread?)

➢ Difficult to estimate





This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

The Variables of Fire Danger: Dead Fuel Moisture

- The **accumulation of dead fuels** (dead trees, branches, leaves, shrubs…) play a crucial role in determining the probability of ignition in a certain area
- Their **moisture content** is related to the **weather conditions** (temperature, humidity…)
- Easier to estimate

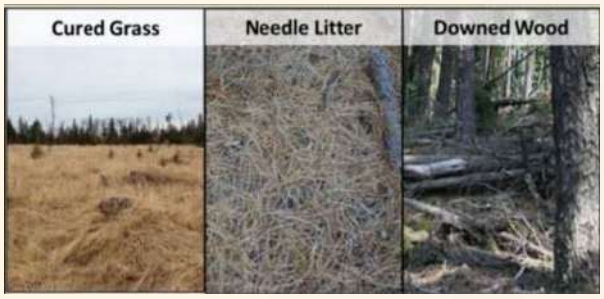
Very Dry Dead Fuels

↓

Fire more likely to ignite and propagate

↓

High Fire Danger



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

11

The Variables of Fire Danger: Evapotranspiration

- **Evapotranspiration** is the combination of the processes of **evaporation** and **transpiration**, in which water is lost by the soil surface and by the vegetation
- It can be used as a measure of the **hydric stress** of the vegetation
- It is related to the **topography**, to the **weather** and to the amount of **sunlight** that reaches the surface

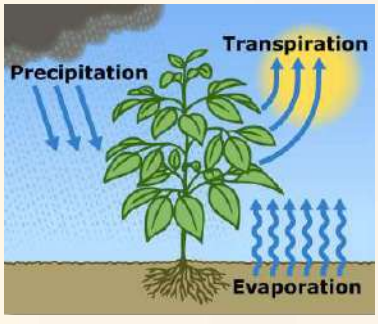
High Evapotranspiration

↓

Very stressed vegetation

↓

High Fire Danger



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

12

The Variables of Fire Danger: Wind Speed

Wind can have many **dangerous interactions** with fire:

- Provide **oxygen** for the fire to burn
- Pre-heats fuel and **reduces moisture**
- Scatter smouldering ashes and start more fires

Strong Winds

↓

Easier fire propagation

↓

High Fire Danger



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

13

The DFDI Model

$$DFDI = f_1(1 - \overline{LFMC}) + f_2(1 - L_f) + f_3(1 - TN_f) + f_4\bar{w} + f_5\overline{Et_0}$$

- $\overline{LFMC}$ is the historical minmax normalized **LFMC** value
- L_f is the **fraction of live vegetation**
- TN_f is the fractional **moisture** of the **10-hour timelag fuels** (i.e. small dead fuels)
- $\bar{w}$ is the historical minmax normalized **wind speed** at 2 meters height
- $\overline{Et_0}$ is the historical minmax normalized reference **evapotranspiration**
- f_i are the parameter weights

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

14

DFDI Calibration

- The DFDI coefficients are calibrated using a **Random Forest** model fitted onto **historical wildfire records**
- The values of the fire weather variables are linked with the **forest fire radiative power** measured by satellites in order to understand which variables play a more important role in a given region
- **Fewer fires in northern Europe → less data for calibration**

Site/Coefficient	LFMC (f_1)	RG (f_2)	TN_f (f_3)	W (f_4)	ET_0 (f_5)
DA4 (Sardinia)	12	19	37	22	10
PS3 (Central Portugal)	17	17	17	28	21
PS2 (Central Europe)	**42**	**11**	**12**	**5**	**31**

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

15

Bohemian Switzerland National Park Wildfire


mdr NACHRICHTEN & THEMEN MEDIATHEK & TV AUDIO & RADIO Suchen

Sachsen Sachsen-Anhalt Thüringen Deutschland Welt Sport Leben Kultur Wissen

MDR.DE › Nachrichten › Sachsen › Region Dresden › Freital und Pirna

TICKER AM DIENSTAG

Waldbrände in Tschechien, Brandenburg und Sachsen: 250 Hektar Wald in Sächsischer Schweiz in Flammen

26. Juli 2022, 22:29 Uhr

ARTIKEL HÖREN

Seit Sonntag brennt es in der Böhmischen Schweiz in Tschechien. Inzwischen hat sich das Feuer deutlich ausgebreitet - auch im Nationalpark Sächsische Schweiz kämpfen Einsatzkräfte gegen den Waldbrand. An der Landesgrenze zu Brandenburg stehen Wald und Felder hektarweise in Flammen. Wir halten Sie mit unserem News-Ticker über alle Entwicklungen auf dem Laufenden!

- Dorf **Vysoká Lípa wird evakuiert**
- **Bundeswehr schickt Hubschrauber nach Sachsen** und Brandenburg
- **Acht Häuser in Mezná** abgebrannt

TEILEN

- Wildfire started on the **24th of July 2022** at the German-Czech border
- More than 1000 ha destroyed

16

Bohemian Switzerland National Park Wildfire

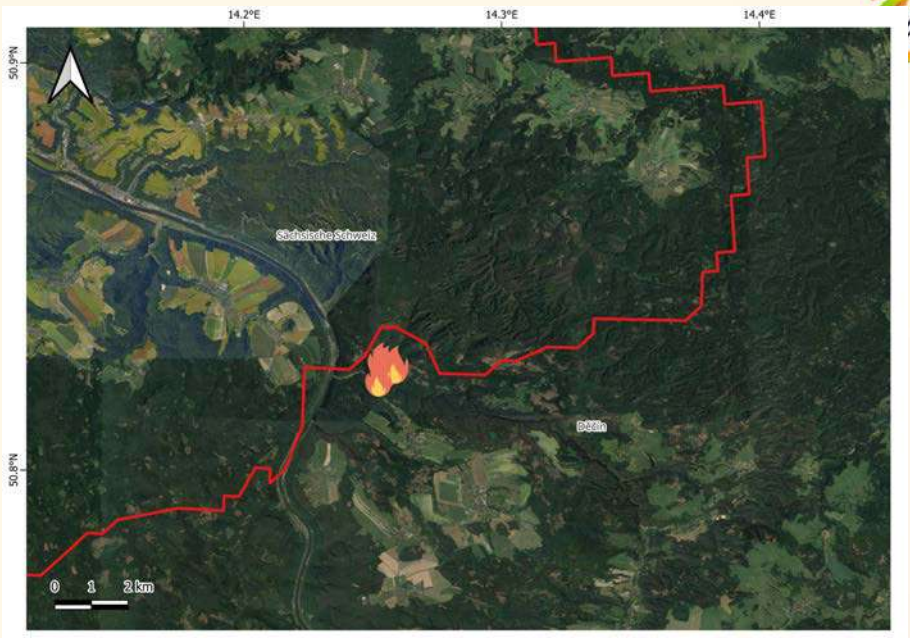


Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite between the 24th and the 29th of July 2022

17

Bohemian Switzerland National Park Wildfire

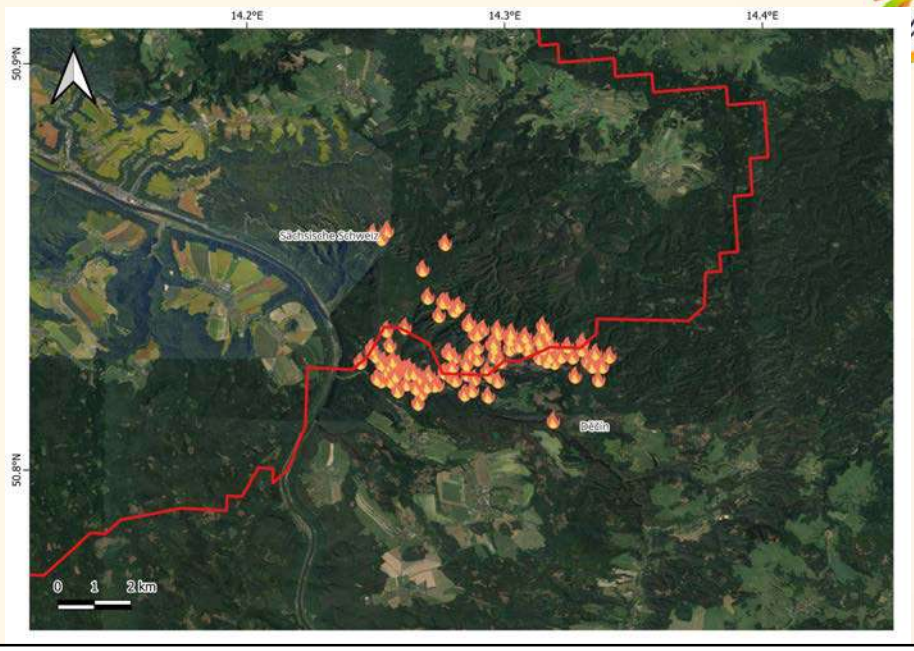


Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite on the 24th (first ignitions)

18

Bohemian Switzerland National Park Wildfire



Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite between the 24th and the 29th of July 2022

19

Fire Weather Index (EFFIS) Sample



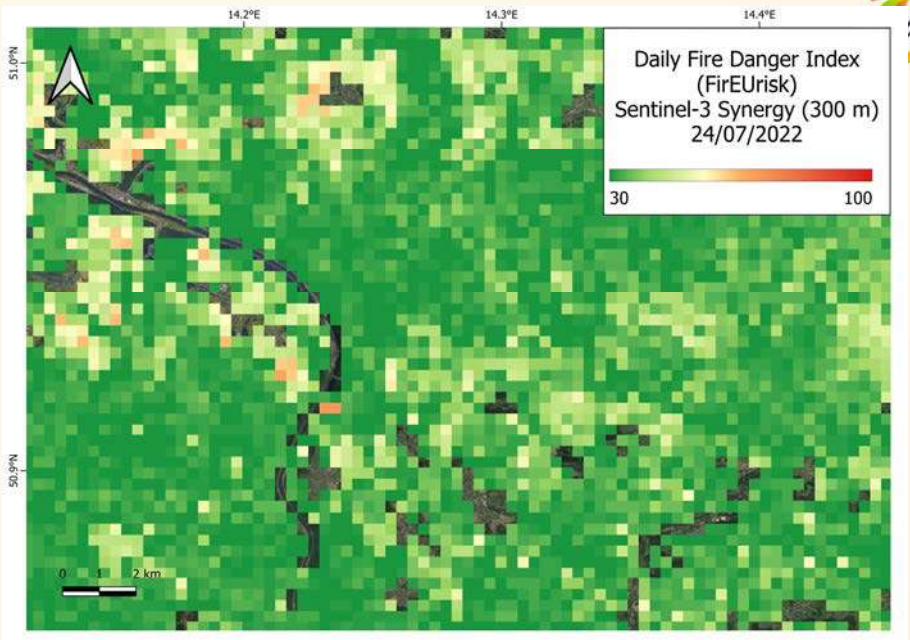
FWI on the 24th of July 2022, Day of the Bohemian Switzerland Fire

Source: **Fire danger indices historical data (ECMWF)**

Resolution: **0.1x0.1 degrees**

20

Daily Fire Danger Index Sample (Not Validated)



DFDI on the 24th of July 2022, Day of the Bohemian Switzerland Fire

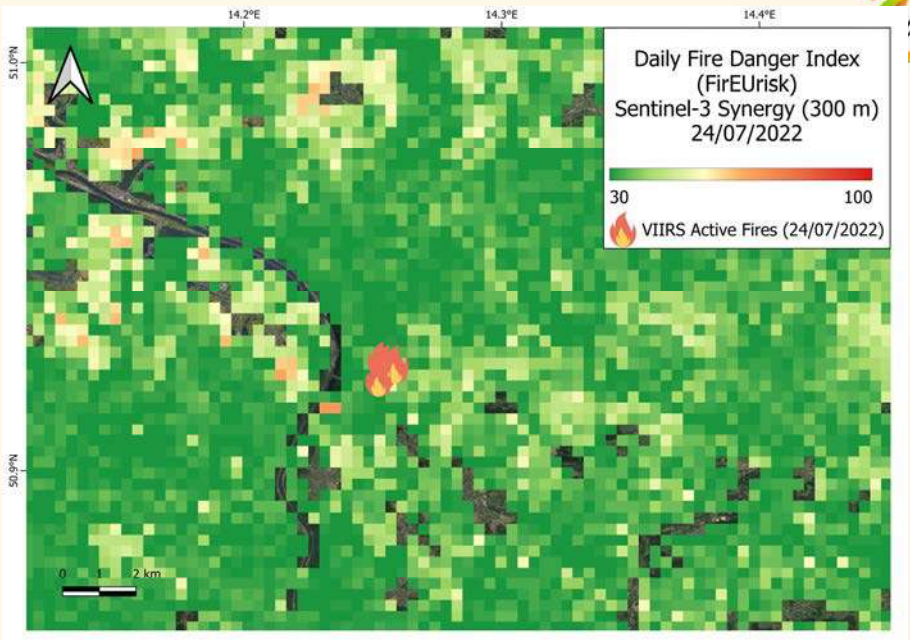
Source:
FirEURisk (SIA)

Satellite:
Sentinel-3

Resolution:
300x300 m

21

Daily Fire Danger Index Sample (Not Validated)



DFDI on the 24th of July 2022, Day of the Bohemian Switzerland Fire

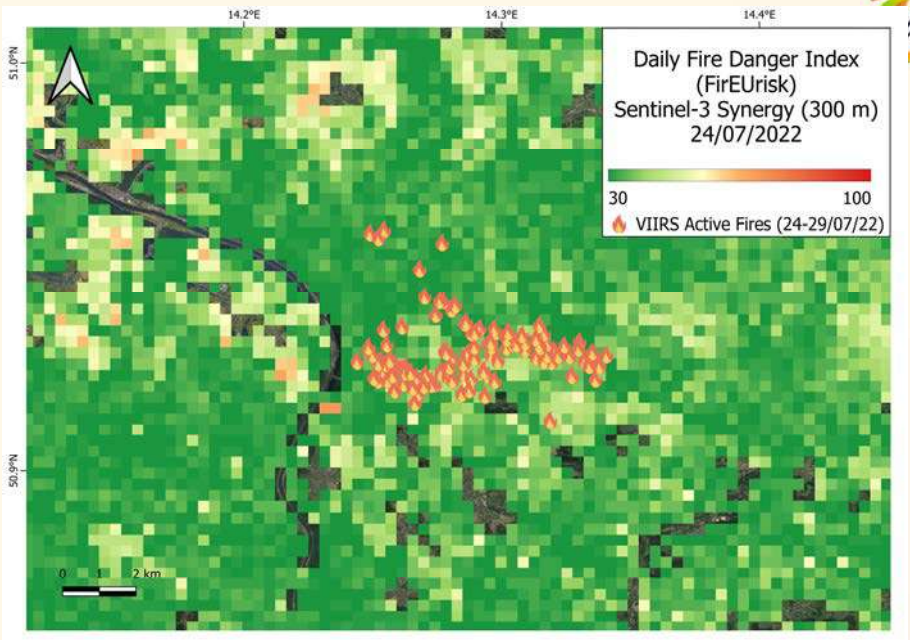
Source:
FirEURisk (SIA)

Satellite:
Sentinel-3

Resolution:
300x300 m

22

Daily Fire Danger Index Sample (Not Validated)



DFDI on the 24th of July 2022, Day of the Bohemian Switzerland Fire

Source:
FirEUrisk (SIA)

Satellite:
Sentinel-3

Resolution:
300x300 m

23

Conclusions and Future Efforts

- Exploiting European Satellite platforms can result in Fire Danger Products with dramatically **better resolution** than the current ones
- The **resolution can be scaled** depending on the needs of the user
  - Regional/National Scale → 300x300 m (Sentinel-3)
  - Local Scale → 10x10 m (Sentinel-2)
- High-Resolution Fire Danger Products can be used to **target the WUI**
- Need more data to calibrate/validate DFDI in Northern Europe, or a new validation procedure

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

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For inquiries send an email to

valerio.pampanoni@uniroma1.it



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

Live Fuel Moisture Content
For the European Territory
A new Product Based on Sentinel-3 Images

Valerio Pampanoni, Giovanni Laneve
School of Aerospace Engineering, Sapienza University, Rome, Italy

26/01/24 | Central European Pilot Site Demonstration Event

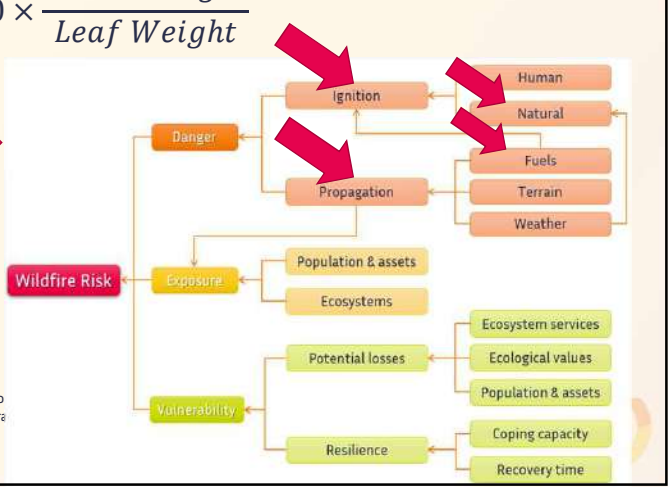
This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

What is Live Fuel Moisture Content?

- **Live Fuel Moisture Content** is defined as the weight ratio between leaf water content and dry matter:

$$LFMC_{\%} = 100 \times \frac{Water\ Weight}{Leaf\ Weight}$$

Conceptual Fire Risk Integration Scheme




fire MDPI
Concept Paper
Towards an Integrated Approach to Wildfire Risk Assessment: When, Where, What and How May the Landscapes Burn

What is Live Fuel Moisture Content?

Live Fuel Moisture Content has an important role in determining the nature of the **interaction of fire with live fuels**:

- Fire **Ignition** (will the fire start?)
- Fire **Severity** (how strong will the fire be?)
- Fire **Spread** (how fast will the fire spread?)

Hence, the strong interest in **measuring** or **estimating** LFMC

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

3

How do we Measure LFMC?

- Live Fuel Moisture Content can be directly measured *in situ* using **gravimetric techniques**:

$$LFMC_{\%} = 100 \times \frac{Fresh\ Weight\ - Dry\ Weight}{Dry\ Weight}$$







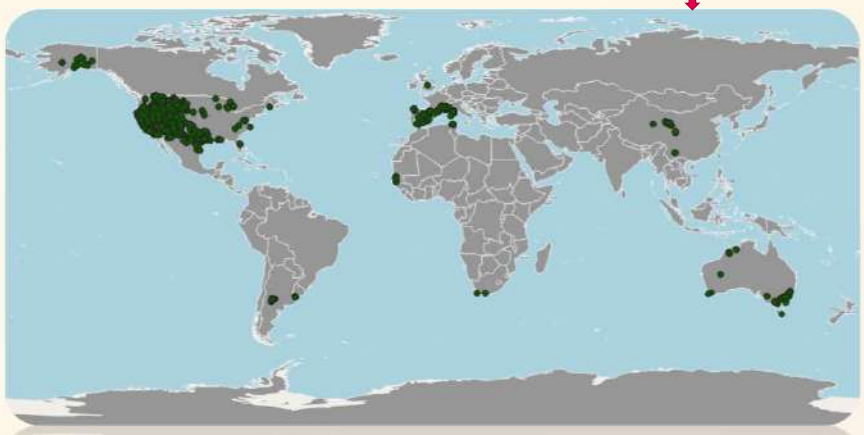


This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

4

How do we estimate it?

- Machine Learning not the solution to all problems



Spatial Distribution of Globe-LFMC v2 datasets

Vast majority concentrated in:

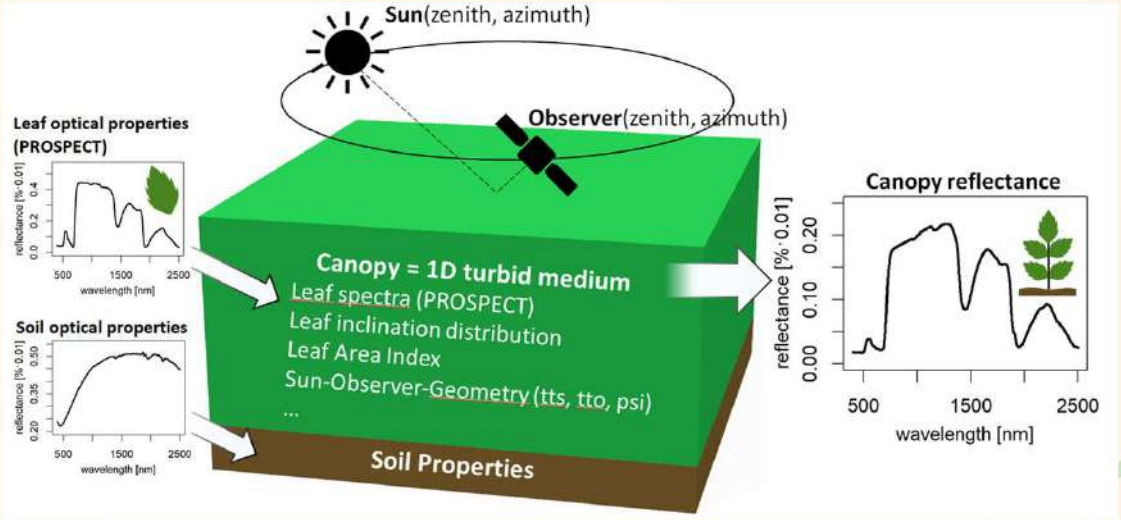
- **USA**
- **Med. Europe**
- **Australia**

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no.101003890

5

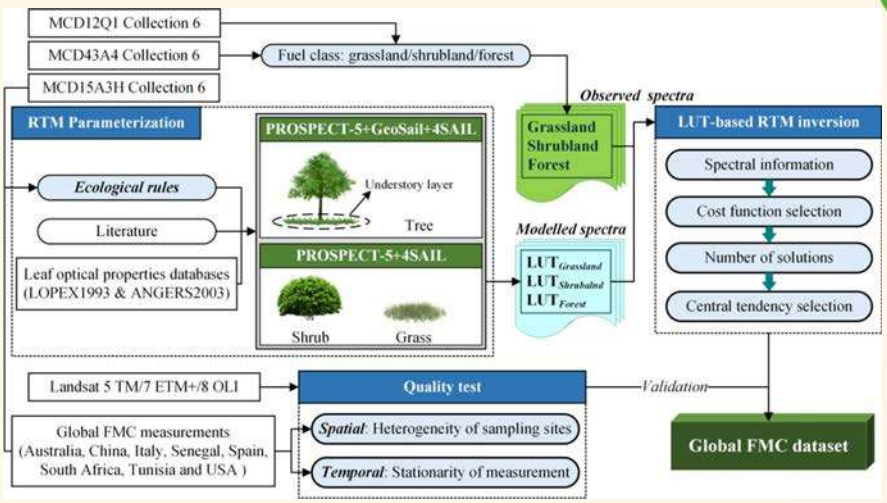
The Radiative Transfer Model

PROSPECT (leaf model) + SAIL (canopy model)



6

Theoretical Basis



Quan, Yebra, Riano, He, Lai, Hu

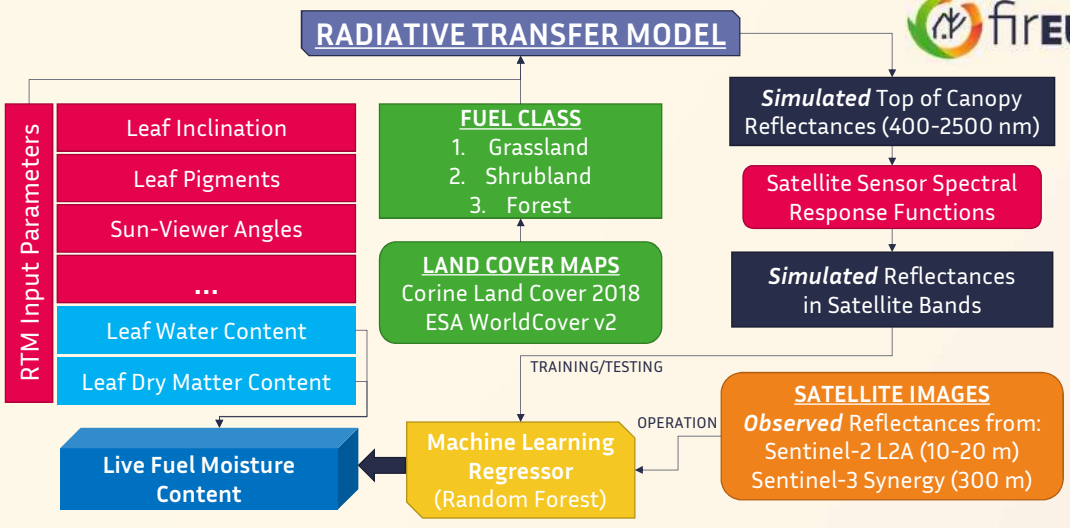
International Journal of Applied Earth Observations and Geoinformation

"Global Fuel Moisture Content Mapping from MODIS"

2021

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

LFMC Inversion Scheme: RTM foundation + ML Inversion

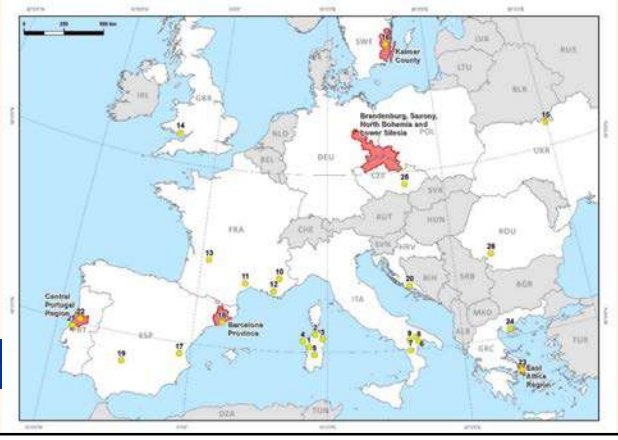


This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

Scope of the Product

- The product was originally developed in A1.1.1 for all the Pilot Sites, but later extended to cover the entire **European Territory**
- Daily product with highest-quality observations in the last 10-days

FirEURisk "Pilot Sites"

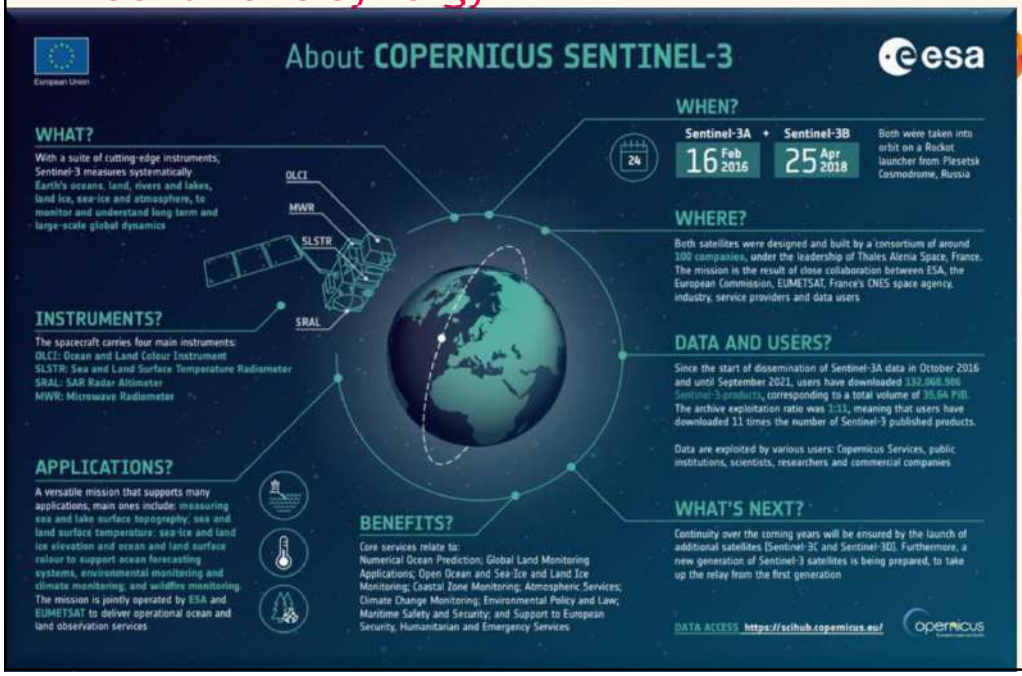


FirEURisk "European Territory"



9

Sentinel-3 Synergy



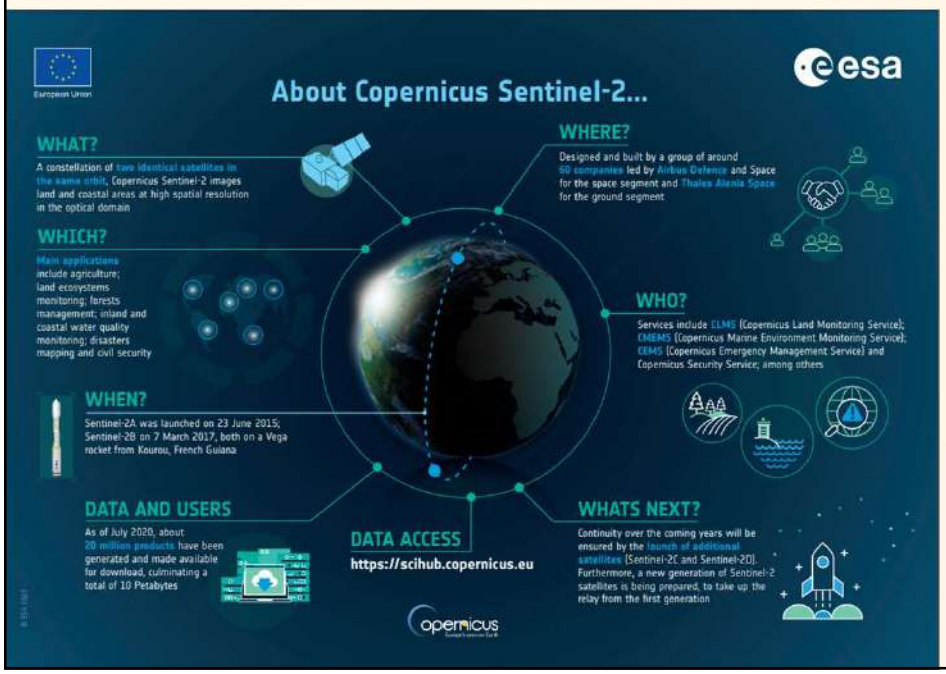
European Territory

300x300 m resolution

Revisit Time < 2d

10

Sentinel-2 L2A



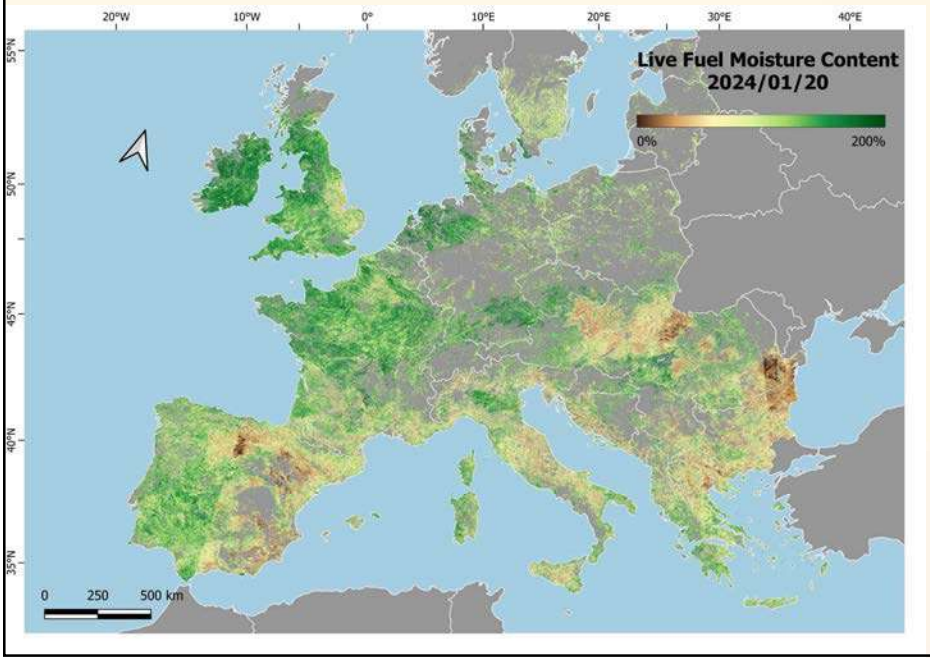
Local Scale, WUI

10x10 m resolution

Revisit Time ~ 5d

11

S3 Product Sample (January 2024)



European Territory

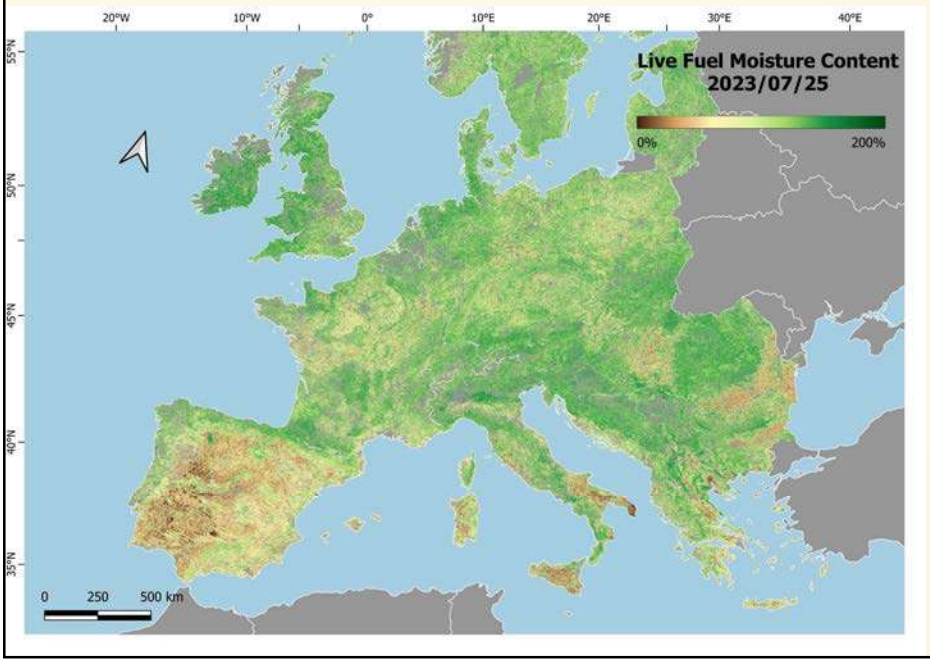
300x300 m resolution

20 Jan 2024

(Best observations from previous 10 days)

12

S3 Product Sample (July 2023)



European Territory

300x300 m resolution

25 July 2023

(Best observations from previous 10 days)

13

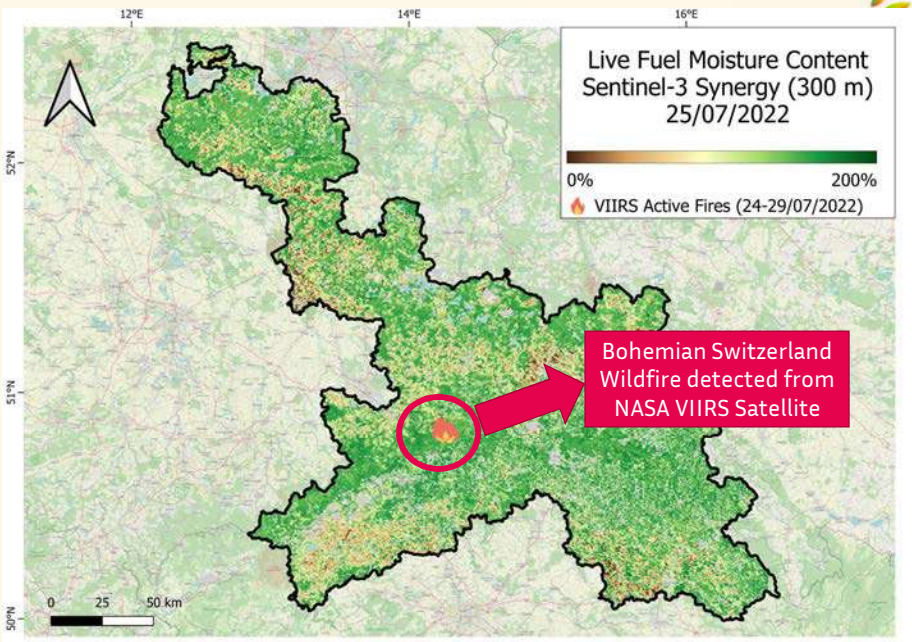
Bohemian Switzerland National Park Wildfire



- Wildfire started on the **24th of July 2022** at the German-Czech border
- More than 1000 ha destroyed

14

Bohemian Switzerland National Park Wildfire

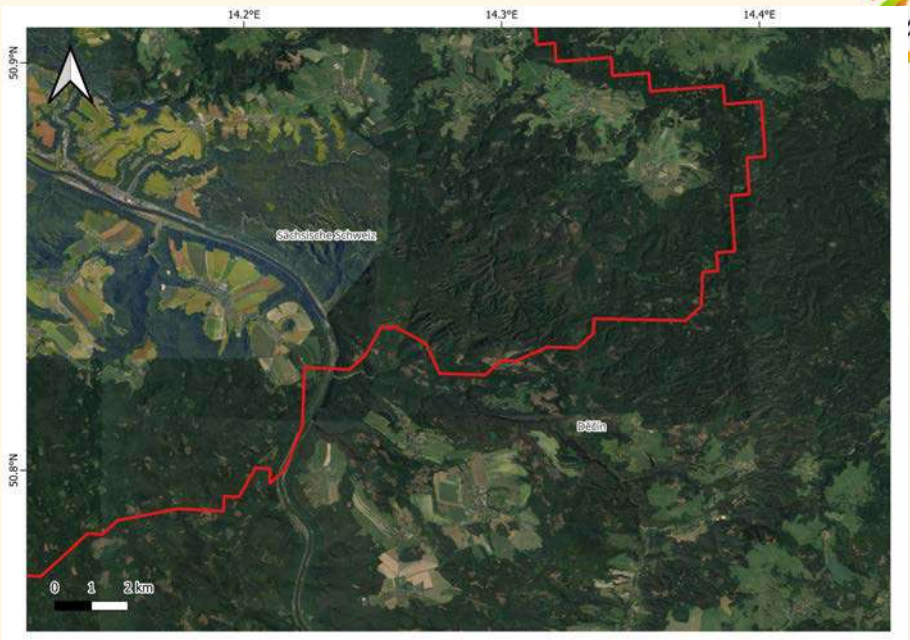


Bohemian Switzerland Wildfire

LFMC in the FirEUrisk Central European Pilot Site (PS2) on the 24th of July 2022

15

Bohemian Switzerland National Park Wildfire



Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite between the 24th and the 29th of July 2022

16

Bohemian Switzerland National Park Wildfire

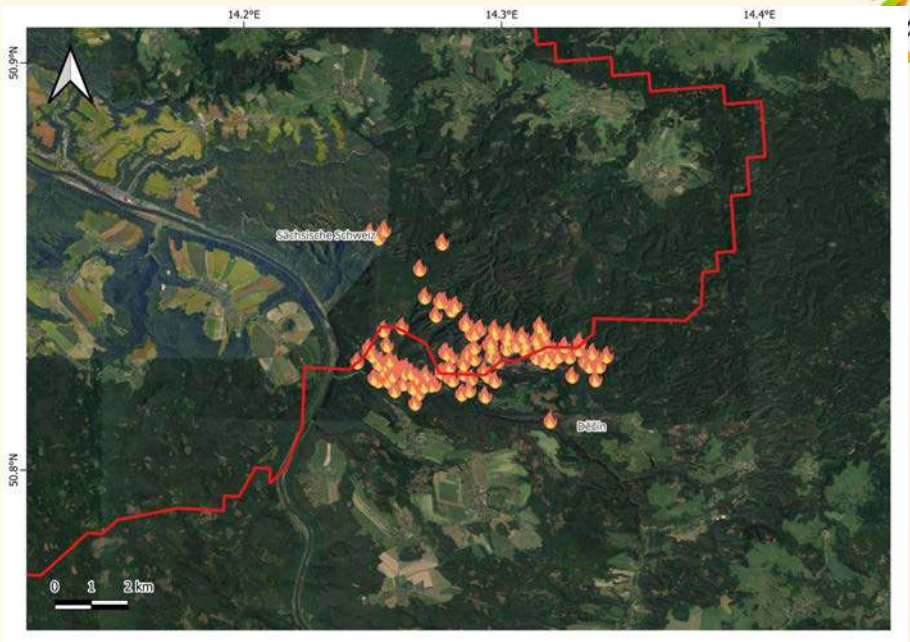


Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite on the 24th (first ignitions)

17

Bohemian Switzerland National Park Wildfire

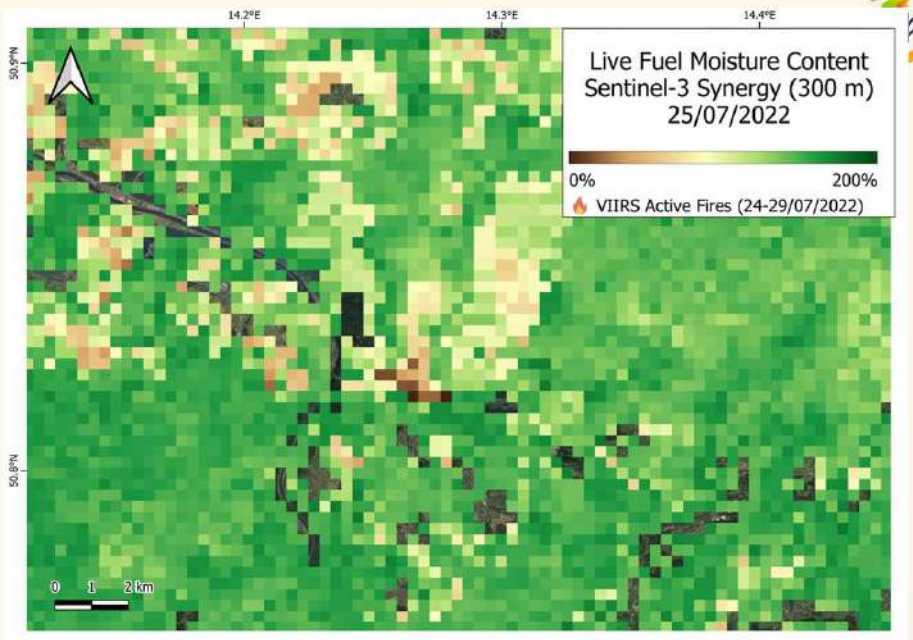


Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite between the 24th and the 29th of July 2022

18

Bohemian Switzerland National Park Wildfire

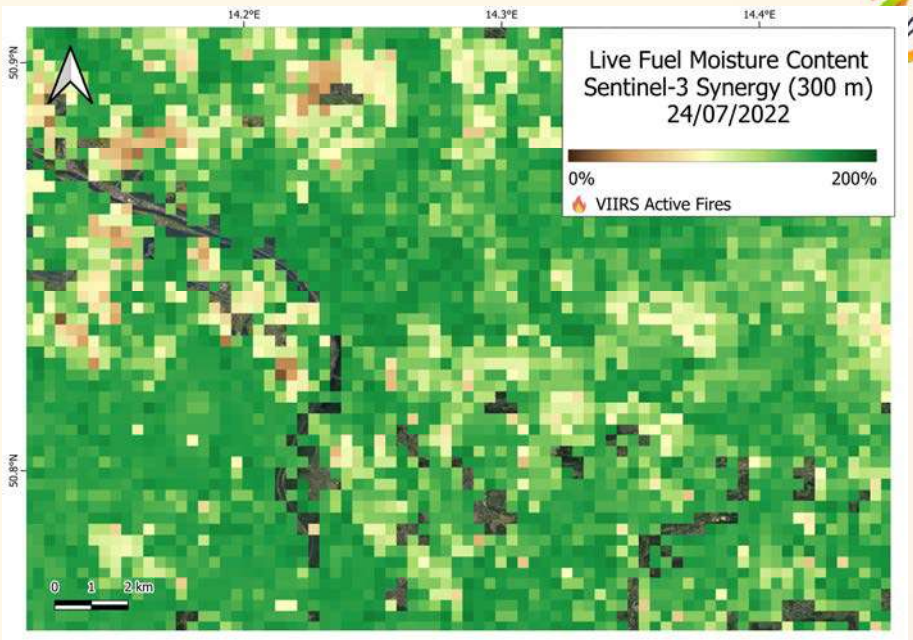


Bohemian Switzerland Wildfire

LFMC estimated using the Sentinel-3 acquisition of the 25th of July

19

Bohemian Switzerland National Park Wildfire

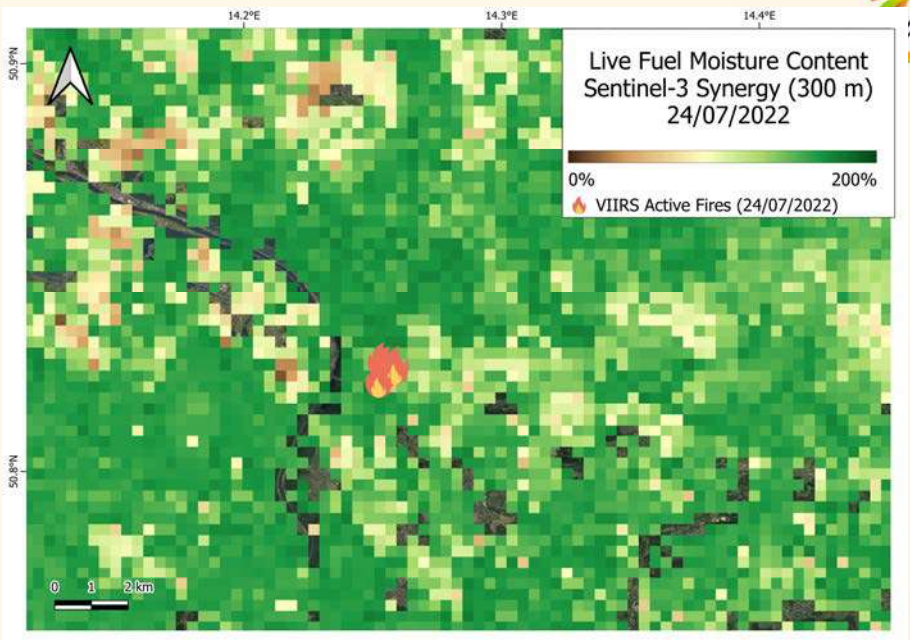


Bohemian Switzerland Wildfire

LFMC estimated using the Sentinel-3 image of the 24th of July

20

Bohemian Switzerland National Park Wildfire

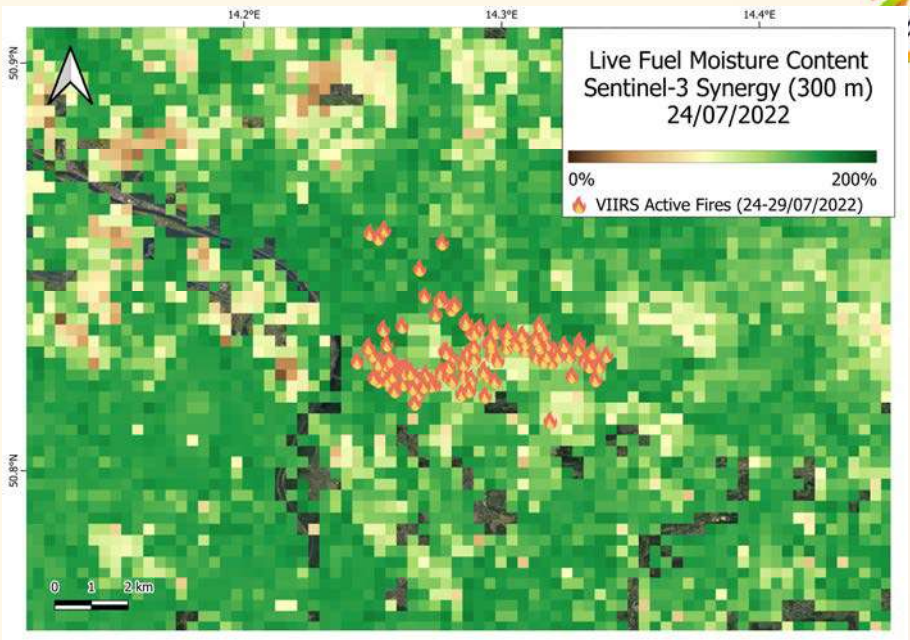


Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite on the 24th of July 2022 (first ignitions)

21

Bohemian Switzerland National Park Wildfire

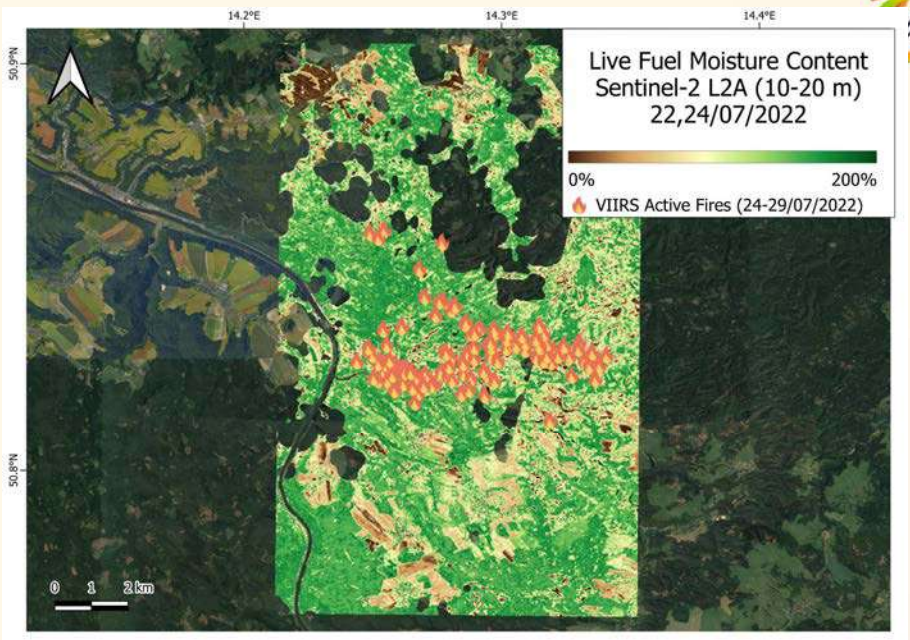


Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite between the 24th and the 29th of July 2022

22

Bohemian Switzerland National Park Wildfire



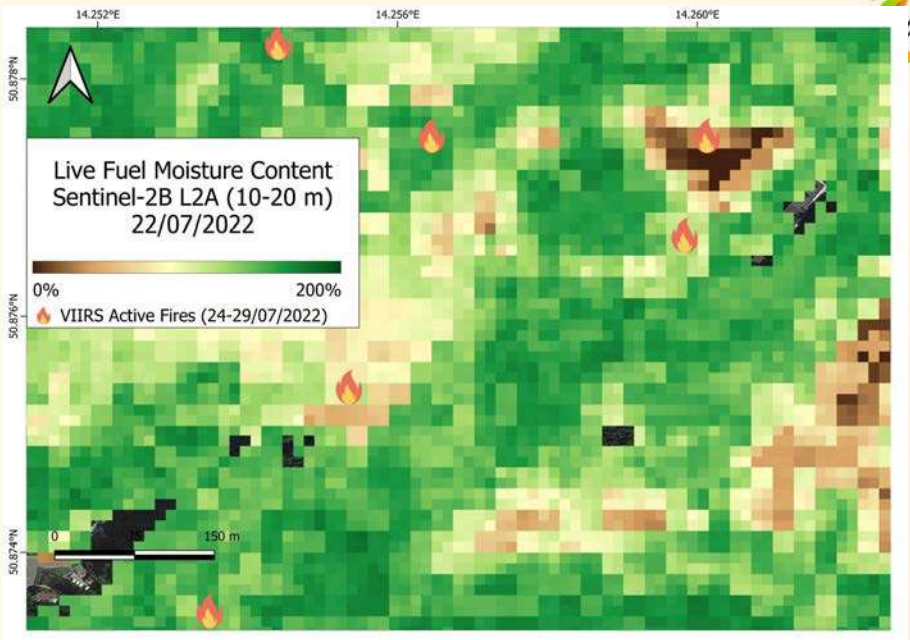
Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite between the 24th and the 29th of July 2022

LFMC estimated using Sentinel-2 images of the 22nd and 24th of July 2022

23

Bohemian Switzerland National Park Wildfire



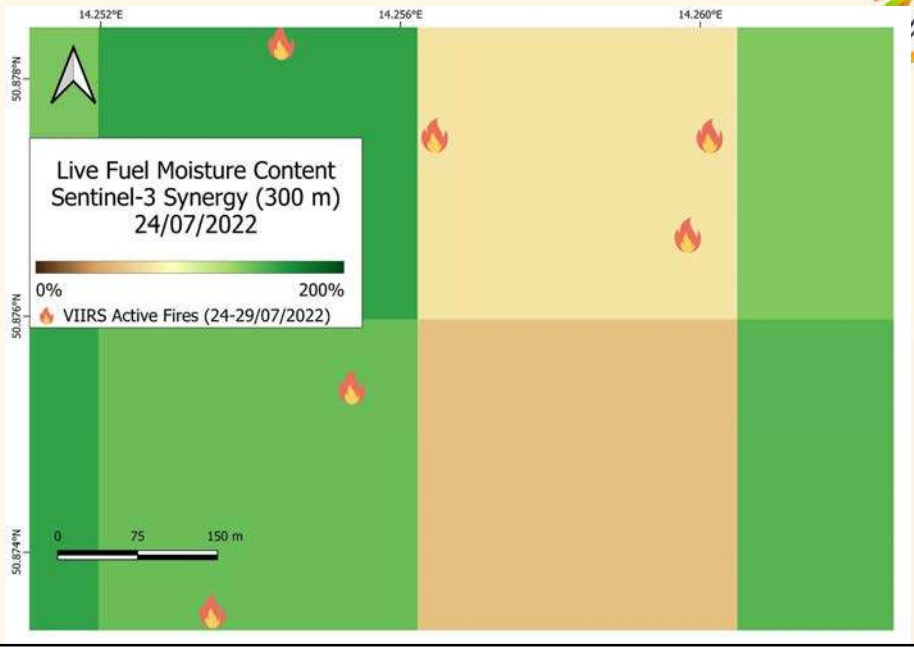
Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite on the 24th of July 2022

LFMC estimated using the Sentinel-2B image of the 22nd of July 2022

24

Bohemian Switzerland National Park Wildfire

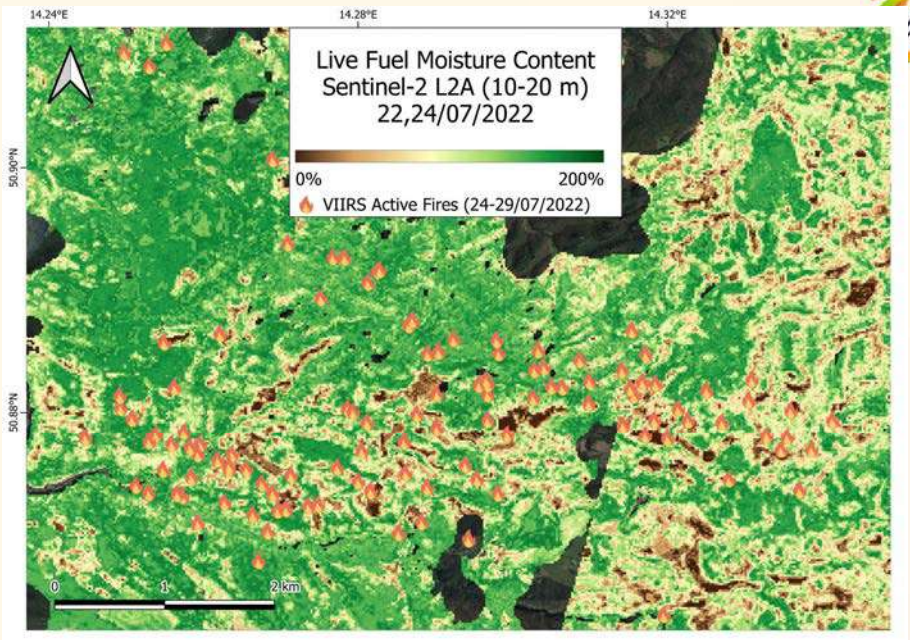


Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite between the 24th and the 29th of July 2022

25

Bohemian Switzerland National Park Wildfire

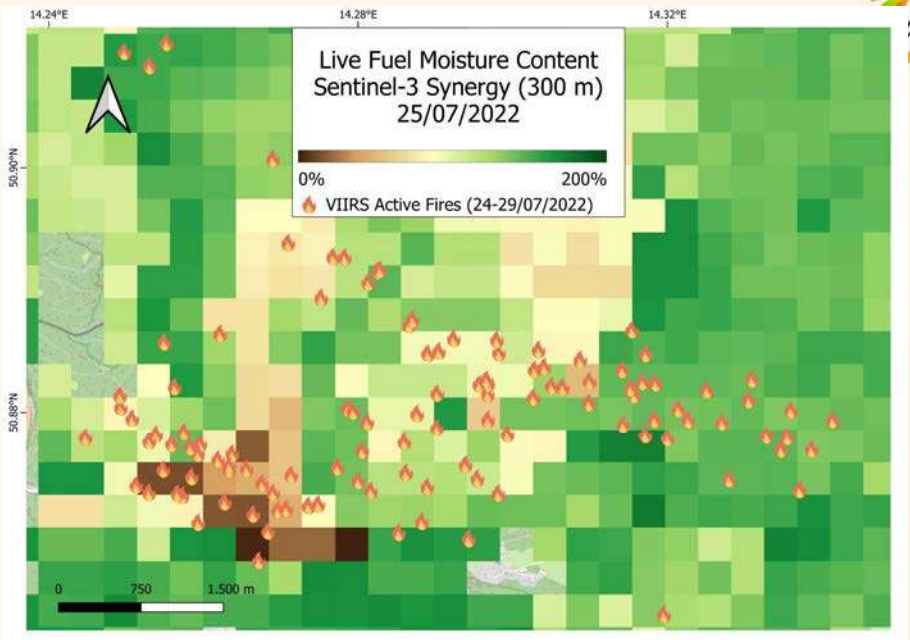


Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite between the 24th and the 29th of July 2022

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Bohemian Switzerland National Park Wildfire



Bohemian Switzerland Wildfire

Active Fires as seen from the NASA VIIRS Satellite between the 24th and the 29th of July 2022

27

Product Validation (ongoing)



Pampanoni, Laneve, Viegas, Alves, Ribeiro, Pellizzaro, Bacciu, Ventura

IGARSS 2023, Pasadena, CA, United States

"Early Validation of a Live Fuel Moisture Content Product based on Sentinel-2 and Sentinel-3 Images"

2023

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

28

Product Validation (PS3, Portugal, Coimbra)

Data provided by ADAI

Good Correspondence with:

- ***Pinus pinaster***
- ***Chamaespartium tridentatum***
- ***Calluna vulgaris***

No correspondence with:

- ***Eucalyptus globulus***

Pampanoni, Laneve, Viegas, Alves, Ribeiro, Pellizzaro, Bacciu, Ventura

IGARSS 2023, Pasadena, CA, United States

"Early Validation of a Live Fuel Moisture Content Product based on Sentinel-2 and Sentinel-3 Images"

2023

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

29

Product Validation (PS3, Portugal, Coimbra)

Data provided by CNR

Very good correspondence with:

- ***Species average***

Good correspondence with:

- ***Juniperus phoenicae***

Pampanoni, Laneve, Viegas, Alves, Ribeiro, Pellizzaro, Bacciu, Ventura

IGARSS 2023, Pasadena, CA, United States

"Early Validation of a Live Fuel Moisture Content Product based on Sentinel-2 and Sentinel-3 Images"

2023

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

30

Next Steps

- **Global Validation** of Sentinel-2 and Sentinel-3 Products
  - Will incorporate new data acquired in **Saxony** by TUD
  - Will incorporate data in Southern France provided by IRD
  - Will expand using external datasets (GlobeLFMC v2)
  - ➢ **Results will be published**
- Dataset will be publicly available through the FirEUrisk platform and the FirEUrisk viewer

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

For inquiries send an email to

valerio.pampanoni@uniroma1.it

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

A metric capturing dead fuel moisture and atmospheric instability

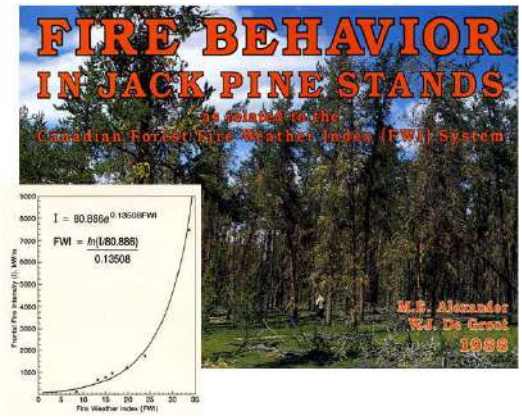
UdL Team

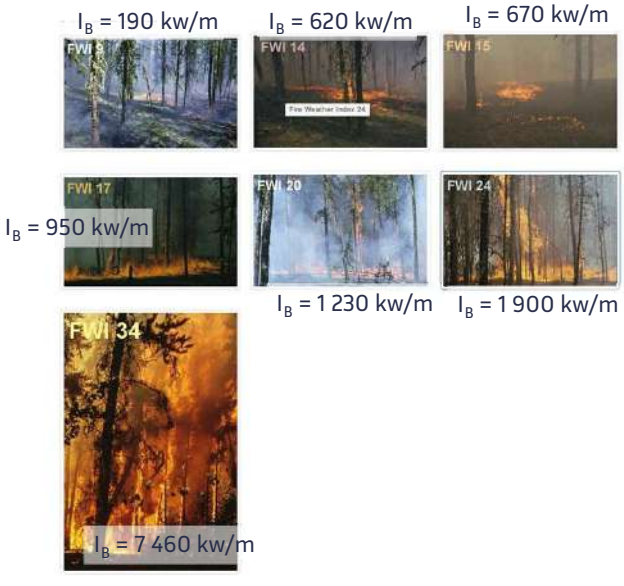
26/01/2024 | EU integrated wildfire prevention strategy

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

FWI

- *Pinus banksiana* (Canada)



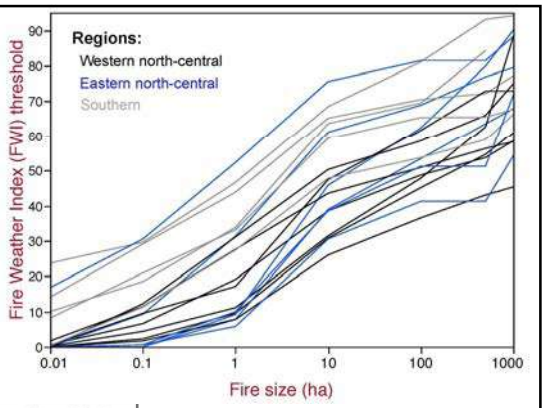


Examples FWI-PT

- FWI: ISI y BUI
- FWI =38->FLI >10,000kw/m

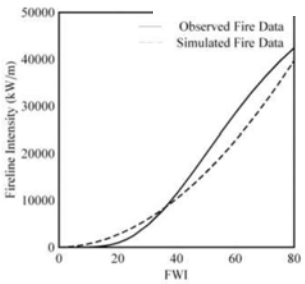
P. pinaster in PT

Lots of regional variability



Fernandes et al 2019

Figure 8. Fireline intensity v simulated fire data.



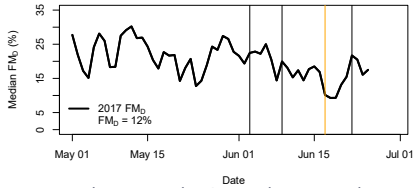
Palheiro y Fernandes

Pedrogao Grande 2017



Weather station	Elevation (m.a.s.l)	Distance and bearing from fire (Km, cardinal points)	FWI	FWI percentile
Ansião	405	22 (WSW)	36.0	73
Proença-a-Nova	379	36 (SE	48.8	83
Pampilhosa da Serra	890	29 (ENE)	54.5	92
Lousã	195	22 (NW)	39.5	88
Tomar	75	44 (SSE)	38.7	66

A model of dead fuel mioisture based on VPD (FM_D) showed unprecedented values:



Boer, Nolan, Resco de Dios et al. 2017. Earth's Future

Pedrogao Grande 2017

Earth's Future

Commentary | Open Access

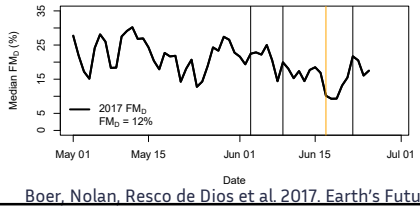
Changing Weather Extremes Call for Early Warning of Potential for Catastrophic Fire

Matthias M. Boer, Rachael H. Nolan, Víctor Resco De Dios, Hamish Clarke, Owen F. Price, Ross A. Bradstock

First published: 22 December 2017 | https://doi.org/10.1002/2017EF000657 | Citations: 49



A model of dead fuel mioisture based on VPD (FM_D) showed unprecedented values:



Boer, Nolan, Resco de Dios et al. 2017. Earth's Future

Rationale - MEDEU Pyroregions

fireurisk

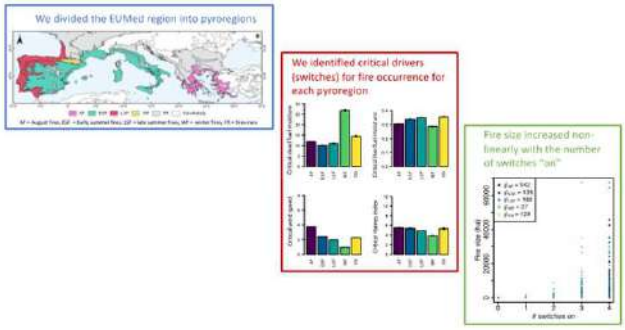
Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Convergence in critical fuel moisture and fire weather thresholds associated with fire activity in the pyroregions of Mediterranean Europe

Víctor Resco de Dios [a,b,c,*], Àngel Cunill Camprubí [c], Núria Pérez-Zanón [d], Juan Carlos Peña [e,f], Edurne Martínez del Castillo [g,h], Marcos Rodrigues [b], Yinan Yao [a,**], Marta Yebra [i,j], Cristina Vega-García [k], Matthias M. Boer [m]



This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

6

LFMC database development

https://zenodo.org/record/6784663#.YzvnQS8Rqkw

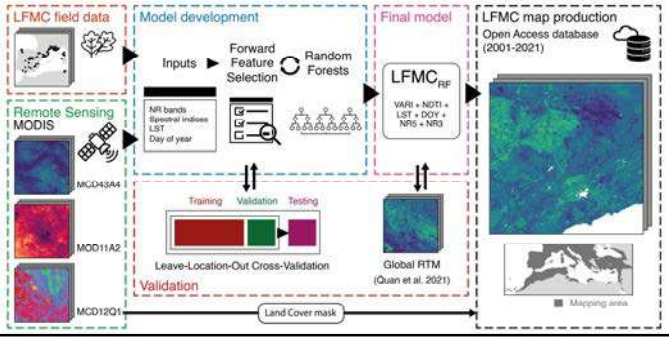
remote sensing

MDPI

Article

Live Fuel Moisture Content Mapping in the Mediterranean Basin Using Random Forests and Combining MODIS Spectral and Thermal Data

Àngel Cunill Camprubí [1,2,*], Pablo González-Moreno [3] and Víctor Resco de Dios [1,2,4]



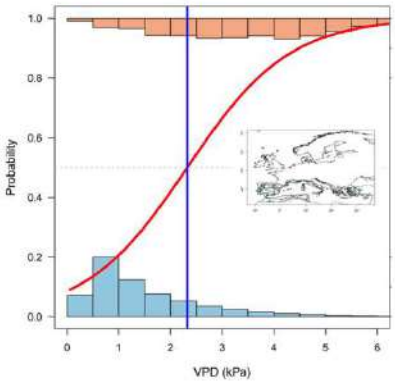
Method	Fuel Type	Variables	Filter *	MBE (%)	MAE (%)
EXT	All	Selp	NF	2.75	13.05
	Forests			7.40	13.57
	Savannas			1.63	13.16
	Shrublands			−4.62	12.08
	Grasslands			0.86	8.58

Fire-days

fireurisk

d Europe

Mediterranean Forests, Woodlands & Scrub



nature communications

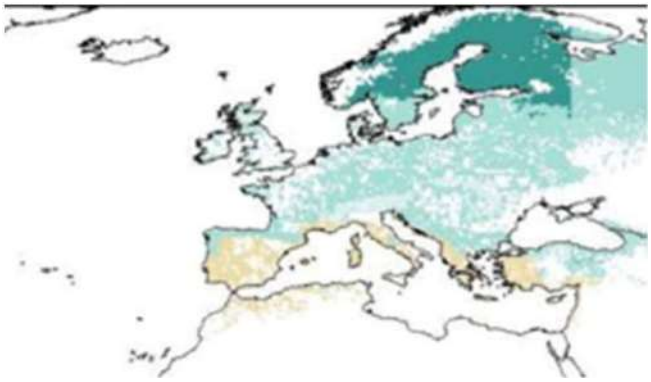
Article

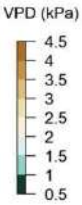
Forest fire threatens global carbon sinks and population centres under rising atmospheric water demand

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

8

VPD thresholds



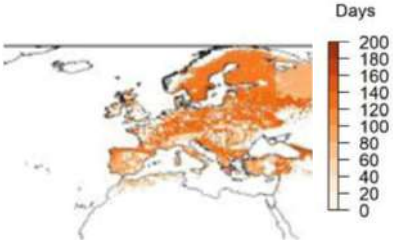


This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

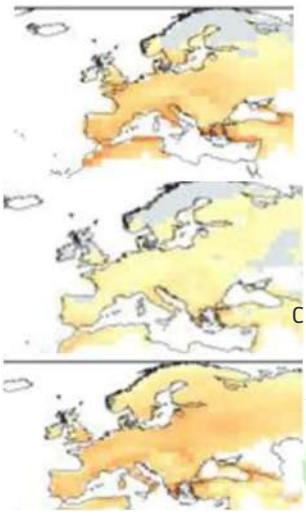
9

Current & future fire days (VPD exceedances)

Current



RCP 8.5



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10

VPD as best proxy for DFMC

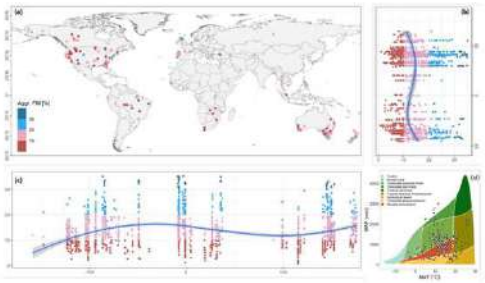
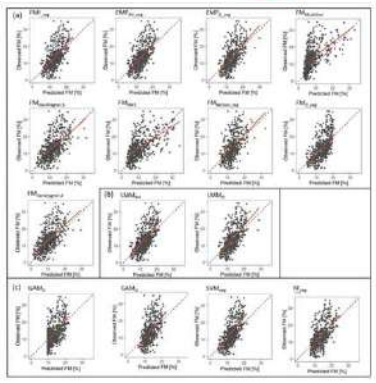


Figure 1. Overview of the BONFIRE database selected records. a) geographical distribution of measurement sites; b) latitudinal trend in FM [%]; c) longitudinal trend in FM [%]; d) Whittaker



VPD-based models of dead fine fuel moisture provide best estimates in a global dataset

Marcos Rodrigues, Víctor Resco de Dios, Ángelo Sil, Ángel Cunill Camprubí, Paulo M. Fernandes



the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

11

VPD as best proxy for DFMC but limited performance under 10%

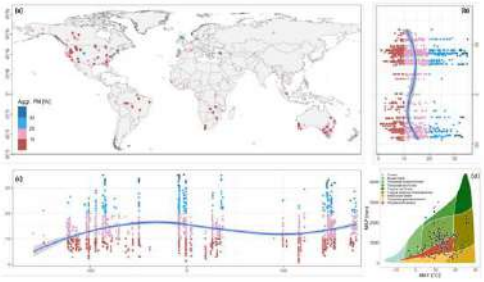
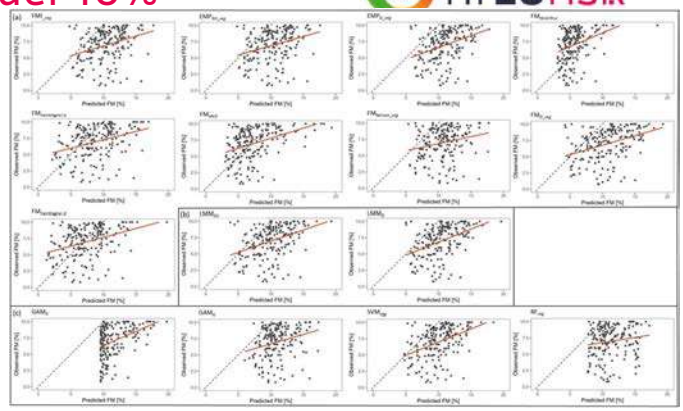


Figure 1. Overview of the BONFIRE database selected records. a) geographical distribution of measurement sites; b) latitudinal trend in FM [%]; c) longitudinal trend in FM [%]; d) Whittaker biomes plot.



VPD-based models of dead fine fuel moisture provide best estimates in a global dataset

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12

VPD as best proxy for DFMC

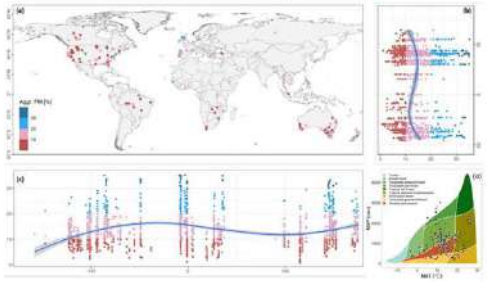


Figure 1. Overview of the BONFIRE database selected records. a) geographical distribution of



VPD-based models of dead fine fuel moisture provide best estimates in a global dataset

Marcos Rodrigues, Víctor Resco de Dios, Ángelo Sil, Ángel Cunill Camprubí, Paulo M. Fernandes

Web app development:
https://hcfm.shinyapps.io/shinyfmd/



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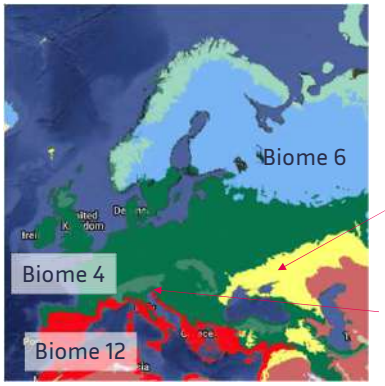
HDU (Hot-dry-unstable)

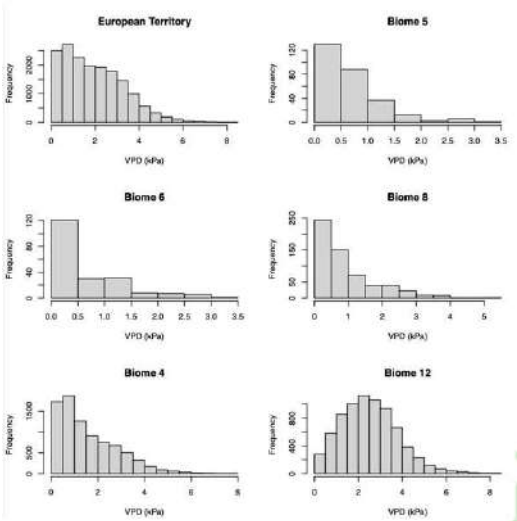
- HDU = VPD + AC/2
- VPD-> DFMC
- AC->atmospheric component: T_{700hPa}-T_{850hPa} (moving window to avoid saturation)

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HDU

- VPD (0-8 kPa)



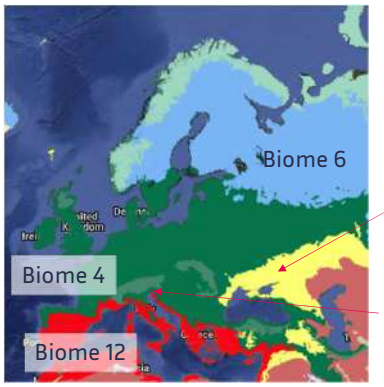


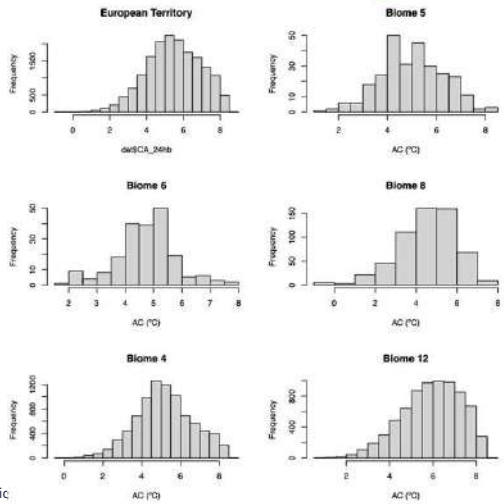
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15

HDU

- AC/2 (0-8 °C)



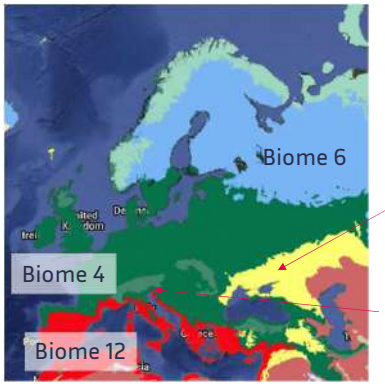


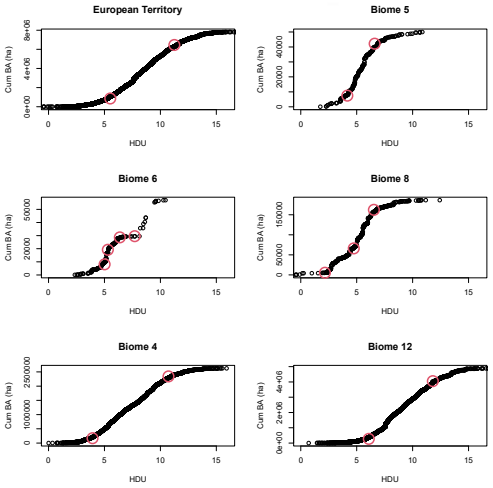
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16

HDU

- HDU





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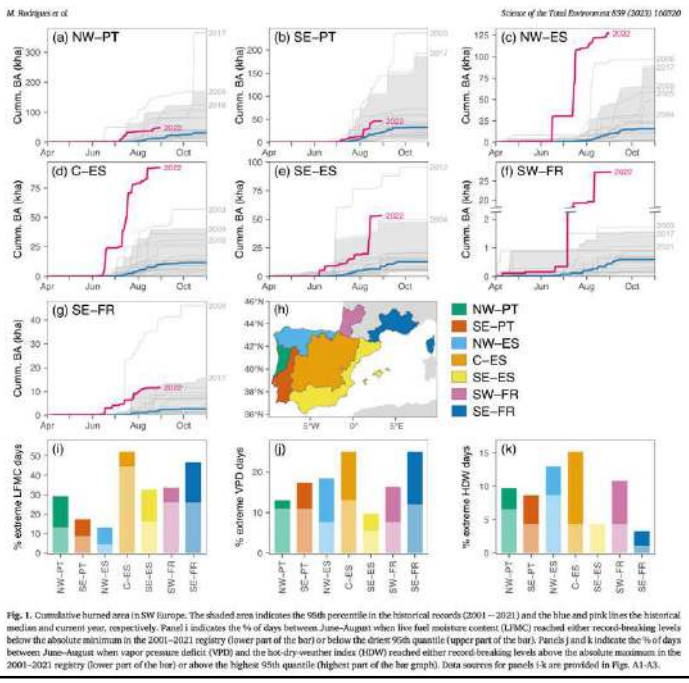
HDU

- HDU – fire sizes (ha) associated with different HDU values across biomes
- Problems in Biome 5 & 8

Quantile	European Territory			Biome 5			Biome 6			Biome 8			Biome 4			Biome 12		
	low HDU	mid HDU	high HDU	low HDU	mid HDU	high HDU	low HDU	mid HDU	high HDU	low HDU	mid HDU	high HDU	low HDU	mid HDU	high HDU	low HDU	mid HDU	high HDU
0.5	86	150	279	65	75	65	65	43	367	86	86	86	86	108	215	107	193	387
0.75	215	365	752	172	194	129	108	173	2344	280	215	204	215	258	516	258	473	1053
0.95	839	1526	4126	796	857	403	410	593	7848	1747	1549	624	989	1011	1870	1034	1956	6929

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

Putting it all together




Science of the Total Environment

Drivers and implications of the extreme 2022 wildfire season in Southwest Europe

Marcos Rodrigues, Ángel Cunill Camprubí, Rodrigo Balaguer-Romano, Celso J. Coco Megía, Francisco Castañares, Julien Ruffault, Paulo M. Fernandes, Víctor Resco de Dios

Fig. 1. Cumulative burned area in SW Europe. The shaded area indicates the 95th percentile in the historical records (2001 – 2021) and the blue and pink lines the historical median and current year, respectively. Panel i indicates the % of days between June–August when live fuel moisture content (LFMC) reached either record-breaking levels below the absolute minimum in the 2001–2021 registry (lower part of the bar) or below the driest 95th quantile (upper part of the bar). Panels j and k indicate the % of days between June–August when vapor pressure deficit (VPD) and the hot-dry-weather index (HDW) reached either record-breaking levels above the absolute maximum in the 2001–2021 registry (lower part of the bar) or above the highest 95th quantile (highest part of the bar graph). Data sources for panels i-k are provided in Figs. A1-A3.

A metric capturing dead fuel moisture and atmospheric instability

- Definition of fire-days
- Quantifications of key drivers of fire activity in MedEU
- Determination of best DFMC model
- Development of HDU
- Coupling with GCM

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890



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Fire Weather and Fuel Moisture Field Campaign

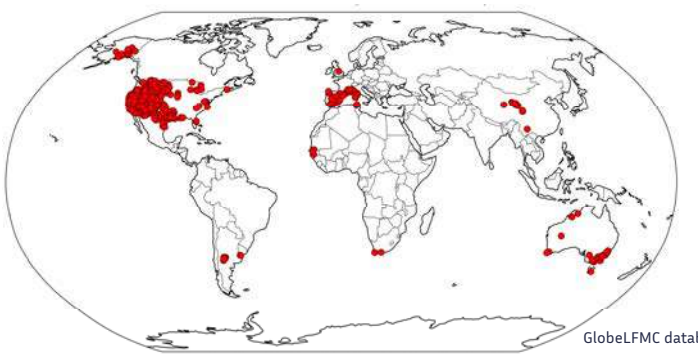
Johanna Kranz (TU Dresden)
Matthias Forkel, Konrad Bauer, Christopher Marrs, Markéta Poděbradská

26/01/24 | Central Europe Pilot Site Demonstration Event

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

Fuel Moisture Content

- Important determinator for fire ignition probability and fire propagation
- Lack of data in Central Europe:



GlobeLFMC database (Yebra et al. 2019)

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Fuel Moisture Content

$$FMC = \frac{m_{wet} - m_{dry}}{m_{dry}} \cdot 100\ [\%]$$

Live fuel moisture content (LFMC)

- Moisture stored within living plant parts of vegetation (leaves, needles, branches, stems)
- Dynamics influenced by plant traits, hydrological and meteorological conditions




Dead fuel moisture content (DFMC)

- Moisture within dead parts (litter, fine and coarse woody debris)
- Depending on meteorological conditions




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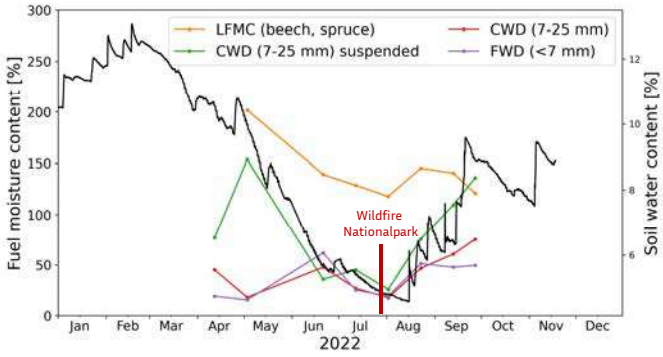
3

Fuel Moisture Content – Sampling at ICOS site DE-Tha



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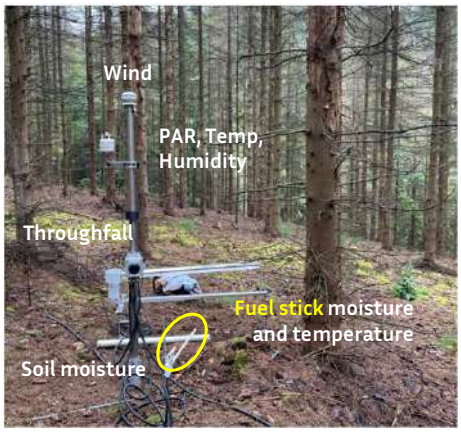
Fuel Moisture Content – Sampling at ICOS site DE-Tha





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Fire Weather Stations – Setup



4 Fire Weather Stations

National park: Höllweg, Winterberg
Forest Tharandt: ICOS DE-Tha, Landberg

In situ samples for fuel moisture in 2022 (only DE-Tha) and 2023

Continuously measuring fuel stick in 2023

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Fire Weather Stations - Locations

DE-SHW: dead stand of young spruces (*picea abies*)



DE-BWB: beech stand (*fagus sylvatica*)



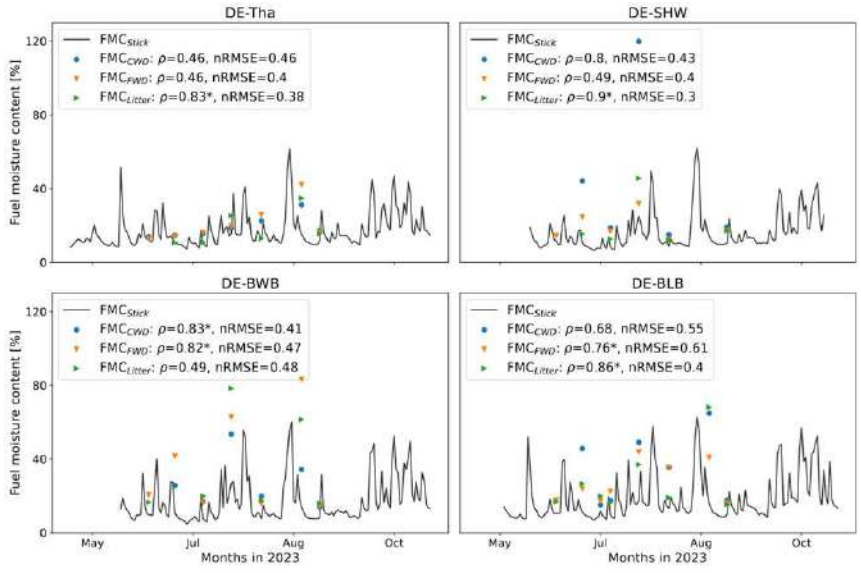
DE-BLB: beech stand with undergrowth *(fagus sylvat.)*



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7

In-Situ DFMC and Fuel Stick



Spruce stands:

Correlation between litter and fuel stick



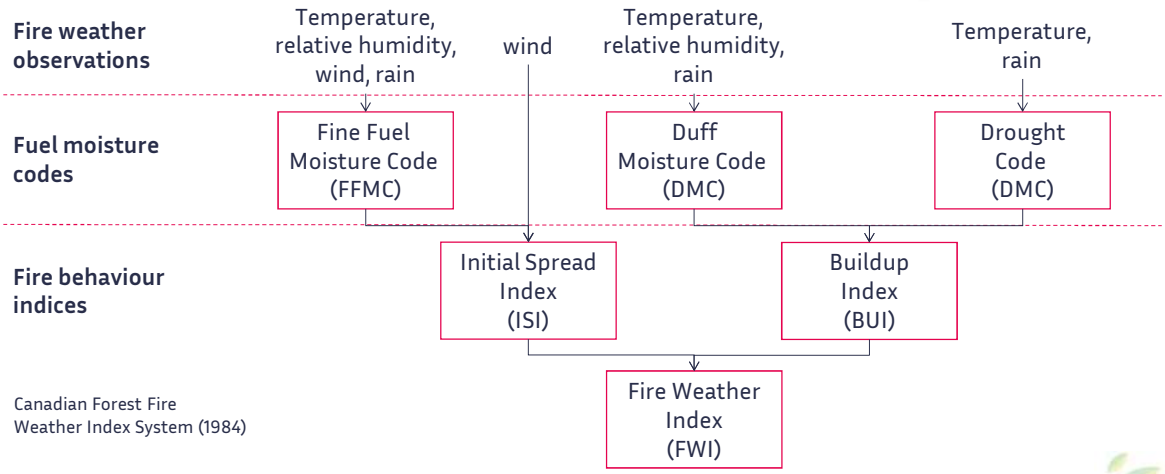
Beech stands:

Correlation between FWD and fuel stick



8

Fire Weather Index



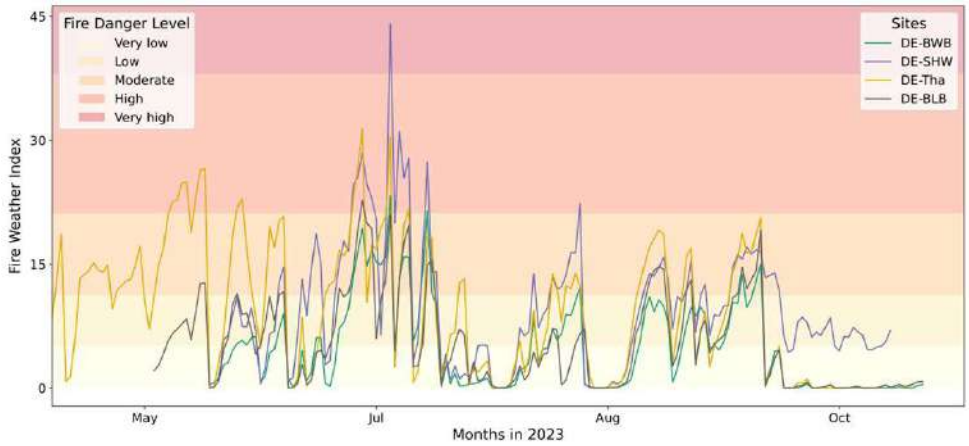
Canadian Forest Fire Weather Index System (1984)

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9

Fire Weather Index

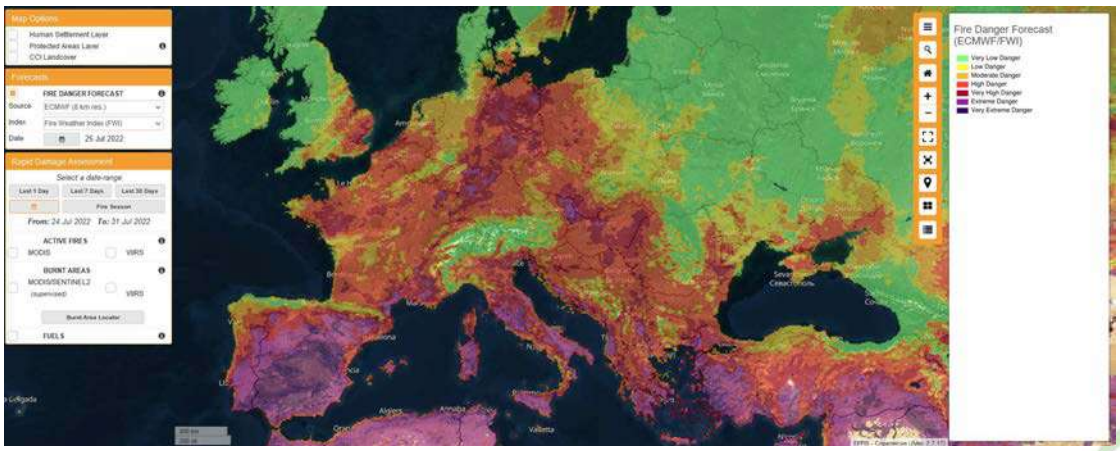
- Live and dead spruce stands show higher fire danger levels during dry periods



10

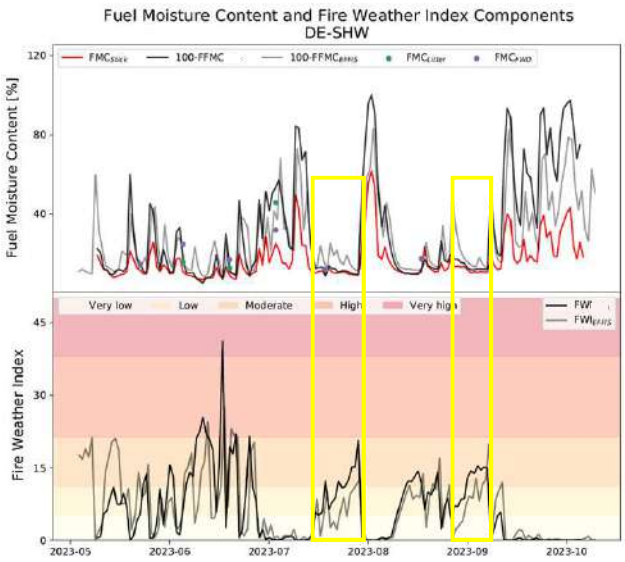
EFFIS – pan-European FWI

FWI system is implemented in EFFIS for fire danger rating on European scale → https://effis.jrc.ec.europa.eu/



11

Regional and local FWI measurements

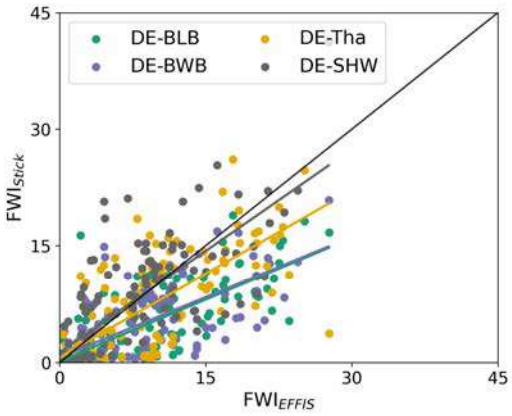


DE-SHW (dead spruce stand)

- EFFIS overestimates fine fuel moisture and **underestimates fire danger** in dry periods

12

Regional and local FWI measurements



DE-BWB and DE-BLB (beech stands)

- EFFIS underestimates fine fuel moisture and **overestimates fire danger**

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Conclusions

- Local monitoring of fuel moisture and fire weather at 4 sites in Germany (Tharandt and NP Saxon Switzerland)
- Fuel sticks represent local conditions of fine fuel moisture and fire risk
- Meteorological conditions cannot reflect LFMC conditions
  - Satellite-based modelling approaches necessary
- EFFIS does not capture local variability and differences in fuel types due to coarse resolution

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fireEUrisk
johanna.kranz@tu-dresden.de
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The Wildland Urban Interface in Central Europe

Prof. Avi Bar-Massada, University of Haifa

26/1/24 | PS2 Demonstration Event

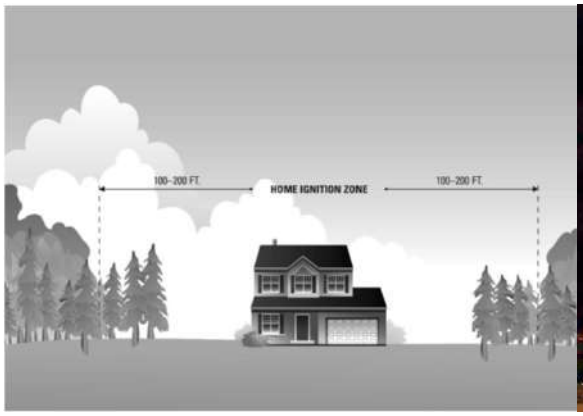
This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

The WUI definition

Where settlements are interspersed within or adjacent to flammable vegetation

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Why are we so worried about the WUI?





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3

Wildfire exposure in the WUI



Direct exposure: a building is surrounded by flammable vegetation



A building is within spotting distance from a sufficiently large patch of flammable vegetation

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4

Intermix vs. interface WUI

Intermix WUI: settlements are within vegetation



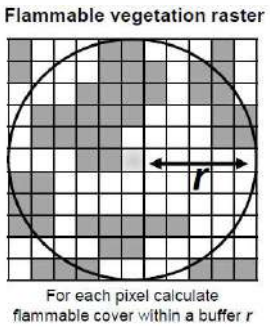
Interface WUI: settlements adjoin vegetation

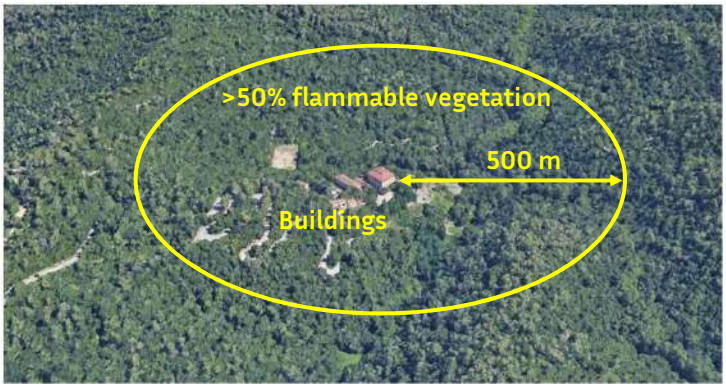


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5

Identifying intermix WUI

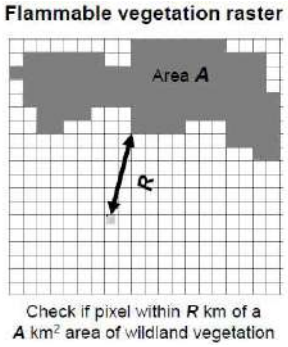




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6

Identifying interface WUI



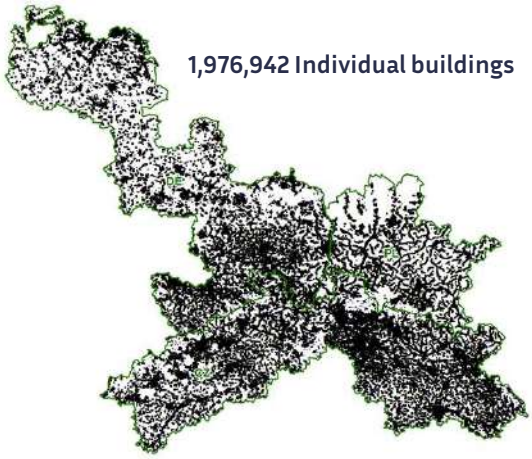


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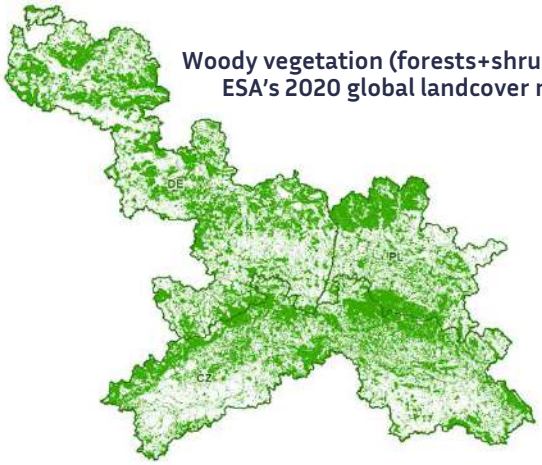
7

Inputs (10m spatial resolution)

1,976,942 Individual buildings



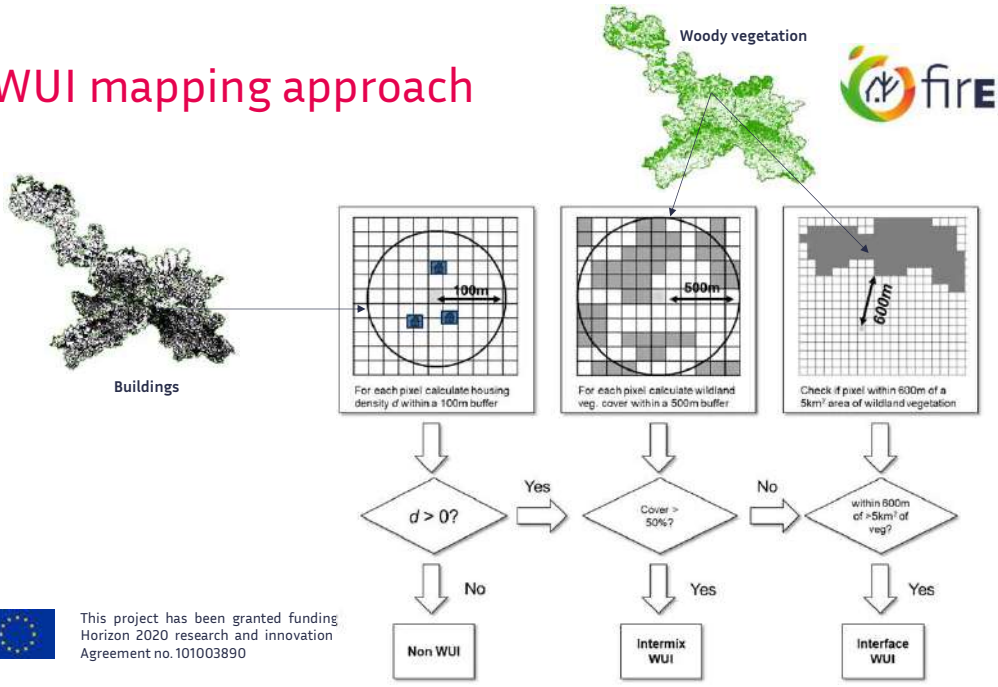
Woody vegetation (forests+shrublands)
ESA's 2020 global landcover map



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8

WUI mapping approach



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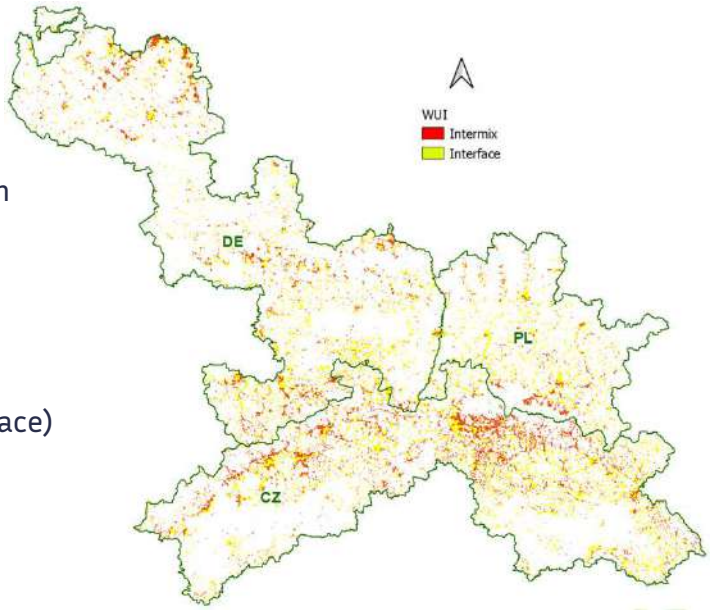
9

How much WUI?

382,098 ha, or ~**11.62%** of the region

154,148 ha (40.3%) intermix WUI
227,950 ha (59.7%) interface WUI

Per country:
CZ: 14.8% (44%/56% intermix/interface)
DE: 9.6% (39%/61% …)
PL: 8.9% (30%/70% …)



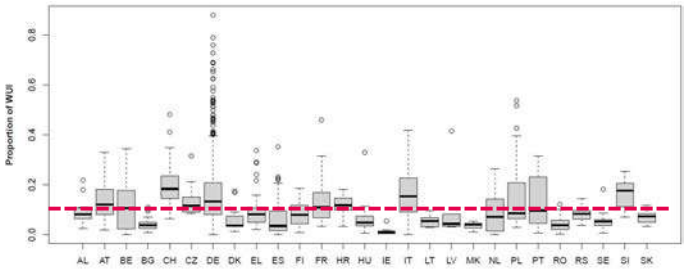
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European context

WUI covers 7.4% of the European territory,
[Central Europe PS 11.6%]

46.6% intermix [40.3%], 53.4% interface [59.7%]



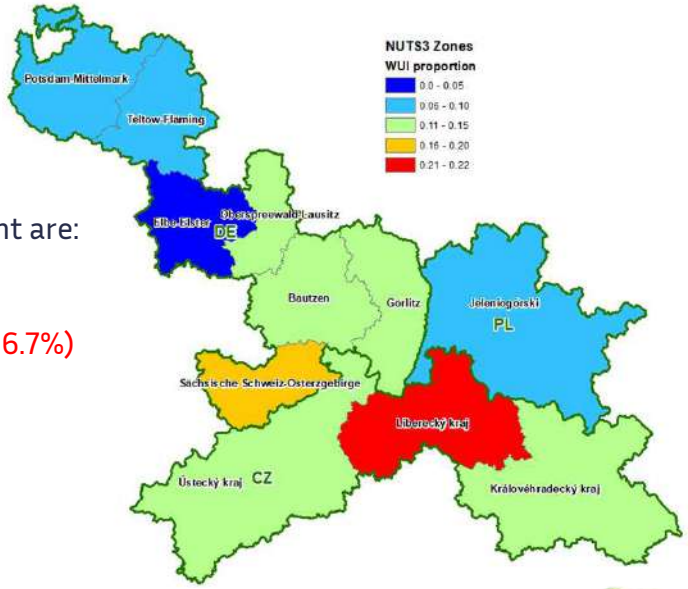


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How much WUI area? (NUTS3 regional level)

Top 3 regions in terms of WUI percent are:

Liberecký kraj (21.9% WUI)
Sächsische Schweiz-Osterzgebirge (16.7%)
Královéhradecký kraj (13.6%)

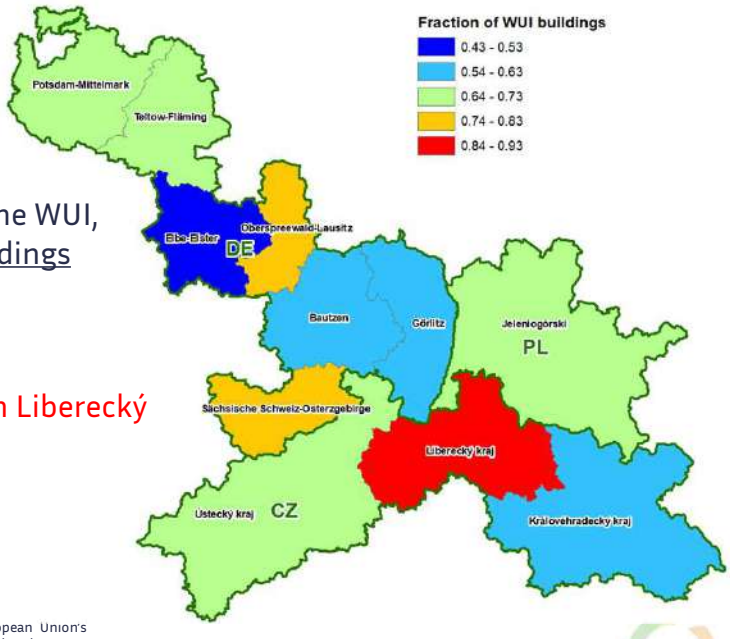


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Buildings in the WUI

There are **1,348,082** buildings in the WUI, which represent **68.1% of the buildings in the entire region**
(CZ: 71.9% DE: 65.7% PL: 63.7%)

More than 90% of the buildings in Liberecký kraj are in the WUI

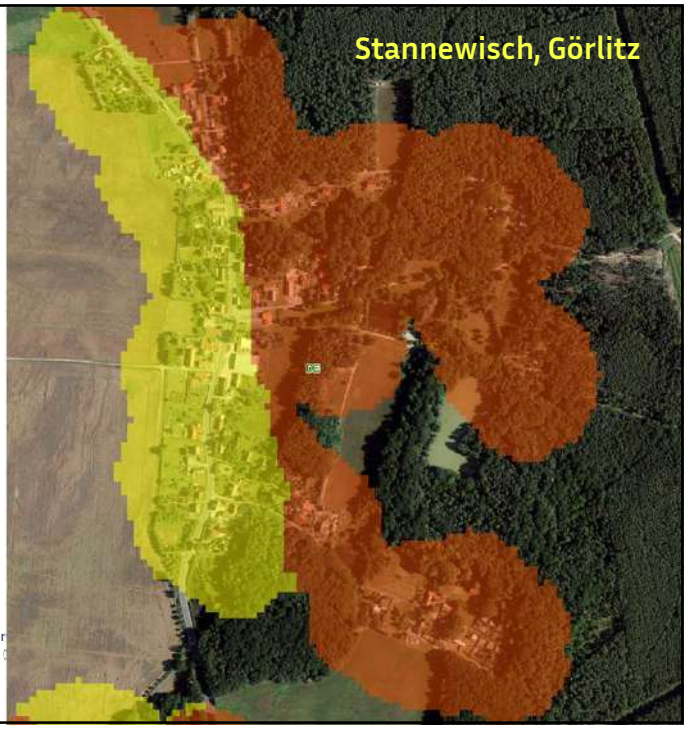


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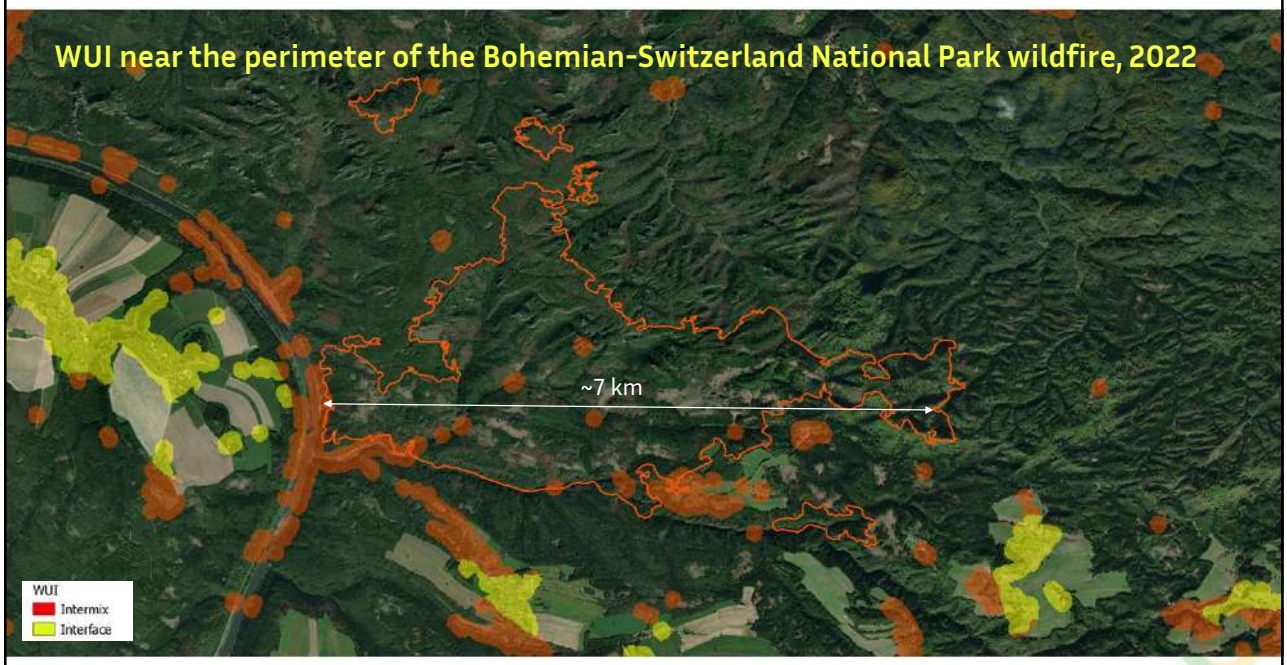
13

Example





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Insights

The PS of Central Europe represents a higher-than average case of wildfire exposure to human settlements in the ET context

It is likely that our estimates of exposure are conservative, as they disregard herbaceous fuels and assume a short travel distance of flaming embers

At the same time, there's some over-estimation of exposure due to disregard of differences in flammability among tree species

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Thank you!

The WUI map is available via the FirEURisk viewer

Feel free to contact me at: avi-b@sci.haifa.ac.il

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Central Europe Pilot site January 202

Potential losses of Ecosystem Services affected by wildfires

Juan Ramón Molina – UCO

This project has received funding from the European Union 's Horizon 2020 research and innovation programme under grant agreement No 101003890

Ecosystem services at PS scale

- In this scale, the economic valuation is based on D1.6 (SEVEIF model)

FIREURISK - DEVELOPING A HOLISTIC, RISK-WISE STRATEGY FOR EUROPEAN WILDFIRE MANAGEMENT

D1.6 – On-line methodological handbook for socio-economic assessment of fire impacts/damages

Ecosystem service	Mathematical formulation	Resource condition	Source
Timber	$L_{timber} = (a*E*B)/(E+b*B)$	Mature and Immature	Rodríguez y Silva, 2012
	$E = C_0*p\,[i^n + g(i^n -1)] + A*(i^n - 1)$	Sapling, thicket	Martínez, 2000
	$E = (C_{0(z)}*t\,[i^n + g(i^n -1)] + (C_0/z)*0.5*(i^n - 1)$	Polewood	Martínez, 2000
	$E = [P*V - P_1*V_1] + P*V\,[(i^n - 1)/(i^n)]$	Mature	Martínez, 2000
	$B = [(V*P*1.025^n)/1,04^n]*[1-(1.025/1.04)^n]*[1 + X*h*p]$	Sapling, polewood	González-Cabán, 2000
	$B = V*h*t[R*P + (1 - R)*P_1]$	Mature	González-Cabán, 2000
Firewood	$L_{fire} = P_x*R_x*[((1+i)^n - 1)/(i*(1+i)^n]$	-	Martínez, 2000
Non-timber products	$L_{fruit} = P_x*R_x*[((1+i)^n - 1)/(i*(1+i)^n]$	Mature	Martínez, 2000 Molina et al., 2011
Pasture	$L_{past} = P_x*R_x*[(1+i)^n - 1)/(i*(1+i)^n]$	Silvopastoral system	Martínez, 2000 Molina et al., 2011
Hunting	$L_{hunt} = P_x*R_x*[(1+i)^n - 1)/(i*(1+i)^n] + S$		

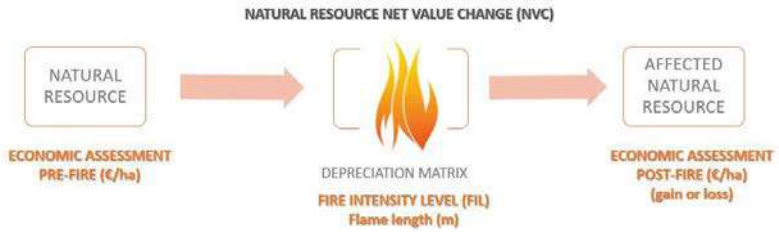
Ecosystem service	Mathematical formulation	Resource condition	Source
Carbon storage	$L_{car} = 3.67*[CS*Pc + AS*Pc*[((1 + r)^y)-1)/(r*((1 + r)^y)]$	Forests and treeless areas	Molina et al., 2019a
Soil erosion	$L_{eros} = V*\,[((1 + r)^n - 1)/(r*(1 + r)^n]$	Forests and treeless areas	Molina et al., 2009
Endangered o flagship species	$L_{endag} = V*\,[((1 + r)^n - 1)/(r*(1 + r)^n]$	Presence of endangered animals	Molina et al., 2019b
Landscape and recreational resources	$L_{lands} = V*\,[((1 + r)^n - 1)/(r*(1 + r)^n]$	Forests and treeless areas	Molina et al., 2019c
Non-use or existence value	$L_{non-use} = V*\,[((1 + r)^n - 1)/(r*(1 + r)^n]$	Forests and treeless areas	Molina et al., 2009

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Methodological framework for fire impacts assessment

The economic assessment of fire impacts requires the following three main phases:

- Economic assessment of each resource based on the mathematical formulations and their input variables.
- Depreciation ratio estimation for each natural resource according to fire behaviour.
- Integration of each resource value and depreciation to calculate the net value change or fire impact (value loss or value gain).

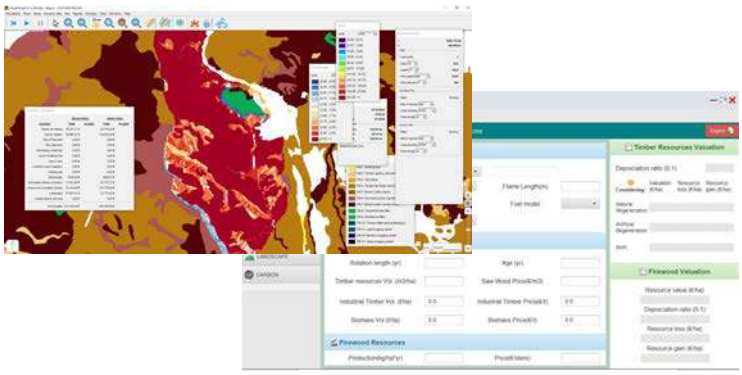


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3

On-line SEVEIF tools for fire impacts assessment

- AppERIIF (www.labif.es)
- Visual SEVEIF (www.labif.es)



Applications of the fire impact assessment methodology

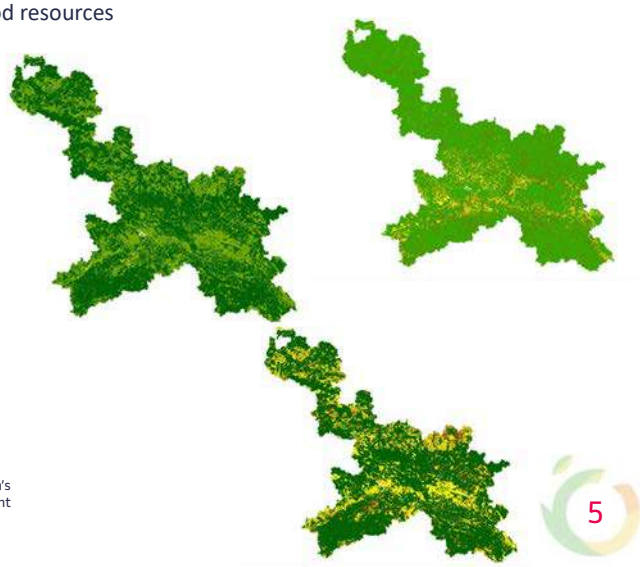
- Fire prevention
- Fire suppression
- Post-fire analysis

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4

Potential losses in Central Europe

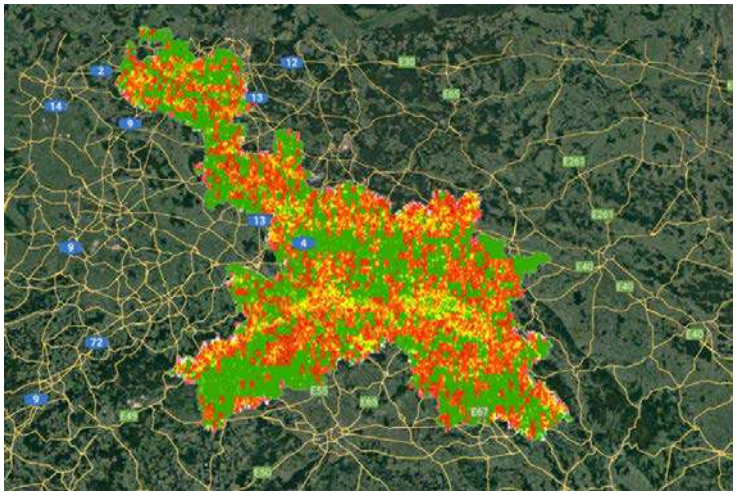
- Timber products resources: timber, biomass, and firewood resources
- Tree fruit resources
- Pasture resources
- Hunting resources
- Carbon sequestration and soil protection resources
- **Soil erosion**
- **Endagered species resources**
- **Landscape and leisure resources**



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5

Potential losses in Central Europe



Available product

Spatial resolution of 100 x 100 m

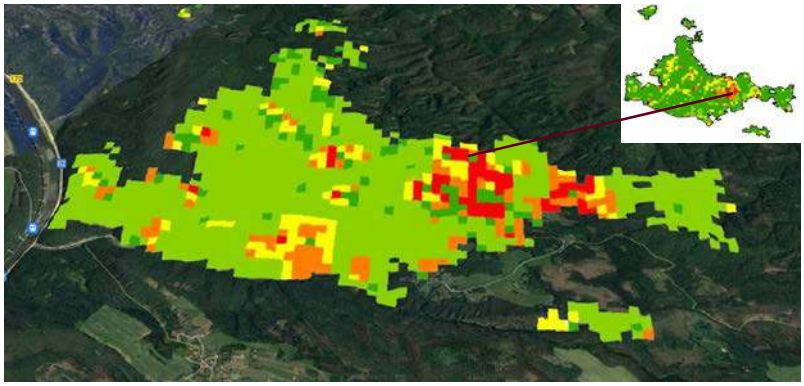
Static cartography based on flame length tasks

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6

Next steps at PS scale

- Test of tangible assets losses using real fires



?

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Thank you!

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Central Europe Pilot Site Demonstration Event

Factors for building survival in north-European wildfires

Frida Vermina Plathner – RISE Research Institutes of Sweden



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003890

2 HOME IGNITION ZONE (HIZ)

The immediate zone
(0-1.5 m)
The building and its closest vicinity

The intermediate zone
(1.5-10 m)
The garden

The extended zone
(10-30 m)
The surrounding forest

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3
BACKGROUND
The determining features for building loss in wildfire vary across **ecoregions**
• Fuel type
• Land use
• Fire behavior
• Garden vegetation
• Non-veg. combustibles in gardens
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26/01/2024
Central Europe PS Demonstration Event
fireurisk

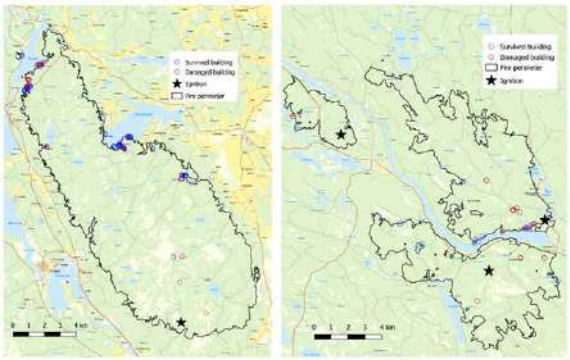

4
BACKGROUND
... and across **settlement types**
• Building materials
• Settlement patterns
• Intermix or interface
• Road network
• Resources
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6

Physical features

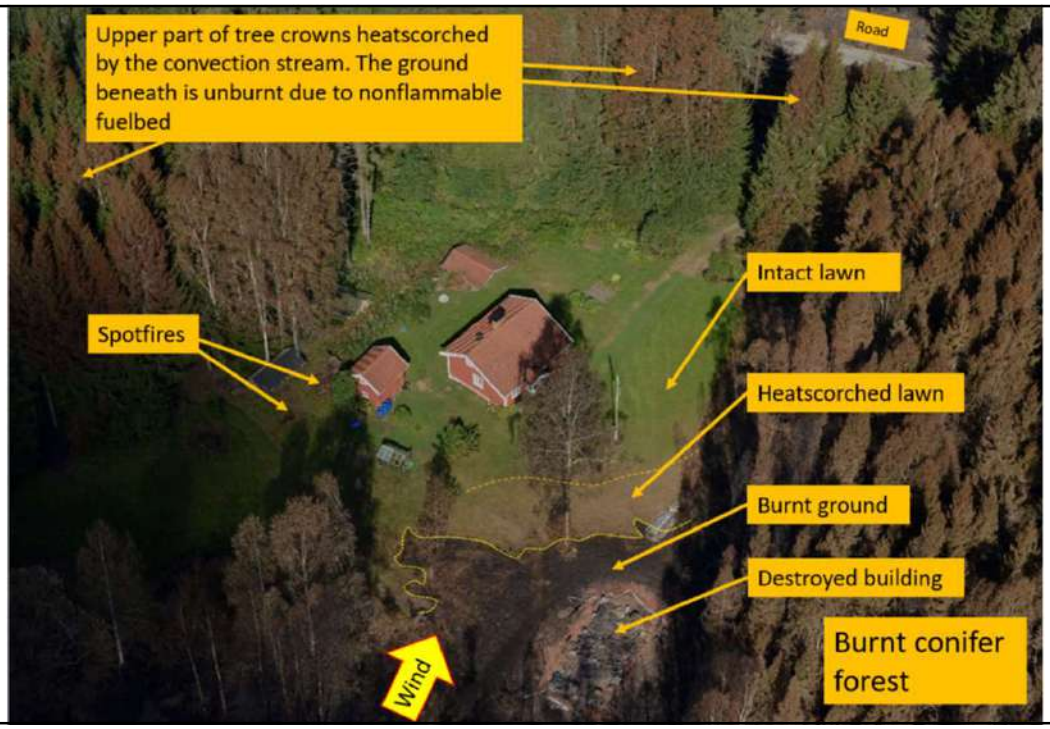
- Evaluate which are the most important physical features for building survival in the HIZ in northern Europe
  - Västmanland fire 2014
  - Ljusdal fires 2018
  - 22 000 ha
  - 187 buildings
    - 66 destroyed
- Building
  - Materials
  - Vents, shutters, gutters etc.
  - etc
- Garden
  - Vegetation type and structure
  - Non-veg. fuel loads
  - Etc.
- Nearby forest
  - Stand type
  - Fire breaks
  - Etc.



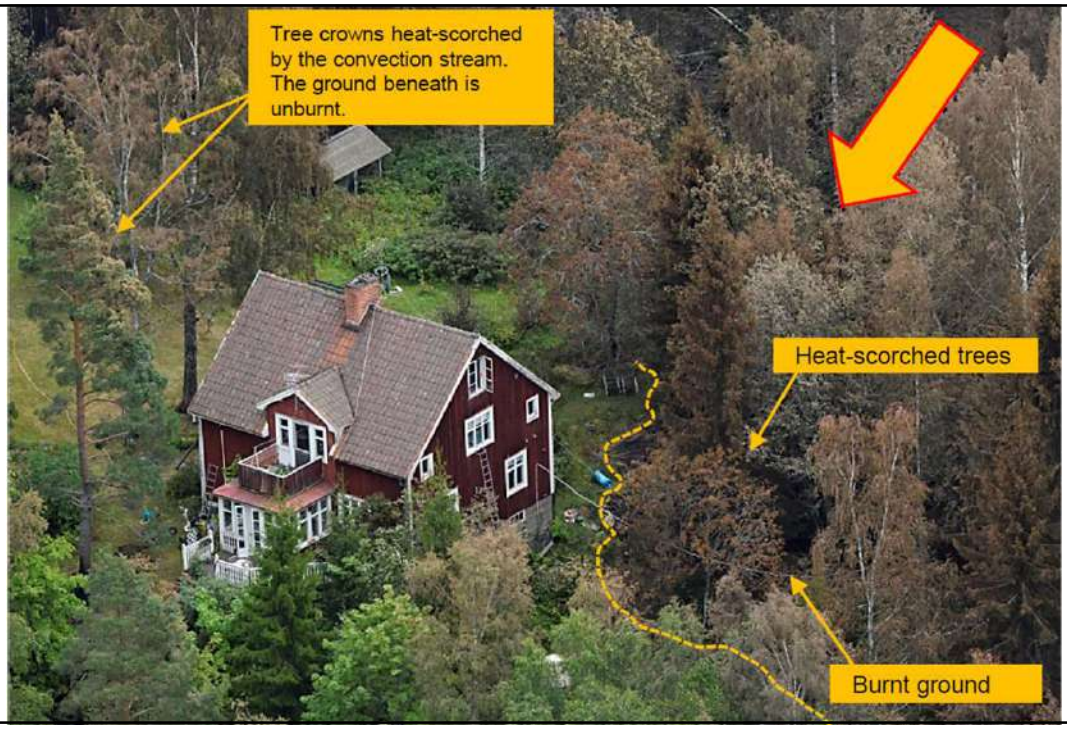
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fireurisk

7


Upper part of tree crowns heatscorched by the convection stream. The ground beneath is unburnt due to nonflammable fuelbed
Road
Intact lawn
Spotfires
Heatscorched lawn
Burnt ground
Destroyed building
Burnt conifer forest
Wind

8


Tree crowns heat-scorched by the convection stream. The ground beneath is unburnt.
Heat-scorched trees
Burnt ground

9

Significant factors for building survival in large forest fires

1. A (r >5 m) lawn surrounding the building
(OR: 3.8)

2. Absence of non-vegetation fuel touching the building
(OR: 2.8)

3. Deciduous wildland vegetation around the garden
(OR: 2.1)

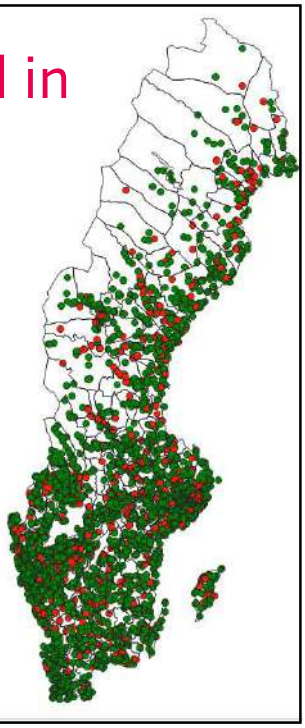
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10

BUT! Most buildings are ignited in small fires

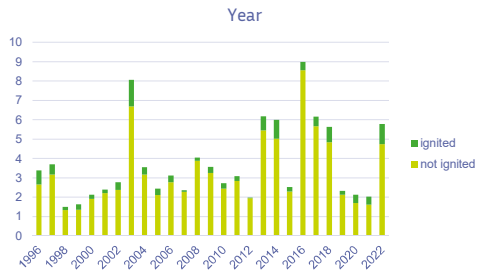
- ~125 wildfires threatens or ignites buildings annually
- ~30 building ignitions and 1 fatality per year from wildfires

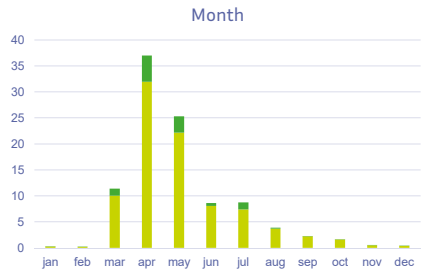


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WUI fires are most prevalent during spring

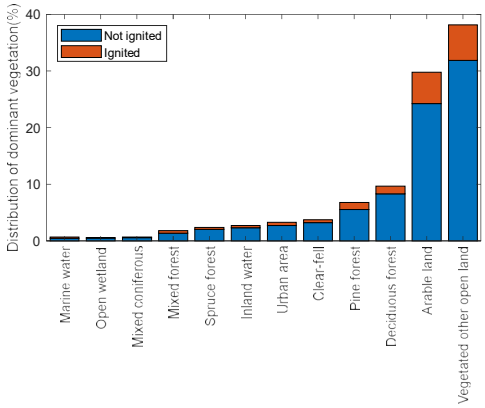


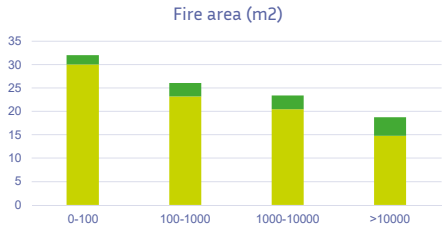


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12

… in small fires in meadows…



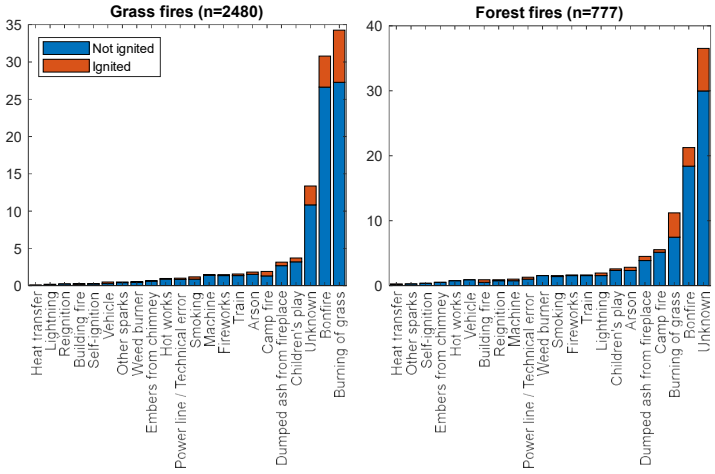


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13

...caused by traditional fire use



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”Locals were burning grass down by the lake. They thought they had extinguished the fire but burn patterns reveal that flames reemerged, then spread in the tall grass to two woodsheds, where the flames reached the facades. The heavy fuel load from the two sheds led to ignition of the eaves of the two adjacent residential homes. We initiated external suppression using water from the lake.”


BONFIRE / OPEN FIRE
”I was burning leaf litter in this barrel. I had two buckets of water and a rake and I had cut the grass around the barrel. All of a sudden the tall grass outside my safety zone had ignited. My wife and I tried to extinguish, but it spread too fast.”
Photo: Nisse Schmidt


URBAN VEGETATION FIRE
”The spruce hedge was burning furiously upon our arrival, with 6-7m flames. In the middle of the hedge was a small house with burning eaves, and a workshop in the end of the hedge was just about to ignite. Cause of ignition: a weed burner”
fireEUrisk



fireurisk

Frida Vermina Plathner
Research Institutes of Sweden
frida.vermina.plathner@ri.se


Central Europe Pilot Site Demonstration Event
The RING (Rate of spread In Northern Grasslands) model
A spring fire danger model for northern grasslands


Grassfires globally
2
Grasslands cover ~1/3 of global land area and account for over 80% of the global burnt area. Mostly savannahs in Africa and south America
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Grassfires globally – also a northern phenomenon

3

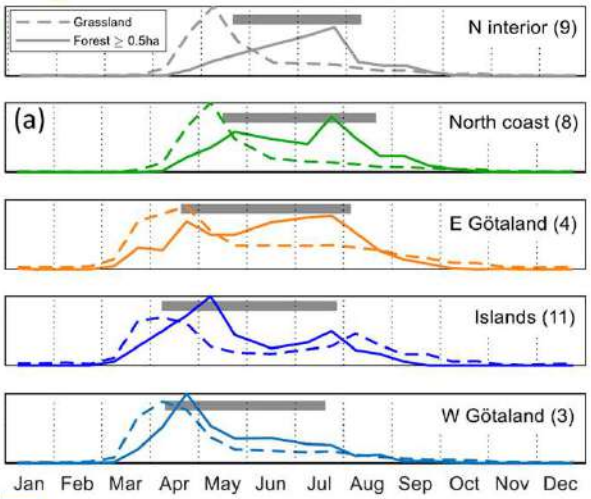
Example from northern areas include the Marshall fire, Colorado, December 2021.

2400 ha, 1091 buildings and two fatalities

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Northern spring fires – fundamentally different from forest fires (Swedish example)

4



- Most fires occur in spring, although not the largest or most intense
- Fires on open land have a completely different seasonality than forest fires

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Northern spring fires – fundamentally different from forest fires
5
Fires in light litter in tree-less areas can exhibit VERY high spread rates
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Spring fires – fundamentally different from forest fires
6
Rain all night is no guarantee against rapid fire spread during afternoon
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Spring fires – fundamentally different from forest fires

7

During spring, people tend to underestimate the risk of fast fire spread

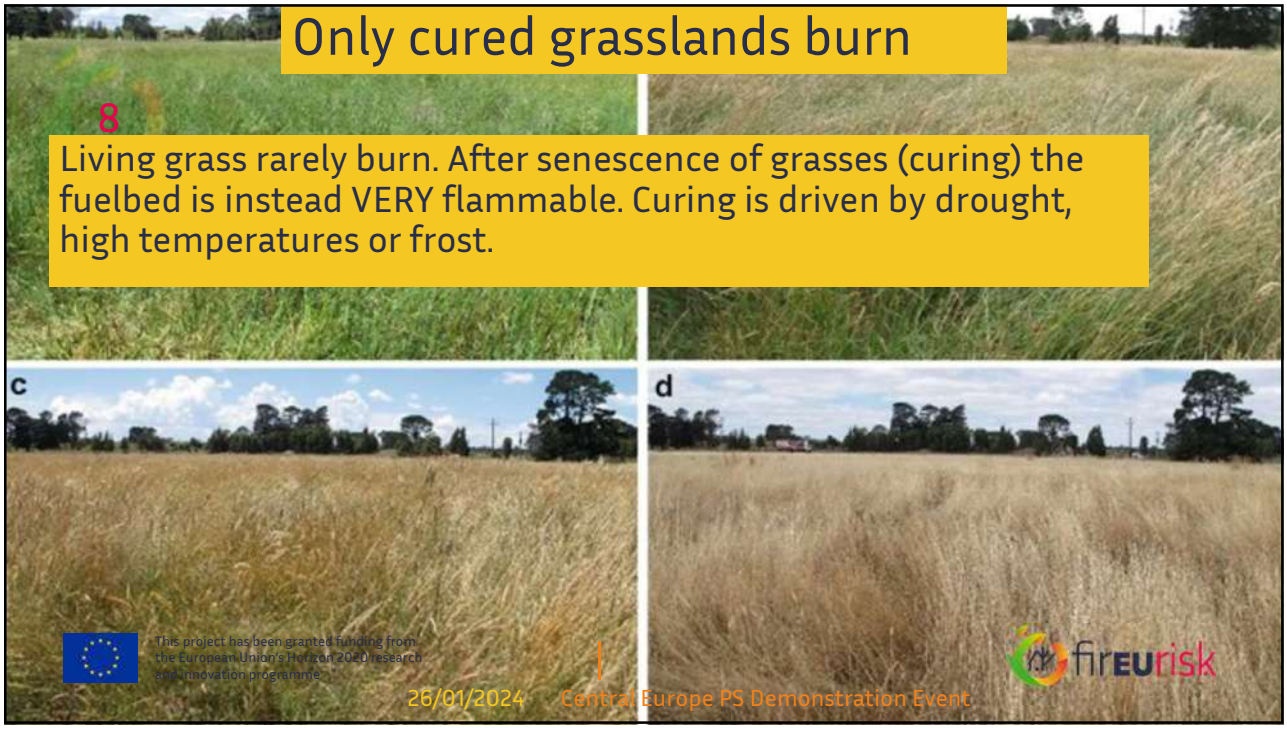


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Only cured grasslands burn

8

Living grass rarely burn. After senescence of grasses (curing) the fuelbed is instead VERY flammable. Curing is driven by drought, high temperatures or frost.



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9

Evolution of a grassland in Northern Europe with mild winters (occational snow)



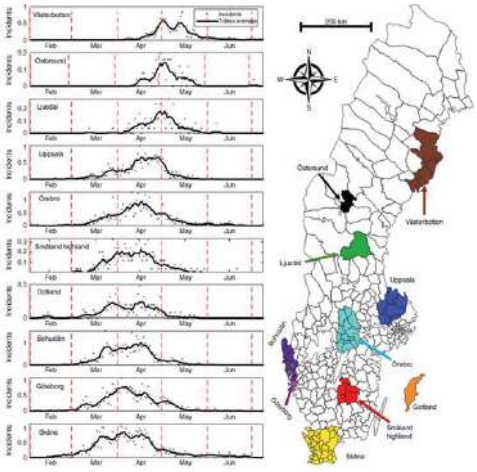
After winter, the fuel bed is completely cured, followed by 'reversed curing' as green grass emerges

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10

Evolution of a grassland in Northern Europe with harsh winters

The grassfire season shifts to later in the season and gets shorter for higher latitudes





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Constructing a fire danger model for northern grasslands

The risk index for grasslands is based on *Rate of spread* as opposed to *fireline intensity* for forest fires

Important factors for spread rate

- Fuel height (but fuel load is less significant)
- Fuel moisture content
- Wind speed
- Curing degree

We use a model system 7-13 cm compressed with occasional standing grass. (300 g/m² – drymass)

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Constructing a fire danger model for northern grasslands

The risk index for grasslands is based on *Rate of spread* as opposed to *fireline intensity* for forest fires

Important factors for spread rate

- Fuel height (but fuel load is less significant)
- Fuel moisture content
- Wind speed
- Curing degree

Accounts for
- **Rain**
- **Temperature**
- **Sun irradiation**
- **Wind speed**
- **Relative humidity**

De have defined new equilibrium moisture contents for colder temperatures

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26/01/2024 Central Europe PS Demonstration Event

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Constructing a fire danger model for northern grasslands

The risk index for grasslands is based on *Rate of spread* as opposed to *fireline intensity* for forest fires

Important factors for spread rate

- Fuel height (but fuel load is less significant)
- Fuel moisture content
- Wind speed
- Curing degree

Known from many experiments in Australia and North America

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Constructing a fire danger model for northern grasslands

The risk index for grasslands is based on *Rate of spread* as opposed to *fireline intensity* for forest fires

Important factors for spread rate

- Fuel height (but fuel load is less significant)
- Fuel moisture content
- Wind speed
- Curing degree

Determined from 25 years of incident statistics in Sweden together with burn series following full seasons.

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26/01/2024 Central Europe PS Demonstration Event

15

Constructing a fire danger model for northern grasslands

The risk index for grasslands is based on *Rate of spread* as opposed to *fireline intensity* for forest fires

$$ROS = R_W \emptyset_{mc} \emptyset_C$$

Spread rate in completely cured and completely dry grasslands

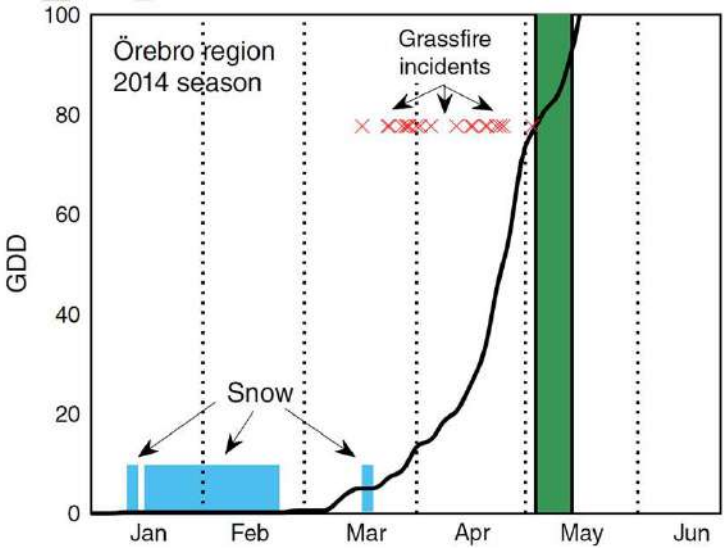
Reduction due to moisture content

Reduction due to decreasing curing as green grass grows

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Grassfire season is defined from 25 years of fires in ten different regions



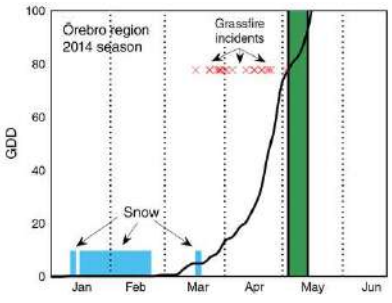
GDD = Growing Day Degrees

GDD = 0 – grasslands completely cured
GDD = 100 – fuel can hardly support spread



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Grassfire season is defined from 25 years of fires in ten different regions



$$\mathrm{GDD}(d) = \frac{1}{4}\Sigma_{i=1}^{d}(T_i - 2) \times \left[1 + \mathrm{erf}\left(\frac{i-80}{60}\right)\right]$$

$$T_i = \left(\Sigma_{j=i-3}^{i} T_{\mathrm{corr},\,j}\right)/4, \quad \text{Limited by } T_i \geq 2$$

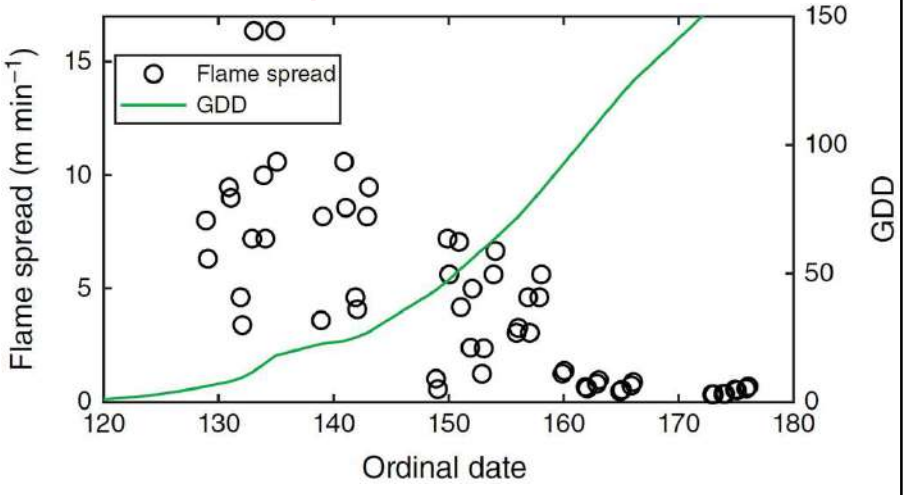
$$T_{\mathrm{corr}} = \begin{cases} 0 & \text{(if snow)} \\ 0.1 \times T_{\mathrm{air}} & \text{(if no snow \& } T_{air} < 0\text{)} \\ T_{\mathrm{air}} & \text{(else)} \end{cases}$$

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Grassfire season's effect on spread rate is defined from burn experiments

Large fluctuations due to different moisture and wind conditions between the days



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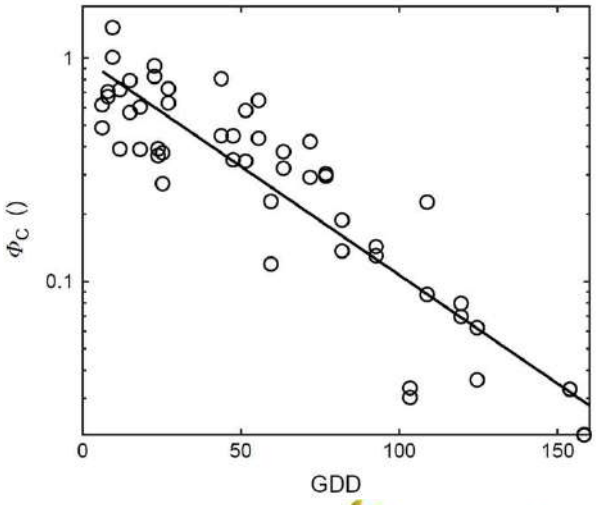
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Grassfire season's effect on spread rate is defined from burn experiments

Correct for the mc and wind.
Only the seasonality remains

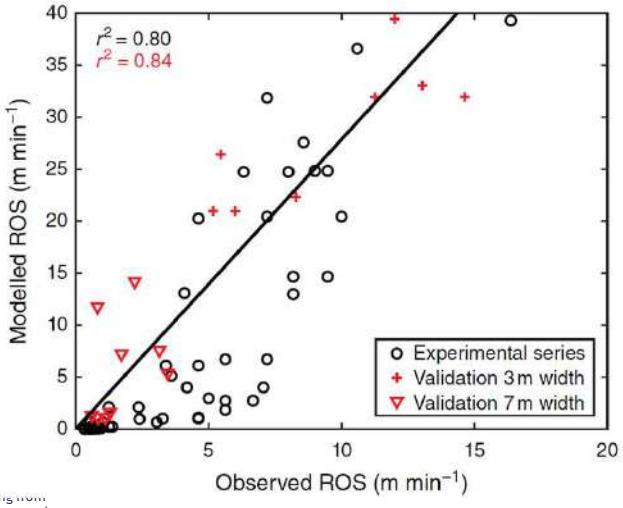
$$\Phi_C = e^{-0.0224 \times GDD}$$



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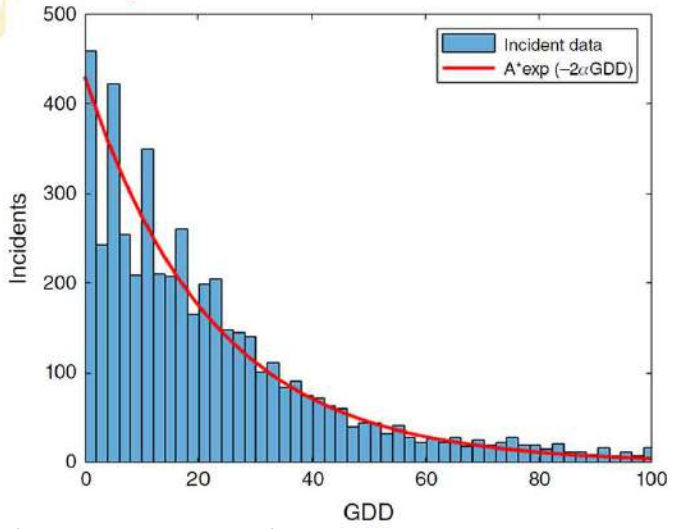
The model is complete and we compare it to fires with known spread rates



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The model for curing agrees well with dispatch occurrence over 25 years



Exactly 2 times the exponent for rate of spread. Account for that also the likelihood of ignition varies with the same dependence as ROS.

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(1) Caluclate season's length Average daily temperatures and snow cover

$$\mathrm{GDD}(d) = \frac{1}{4}\Sigma_{i=1}^{d}(T_i - 2) \times \left[1 + \mathrm{erf}\left(\frac{i-80}{60}\right)\right]$$

$$T_i = \left(\Sigma_{j=i-3}^{i} T_{\mathrm{corr},j}\right)/4, \quad \mathrm{Limited by} T_i \geq 2$$

$$T_{\mathrm{corr}} = \begin{cases} 0 & \text{(if snow)} \\ 0.1 \times T_{\mathrm{air}} & \text{(if no snow \& } T_{air} < 0\text{)} \\ T_{\mathrm{air}} & \text{(else)} \end{cases}$$

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(2) For each hour, calculate Equilibrium moisture content
Temp, RH, wind, solar radiation

$$T_g = T + 35.07 \times I \times e^{-0.2237 \times W}$$

$$RH_g = RH \times 10^{7.5\left(\frac{T}{237+T} - \frac{T_g}{237+T_g}\right)}$$

$$EMC_D = 2.21 \times RH_g^{0.46} + 13.7 \times e^{\frac{RH_g - 100}{13}} + 0.08 \times (26.67 - T_g)$$

$$EMC_W = 2.00 \times RH_g^{0.44} + 12.0 \times e^{\frac{RH_g - 100}{18}} + 0.08 \times (26.67 - T_g)$$

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(3) For each hour, calculate fuel moisture content
Temp, RH, wind, solar radiation

$$\Delta mc = 100 \times (P/0.3)$$

$$mc_0 = mc(t - \delta) + \Delta mc, \ (mc_0 \leq 400\%)$$

$$R = \begin{cases} RH_g/100 \text{ (fordrying)} \\ 1 - RH_g/100 \text{ (forwetting)} \end{cases}$$

$$k\,[h^{-1}] = 0.897 \times e^{0.0365 \times T_g} \times [0.424 \times (1 - R^{1.7}) + 0.1317 \times \sqrt{W} \times (1 - R^8)]$$

$$mc(t) = EMC + [mc_0 - EMC] \times e^{-k \times \delta}$$

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(4) Calculate Rate Of Spread

$$\Phi_{mc} = \begin{cases} \exp(-0.108 \cdot mc), & (mc \leq 12\,\%) \\ 0.684 - 0.0342 \cdot mc, & (mc > 12\,\%\ W < 3\ \mathrm{m\ s^{-1}}) \\ 0.547 - 0.0228 \cdot mc, & (mc > 12\,\%\ W > 3\ \mathrm{m\ s^{-1}}) \end{cases}$$

$$\Phi_C = e^{-0.0224 \cdot GDD}$$

$$ROS = \begin{cases} [0.9 + 16.13 \cdot W]\,\Phi_{mc}\Phi_C, & (\text{for } W < 1.4\ \mathrm{m\ s^{-1}}) \\ [23.33 + 41.18 \cdot (W - 1.3889)^{0.844}]\,\Phi_{mc}\Phi_C, & (\text{for } W \geq 1.4\ \mathrm{m\ s^{-1}}) \end{cases}$$

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(5) Set a danger class

Danger level	ROS ($\mathrm{m\ min^{-1}}$)
Low	$ROS \leq 5$
Moderate	$5 < ROS \leq 15$
High	$15 < ROS \leq 25$
Very high	$ROS \geq 25$

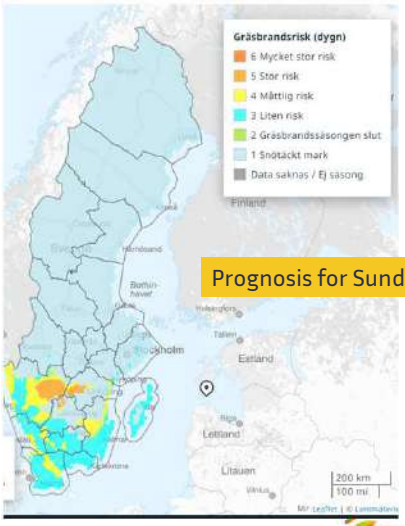
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Example from the Swedish warning system





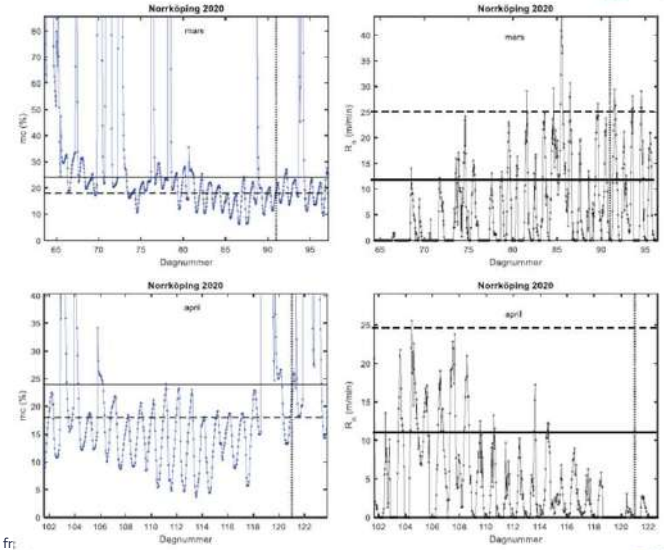
Prognosis for Sunday Jan 28th, 2023

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Example from the Swedish warning system

March & April for Norrköping



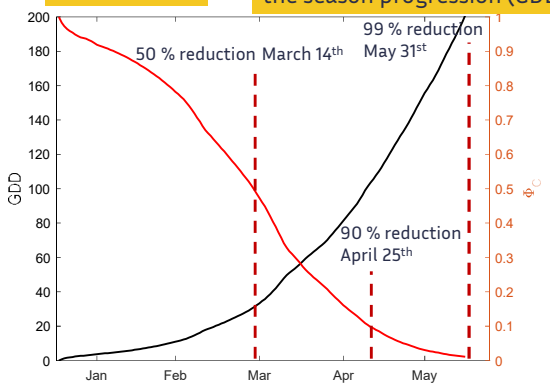
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Evaluated to Dresden

Dresden 2023

Reduction (Φ_c) of spread rate and the season progression (GDD)



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Read more

https://www.publish.csiro.au/wf/pdf/WF23013



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Thank you
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