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

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# D5.8 – Report of FirEUrisk Pilot Site 3 Demonstration

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| **Authors:** | Miguel Almeida (ADAI), Tiago Rodrigues (ADAI), Luis Mário Ribeiro (ADAI), MohamadReza Modares (ADAI), Hafsae Lamsaf (ADAI), Domingos Xavier Viegas (ADAI), Julia Yague (GMV) |
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# Executive Summary

The FirEURisk project, which brings together a very large consortium involving 38 institutions from 17 countries, is an ambitious project addressing the problem of integrating forest fire management, particularly those fire events occurring under extreme conditions that endanger human lives and expose assets to risk. Demonstration Events bringing together relevant stakeholders are organized within the project with the aim of presenting, co-developing, and refining developed solutions and methodologies.

The project's second Pilot Site Demonstration Event was organized by ADAI and took place in Coimbra, Portugal, on the 3rd of November 2023. This Demonstration Event was hosted by the Commission for Coordination and Regional Development of the Centre (CCDRC), at their headquarters, and took place simultaneously online for remote attendees. In the event, 15 out of 80 FirEurisk products were presented to relevant stakeholders from various fields of expertise and with a local, regional, and national scope of action.

The Central Region of Portugal was selected as a Pilot Site, mostly because this region was the stage of the devastating extreme wildfires occurred in 2017, which resulted in massive losses and many deaths. New products – FirEURisk Products – were developed for this area, addressing three key pillars of the FirEURisk project: fire risk assessment, reduction, and adaptation. The Demonstration Event agenda was developed considering these components or topics to better integrate solutions and to encourage subsequent discussions aiming at the obtainment of feedback from the audience. Moreover, a post Demonstration Event debriefing session was organized on the 13th of November2023 involving a group of 10 experts who participated in the Demonstration Event. They were selected according to their potential interest in using FirEURisk products. All attendees received product descriptions before the Demonstration Event to improve their knowledge and understanding of the products. During the Demonstration Event and the debriefing session, attendees provided suggestions and feedback on the products that were presented.

The Demonstration Event effectively engaged multiple relevant stakeholders and managers. The combination of the Demonstration Event with the debriefing session yielded valuable and practical insights to enhance the integration of the presented products and their upcoming use into the day-to-day working activities of the attendees. Overall, all participants revealed that the products presented were well-suited to their operational territory (scoring 4.2 on a 5-point scale), generated much interest (8.0 on a 10-point scale), and were expected to have a high impact on the territory (7.3 on a 10-point scale). The assessment of suitability, interest, and impact was higher for products in the risk assessment component, followed by the reduction and adaptation components. Participants considered that the products were developed in line with their needs and did not suggest that relevant improvements had to be made. They also expressed a desire to continue following up the project's results and showed expectation to see the final outcome of the products aggregated on the FirEURisk platform, which they considered highly useful and well-conceived (averaging 4.1 on a scale of 0 to 5). In summary, the outcome was highly encouraging and constructive. Attendees provided us with positive and valuable feedback that will be included in other activities of the FirEURisk project.

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# List of Acronyms

*Table 1: List of Acronyms*

| List of Acronyms | |
|---|---|
| ADAI | Association for the Development of Industrial Aerodynamics |
| AGIF | Agency for Integrated Rural Fire Management |
| ANEPC | National Emergency and Civil Protection Authority |
| BP | Burn probability |
| CCDRC | Centre's Regional Coordination and Development Commission |
| CFA | Crown fire activity |
| CIM | Intermunicipal Community |
| DE | Demonstration Event |
| FEPC | Special Civil Protection Force |
| FMC | Fuel moisture content |
| FMD | Fuel model |
| FMUC | Faculty Medicine of the University of Coimbra |
| FL | Flame length |
| GMV | GMV Aerospace and Defence Sa |
| GNR | National Guard |
| GTF | Forestry technical office |
| ICNF | National Forestry Institute |
| IJUC | University of Coimbra Law Institute |
| IP | Ignition probability |
| IPMA | Portuguese Sea and Atmosphere Institute |
| ISEC | Coimbra Institute of Engineering |
| ISIG | Institute of International Sociology |
| NCSRD | National Centre for Scientific Research Demokritos |
| PS | Pilot Site |
| SDI | Suppression difficulty index |
| SEPNA | Nature and Environment Protection Service |
| UA | University of Aveiro |
| UAH | University of Alcalá |
| UEPS | Emergency, Protection and Relief Unit |
| USTO | Sciences and Technology University of Oran |
| WUI | Wildland-urban interface |

# 1 Introduction

The Demonstration Event agenda was created based on the needs of end-users identified beforehand (referencing FirEUrisk - FirEUrisk_D34_D5.1_User requirements database and report_v1.0.pdf). The showcased products were selected to enhance integration among the identified needs and topics, as well as to facilitate their future use. It is important to emphasize that the FirEUrisk project aims to strengthen solutions during the prevention phase, and better organizing and coordinating responses to wildfires, considering the foreseeable need to adapt fire management due to climate change, among other factors affecting the wildfire statistic trends. The integrated strategy of FirEUrisk serve as the foundation for product development, as these products are integrated into components used to calculate wildfire risk (Chuvieco et al., 2023), as shown below.

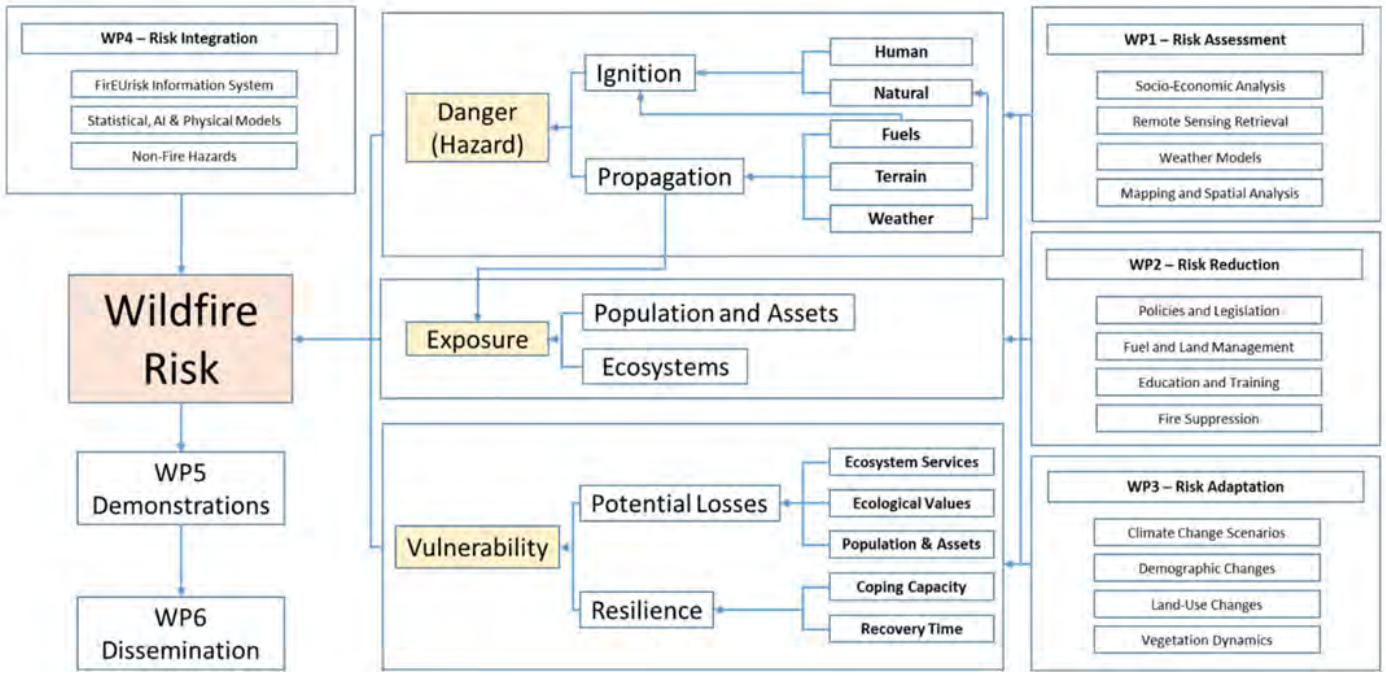


*Figure 1. FirEUrisk's integrated strategy to calculate wildfire risk. Source: FirEUrisk project.*

## 1.1 The FirEUrisk project

The FirEUrisk Project seeks to enhance and standardize current European strategies by integrating socio-economic factors inducing extreme wildfire occurrences alongside biophysical conditions like vegetation and climate. This comprehensive approach enables a deeper comprehension of communities' vulnerability to wildfires and identifies optimal adaptation practices.

The FirEUrisk project encompasses six pilot sites – PS1: Southeast Sweden, PS2: Southern Brandenburg and eastern Saxony (Germany), PS3: Central Region of Portugal, PS4: Barcelona Province (Spain), PS5: Attica Region (Greece), and PS6: European Territory. The Demonstration Event described in this deliverable pertains to the pilot site PS3 situated in Central Region of Portugal. To date, only deliverable D5.9 (D5.9 - Report of FirEUrisk 4 Pilot Site Demonstration) has been released, reporting the Demonstration Event focused on pilot site in Barcelona Province (Spain).

Within FirEUrisk, several products were developed for implementation by stakeholders in wildfire management across Europe. A total of 80 products were created, categorized into three components: assessment, reduction, and adaptation, in alignment with the project's technical framework: WP1: Risk Assessment, WP2: Risk Reduction, and

WP3: Risk Adaptation. However, due to time constraints and practical considerations, only 15 products were showcased during the Demonstration Event.

## 1.2 The Portuguese Pilot Site – Intermunicipal Communities of Coimbra and Leiria Regions

The Pilot Site PS3, situated in the Central Region of Portugal, encompasses two Intermunicipal Communities (NUTS 3): the Coimbra Region Intermunicipal Community (CIM Coimbra) comprising 19 municipalities, 2561 villages over an area of 4336 km², and the Leiria Region Intermunicipal Community (CIM Leiria) including 10 municipalities, 2145 villages distributed by 2449 km² (Figure 2).

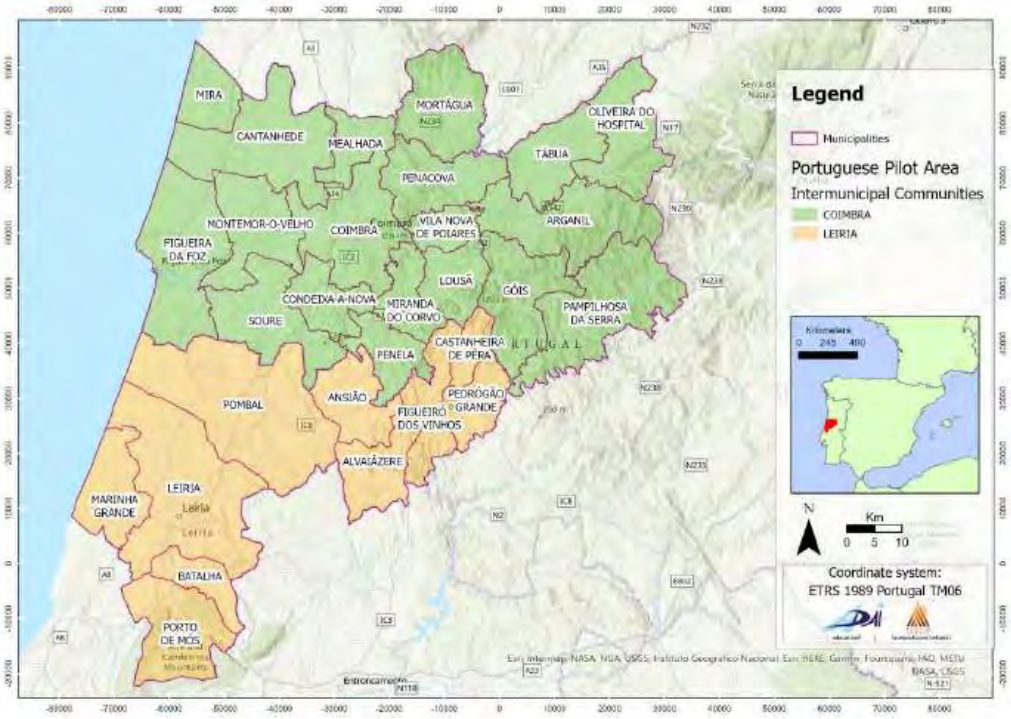


*Figure 2. Area covered by the PS3 Pilot Site in the Central Region of Portugal.*

(a) (b)

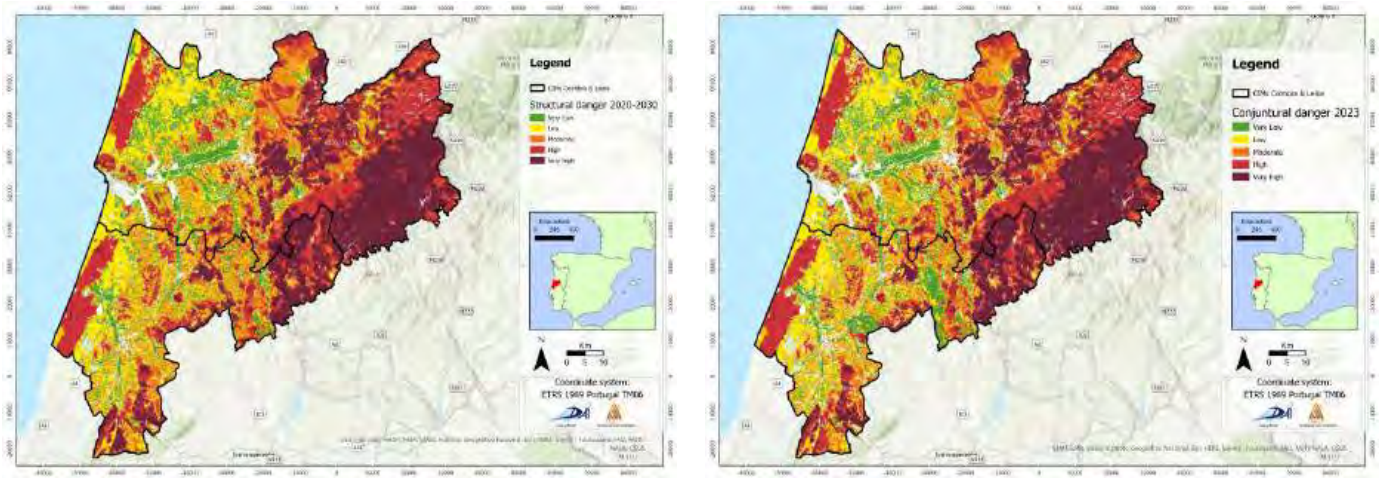


*Figure 3. a) Structural fire danger for the period 2020-2030, and b) 2023 conjunctural fire danger in the area covered by the PS3 Pilot Site in the Central Region of Portugal.*

This region is highly susceptible to wildfires, particularly in its eastern mountainous forested areas and in two longitudinal forest patches along the western coastline, where the fire danger is notably higher (Figure 3).

Socially, the area exhibits significant heterogeneity. The coastal regions to the west have a younger population with higher education levels, and higher population and infrastructure density. Conversely, the inland regions to the east are characterized by an older demographic engaged primarily in agroforestry and livestock activities. The migration of residents from these inland areas to larger coastal cities has led to a decline in population density and inhabited buildings. Consequently, there has been an increase in abandoned or poorly managed agroforestry areas, exacerbating the wildfire risk.

The high fire risk in this region was starkly manifested in the catastrophic fires that ravaged Portugal in 2017, namely the Pedrogão Grande fires on June 17$^{th}$, and the set of fire events on October 15$^{th}$. Figure 4 illustrates the extent of the largest fires during these events, revealing that the PS3 pilot site area encompasses most of these significant fires. Remarkably, these areas coincide with the regions of highest fire danger depicted in Figure 3.

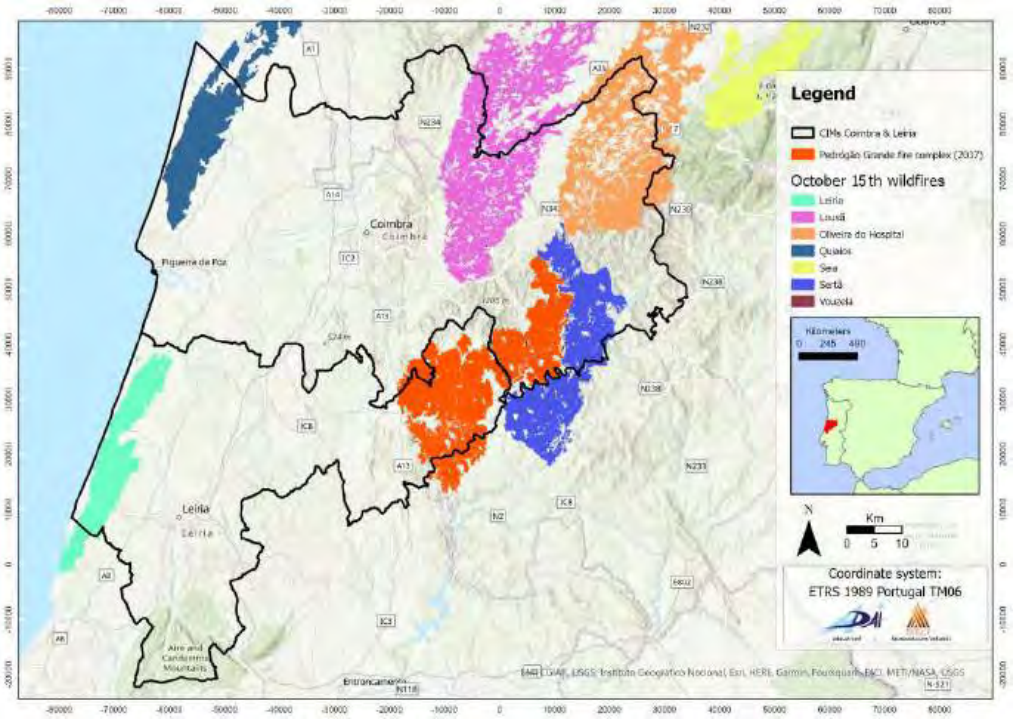


*Figure 4. The 2017 main fires in Portugal and the pilot site PS3 area.*

## 1.3 PS3 Demonstration Event objectives

The main objectives of the Demonstration Events consist of disseminating and evaluating the FirEUrisk products, as well as obtaining any potential improvement proposals, namely:

- Publicly disseminating the project and the developed products, with a particular focus on potential users in Portugal.
- Evaluating the quality of the FirEUrisk products:
    - Assessing the level of interest they generate among potential users.
    - Determining them suitability for the real requirements of risk managers' activities.
    - Understanding participants' perception of them impact can have on the current risk management.
- Obtaining feedback regarding possible improvements in the development of FirEUrisk products.

Since the Demonstration Event was based on the Pilot Site PS3, in central Portugal, the objectives of it primarily focused on this region. Although this Demonstration Event had participation from many people from other regions of Portugal and even from other countries, most participants, and consequently the feedback received, pertained to the central zone of Portugal, which can naturally be extended to other areas.

## 1.4 Purpose of the document

This document aims to comprehensively report relevant aspects associated with the Demonstration Event dedicated to the Central Region of Portugal (PS3), including actions taken, participation, outcomes and more. The document is divided into two main components:

1. Demonstration Event in numbers and features, detailing key statistics and characteristics of the event.
2. Demonstration Event outcomes and lessons learned, outlining outcomes and lessons learned from the Demonstration Event, with relevant feedback from the DE participants, and insights to be integrated into future events.

Furthermore, this document incorporates stakeholder involvement before, during, and after the Demonstration Event. We strive for a practical approach to integrating end-users' perspectives and assessments on the various products presented. The results of the interactive tool used (Mentimeter – "an online presentation-building tool that facilitates audience engagement") and the main outcomes of the debriefing meeting will also be showcased, as they are crucial for validation purposes.

## 1.5 Structure of the Document

The document is structured to facilitate a clear understanding of the key outcomes and insights gathered during the PS3 DE. It begins with a brief introduction highlighting the features and key aspects of PS3. Following this introduction, the document provides details of the event and presents product cards with a description of the FirEUrisk Products addressed in the Demonstration Event. An additional chapter is dedicated to lessons learned focusing on insights crucial for enhancing products and their future utilization. To conclude, main conclusions and recommendations are listed. Additional materials are included as annexes to ensure the document remains comprehensive yet concise.

# 2 Implementation of the PS3 Demonstration Event

## 2.1 Demonstration Event highlights

The Demonstration Event took place at the CCDRC headquarters, which has a maximum capacity of 100 participants. Following invitations to key entities and stakeholders, particularly those organizations and personalities with official involvement in fire management, especially in the areas covered by the event, participation was then open to all end-users interested or engaged with the FirEURisk project. ADAI performed a wide dissemination through their contacts' network by sending an email to several hundreds of potential attendees. Additionally, the DE was promoted on FirEURisk's website and social networks to encourage participation from multiple stakeholders.

100 registrations for attendance in person were carried out of which 85 attenders were present in person. For those who registered, the product cards and the event agenda were sent via email prior to the event.

To accommodate participants from different regions of Portugal and worldwide, the event was held in a hybrid format combining in-person attendance with a Zoom Webinar connection. During the registration process the participants were asked if they had difficulties following presentations in English or Portuguese, depending on their native language, and 60% answered that to be the case. Therefore, live translation between both languages was provided, both in the CCDRC auditorium and in the Zoom transmission, to ensure understanding for all participants.

It's worth mentioning that CCDRC hosted the event without charging any venue fees.

The recording of the Demonstration Event is available on CEIF's YouTube channel (https://www.youtube.com/watch?v=Ni_0InyMCiE), and the PowerPoint slides are available in Annex A.

## 2.2 Meeting Agenda

The program of the Demonstration Event was designed to assure the presentation of the FirEURisk products that could have greatest interest for implementation in Portugal. To facilitate the follow-up of the event, the program was divided into panels dedicated to each technical work package of the project (WP1-WP3). Thus, after an introductory session in which the project and the PS3 area were presented, four panels were held to present the products: a) Risk Assessment Panel (WP1), from 09:50 to 12:05, featuring the presentation of five products, b) Risk Reduction Panel (WP2), from 12:05 to 13:15 and from 14:20 to 15:20, where six FirEURisk products were presented, c) Risk Adaptation Panel, from 15:20 to 16:20, involving 3 products, and d) presentation of the FirEURisk Platform, which integrated all the topics covered in the previous panels. At the end of each session, there was a period for clarifying doubts about the presentations of the respective panel and for collecting feedback from the participants. At the end of all sessions, a period was provided for debate and free intervention by all participants. The closure of the Demonstration Event was completed with the presence and intervention of the Portuguese Minister of Internal Affairs, who expressed his satisfaction with the project and its results, as well as the interest in incorporating the project results into the national fire management system.

| Hora | Topic | Presenter |
|---|---|---|
| 08:45 | Registration | |
| 09:15 | Welcome and FirEUrisk project presentation | Domingos Viegas<br>ADAI, University of Coimbra, Portugal<br>Anselmo Castro<br>CCDR-Centro, Portugal |
| 09:25 | Scientific overview of FirEUrisk | Emilio Chuvieco<br>University of Alcala, Spain |
| 09:40 | Presentation of Pilot Site 3 (PS3) | Miguel Almeida<br>ADAI, University of Coimbra, Portugal |
| 09:50 | Human ignition probability map | Marcos Rodrigues,<br>University of Zaragoza, Spain |
| 10:05 | Fuel type and model map | Pegah Mohammad Pour<br>ADAI, University of Coimbra, Portugal |
| 10:20 | Coffee-break | |
| 10:50 | Wildland - Urban Interface map | Avi Bar-Massada<br>University of Haifa, Israel |
| 11:05 | Wildfire propagation potential | Luís Mário Ribeiro<br>ADAI, University of Coimbra, Portugal |
| 11:20 | Socio-economic vulnerability | Ramona Velea /Riccardo Laterza<br>Institute of International Sociology of Gorizia, Italy |
| 11:35 | Q&A | Luís Mário Ribeiro (moderator)<br>ADAI, University of Coimbra, Portugal |
| 12:05 | Fuel Management Framework for Reducing Operation-based Ignitions | Vassiliki Varela<br>University of Thessaloniki, Greece |
| 12:20 | Maps of suitable areas for LMS use | Alex Neidermeier<br>University of Vrije Amsterdam, Netherland |
| 12:35 | Fire behaviour and Smoke dispersion predictive models | Domingos Viegas[1] and Ana Isabel Miranda[2]<br>[1]ADAI, University of Coimbra, Portugal<br>[2]University of Aveiro, Portugal |
| 12:50 | Curricula for extreme fires and WUI | Sébastien LAHAYE<br>SAFE Cluster, France |
| 13:15 | Lunch (CCDR) | |
| 14:20 | Guidelines to reduce communities' vulnerability to extreme fires and fires in WUI | David Caballero<br>Meteogrid, Spain |
| 14:35 | Citizens/scientist network and Engagement Plan | Ramona Velea<br>Institute of International Sociology of Gorizia, Italy |
| 14:50 | Q&A | Miguel Almeida (moderator)<br>ADAI, University of Coimbra, Portugal |
| 15:20 | Future climate information | Jaime Ribalaygua<br>Meteogrid, Spain |
| 15:35 | Continental land-use change scenarios and stylized fuel management scenarios | Alex Neidermeier<br>University of Vrije Amsterdam, Netherland |
| 15:50 | Future fire regime database | Kirsten Thonicke |

| Hora | Topic | Presenter |
|---|---|---|
| | | Instituto Potsdam for Climate Impact Research, Germany |
| 16:05 | Q&A | Domingos Viegas (moderator)<br>ADAI, University de Coimbra, Portugal |
| 16:20 | FirEUrisk Display Platform | Alejandro Barrios / Petteri Vuorinen<br>Arbonaut Lda., Finland |
| 16:35 | Q&A | Tiago Rodrigues (moderator)<br>ADAI, University of Coimbra, Portugal |
| 16:45 | Wrap-up and debate | Domingos Viegas<br>ADAI, University of Coimbra, Portugal |
| **17:00** | **Closure** | **In the presence of His Excellency, the Minister of Internal Affairs José Luís Carneiro** |
| **Social Coffee** | | |

## 2.3 Attendance characterization

As mentioned before, this was a hybrid event, therefore we will characterize both audiences in separate. In both groups, most of the audience was Portuguese, which is understandable as the Demonstration Event focused on the Pilot Site in the Central Region of Portugal and the FirEUrisk products developed for this area.

### 2.3.1 Presential audience

A total of 85 persons attended the Demonstration Event at CCRDC. As can be seen in Figure 5, from these 85 attendants, 76 were Portuguese, and included the audience and members of the FirEUrisk consortium from. From the foreign participants, 4 also belonged to the project (2 from Spain and 2 from Italy).

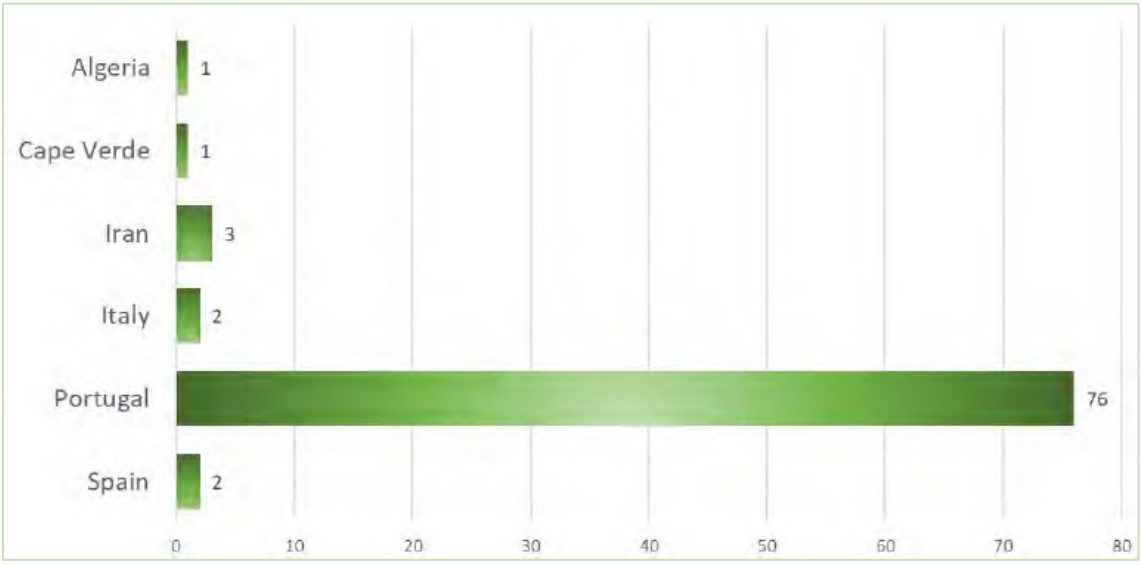


*Figure 5. Distribution of presential participants by country of origin.*

Regarding their professional activity, we grouped the attendees by categories to simplify the analysis, as shown in Figure 6. The majority belonged to research teams or universities, and some of them were related with the project

itself. There are three Portuguese partners (ADAI, UA and IPMA) and 2 Portuguese Linked Third Parties related to academia (IJUC, FMUC) represented in the audience or in the speakers.

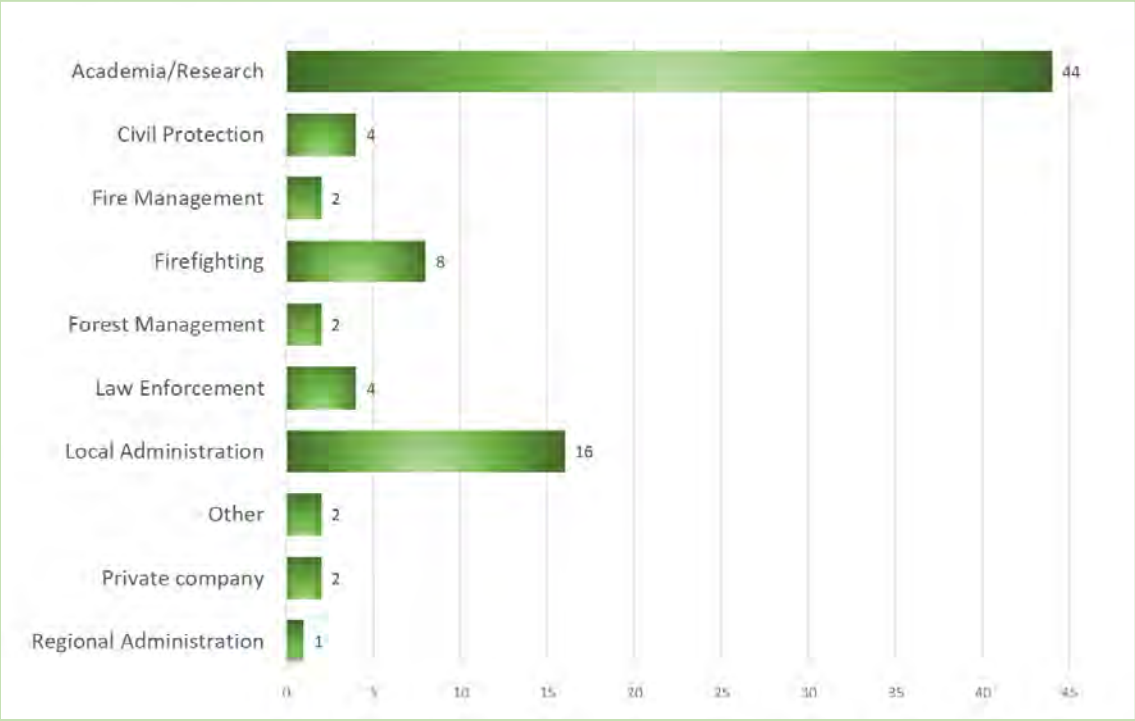


*Figure 6. Distribution of presential participants by Organization type of origin.*

"Local Administration" appears in second place with 16 representatives. This refers mainly to technicians from municipalities that have some responsibility in fire management. "Firefighters" (8) include volunteers from fire brigades in the pilot region, and civil protection and law enforcement related attendees belong to the national fire management structure. In the "Fire Management" category there are two representatives of the Portuguese Agency for Integrated Rural Fire Management (AGIF).

### 2.3.2 Remote audience (Zoom webinar)

Without much surprise, the number of remote attendees was considerably larger than the presential one, with 265 participants via the Zoom Webinar application. Again, as depicted in Figure 7, the vast majority was from Portugal (230), which was most probably due, not only to the extensive network of contacts that ADAI has in the country but also to the great interest that the topic has aroused, particularly in the fire and forest management community working in the pilot site.

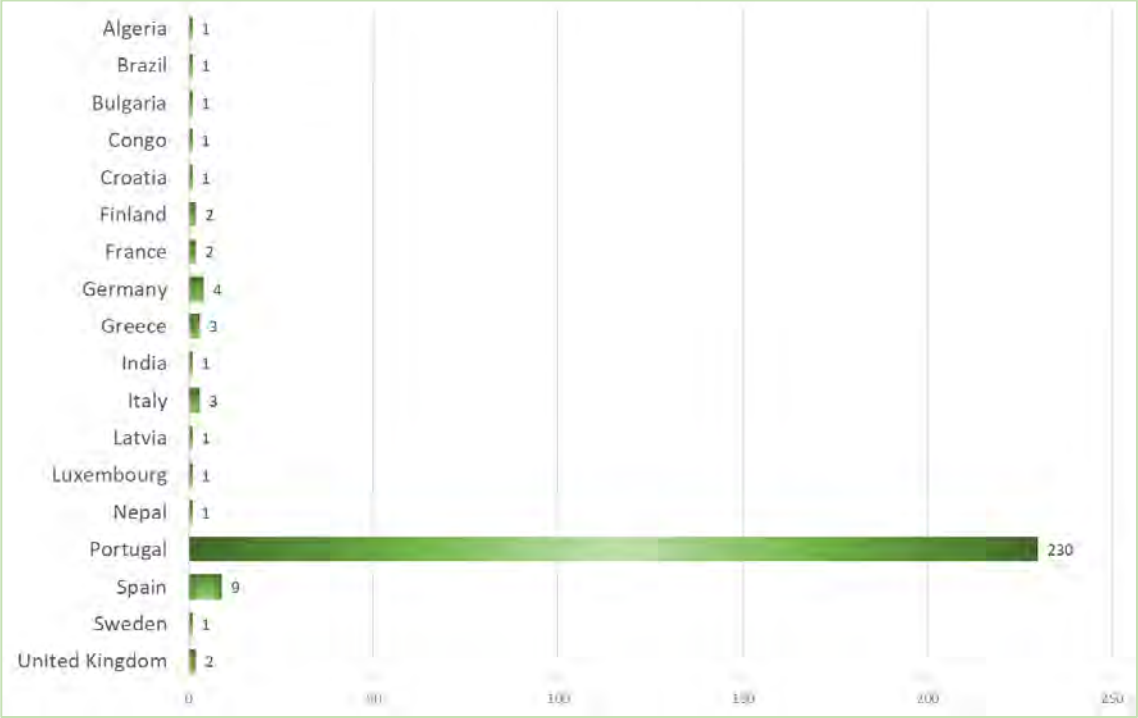


*Figure 7. Distribution of remote participants by country of origin.*

As can be seen, the DE had participants from 18 countries. Spain was the second most represented country (9), followed by Germany (4) and Greece and Italy (3).

Regarding the organization type of the remote attendees, the general tendencies are similar to the presential ones, although the academic audience is no longer in first place. Most Zoom attendees belong to "Local Administration", again almost entirely technicians from the municipalities. In second place are firefighters (55), but this time including not only volunteers, but also professional (9) and elements from the Portuguese National Training School (2). Academia/research comes third with 44 attendees, coincidently the same number as in the presential group. As in the presential audience, "Law Enforcement" (23) was related to elements from the Portuguese national bodies that have responsibilities in surveillance, inspection, firefighting, traffic control, evacuations or other.

We highlight the considerable number of private companies that attended the event (21). Although some of them didn't specify, we could identify companies related to insurance, energy distribution, software, and nature services, among others.

As for civil protection (15), the assistance was divided between elements from the National Agency and municipal groups. "Forest Management" (16) was composed of attendees from the National Forestry Institute (ICNF) and from private associations of forestry owners.

"Regional Administration" included individuals from the intermunicipal communities (similar to the CIM Coimbra and CIM Leiria that compose the Pilot Site PS3) and regional governmental offices.

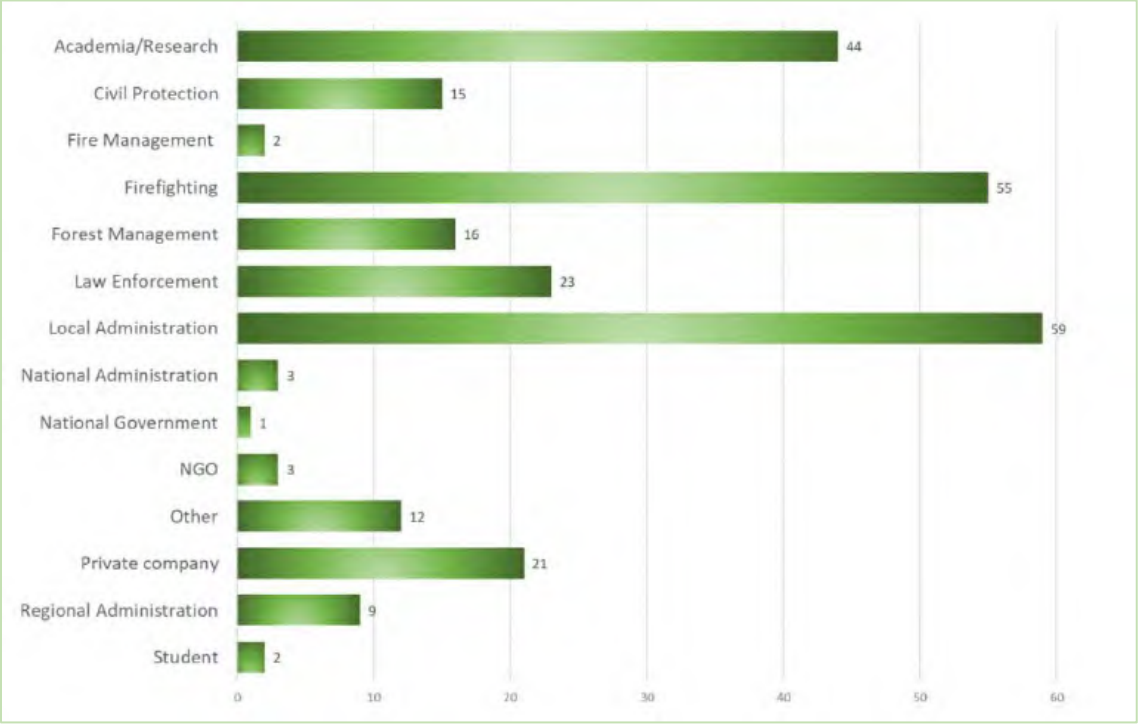


*Figure 8. Distribution of remote participants by Organization type of origin.*

# 3 Products Description

In this chapter, we present a description of the products showcased at the Demonstration Event. Each product is associated with a reference assigned to all FirEUrisk products. The following sections follow the order of presentation in the agenda and not the product reference number.

The description provided for each product is a transcription of the text from each product card (D5.3 - Report on the Standardisation of the Demonstration Products) written those responsible for each product's development.

## 3.1 Product 63. Human ignition probability

- **Session:** Probability of human-caused ignitions in Central Portugal. Marcos Rodrigues University of Zaragoza and Adrián Jiménez-Ruano 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. Developer: UdL. 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, percentage of urban/agricultural/wildland covers).
- **FirEUrisk component of the integrated strategy:** Human ignition
- **https://fireurisk.satways.net/datasets/6343d705e4b0b33bef3a249f#folderId=637f9bffe4b0b33bef3c3dfb&page=0**
- **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** |
| **Spatial resolution:** | **100m (1 ha)** |
| **Data accessibility:** | **https://fireurisk.satways.net/datasets/6343d705e4b0b33bef3a249f#folderId=637f9bffe4b0b33bef3c3dfb&page=0** |

- **Overview:**

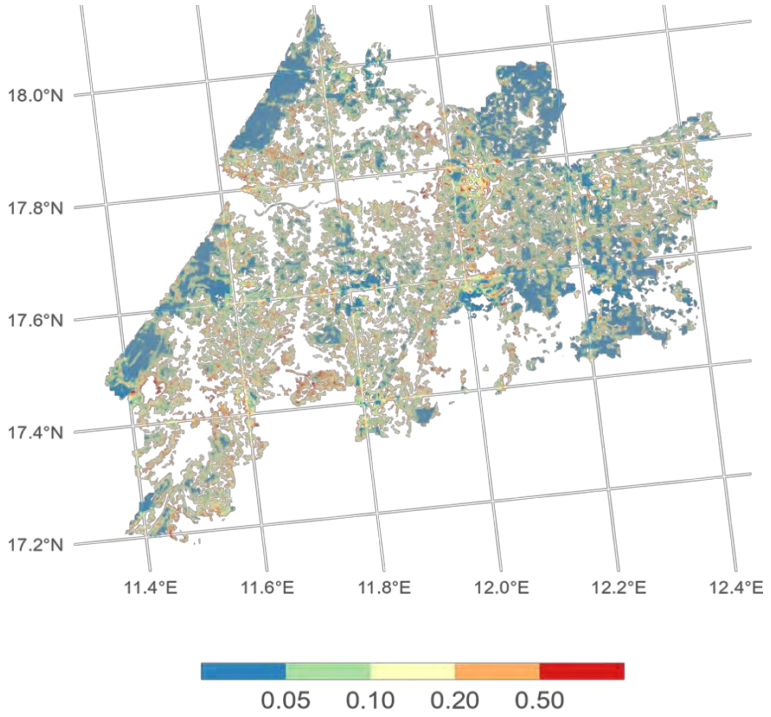


*Figure 9. Human ignition probability map (PS3, Portugal).*

### *Proved accuracy at Demonstration Area and top fire drivers.*

Area under the curve of 0.87. Top fire driver: fuel types, Percentage wildland coverage, Population density, Distance to WGI and WUI.

Product 63. Human ignition probability.

## 3.2 Product 2. Fuel type and model map

- **Session:** Vegetation fuel type map. Pegah Mohammadpour, ADAI and Domingos Viegas, ADAI and Emilio Chuvieco UAH.
- **Developer:** ADAI (Portugal) and UAH (Spain).
- **Activity:** "A1.1.4 Risk-wise landscape and fuel models development".
- **Product description:** The product includes the fuel type and parameters following the standard classification of fuels for the European territory. The final output – fuel classes and static fuel map with the spatial resolution of 100 m.

- **Methodology:** Advanced classification models were applied to LiDAR (GEDI and ICESAT-2), multi and hyperspectral satellite imagery (Sentinel-2, Sentinel-3, PRISMA) for fuel type mapping, using standardised datasets from systematic field campaigns, lab experiments, forest inventory data and biophysical models. Surface fuel and canopy metrics (canopy cover, canopy height, canopy base height and canopy bulk density) are parameterised for running propagation potential (Flammap or FCCS). Custom fuel models were described for special interest ecosystems: Detailed description of algorithm of calculation and data sources available https://edatos.consorciomadrono.es/dataset.xhtml?persistentId=doi:10.21950/YABYCN>
- **FirEUrisk component of the integrated strategy:** Propagation (fuel)
- **https://fireurisk.satways.net/datasets/62d662b9e4b0b33bb117b801Technical characteristics:**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Geospatial |
| Units: | Fuel classes |
| Update Frequency: | Static layer |
| Accuracy: | - |
| Output Format: | .tiff |
| Fire risk component (accordingly to the Integrated Scheme of the FirEUrisk project): | Propagation (fuel) |
| Temporal coverage: | Developed for 2020 |
| Spatial resolution: | 100 m |
| Availability on FirEUrisk platform: | https://fireurisk.satways.net/datasets/62d662b9e4b0b33bb117b801 |

**PS3:**

| Features | Primary map | Final map |
|---|---|---|
| Overall Accuracy | 88.94% ±1 | 83.62% ±1 |
| Min Producer Accuracy | 72.13% | 64.51% |
| Min User Accuracy | 60% | 50% |
| Mean F1-score | 87.65% | 83.45% |

- **Overview:**

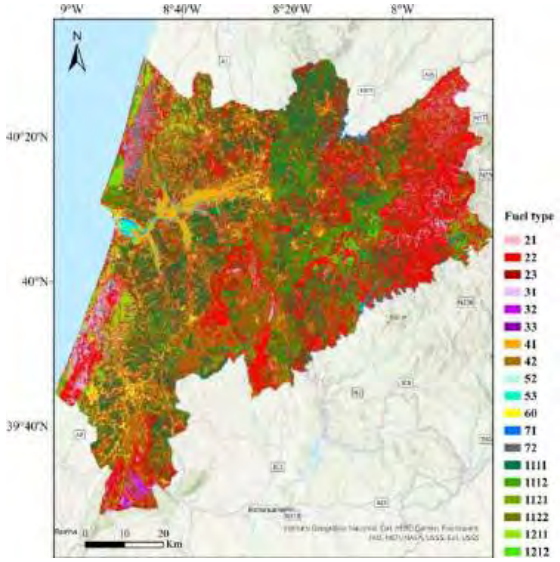


*Figure 10. PS3 vegetation Fuel Type Map.*

Product 2. Fuel type and model map

## 3.3 Product 18. Wildland - Urban Interface map

- **Session:** The Wildland Urban Interface in Central Portugal. Avi Bar-Massada, HU (Israel).
- **Developer:** HU (Israel).
- **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. Detailed description of algorithm of calculation and data sources available here: https://www.sciencedirect.com/science/article/pii/S0169204623000786
- **FirEURisk component of the integrated strategy:** Exposure/vulnerability (Population-Assets)
- **https://fireurisk.satways.net/collection/62bab3dee4b0b33bb116f8ea**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Geospatial product |
| Units: | Categorical: 0 - non WUI, 1 - intermix WUI, 2 - interface WUI |
| Update Frequency: | Static layer |
| Accuracy: | 80-90% |
| Output Format: | .tiff |
| Fire risk component: | Exposure/vulnerability (Population-Assets) |
| Temporal coverage: | 2020 |
| Spatial resolution: | > 1 ha (10m) |
| Availability on FirEURisk platform: | https://fireurisk.satways.net/collection/62bab3dee4b0b33bb116f8ea |

- **Overview:**

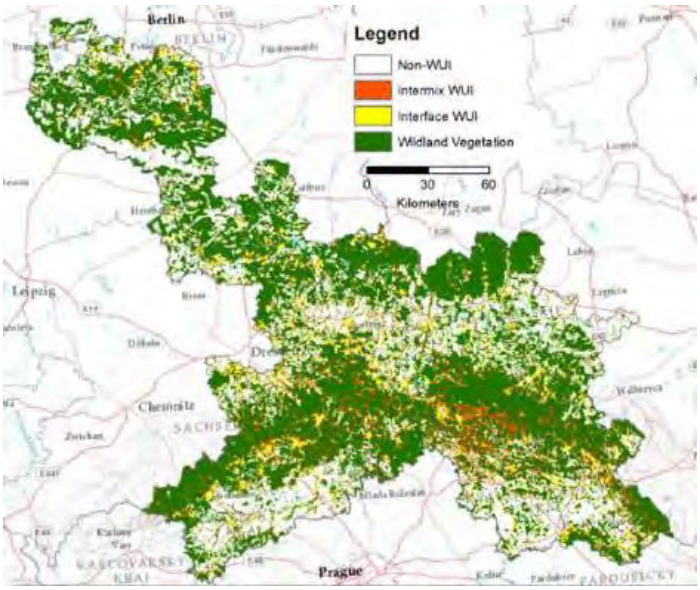


*Figure 11. Example of WUI map.*

## 3.4 Product 32. Propagation potential indicators for Pilot Sites (PS)

- **Session:** Propagation Potential in Pilot Site 3 – Central Portugal. Luís Mário Ribeiro, ADAI (Portugal).
- **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.
- **Methodology:** Propagation potential is important part of Wildfire risk estimation having direct influence on Danger (hazard) and Exposure. In this document a detail methodology for propagation potential calculation on Pilot Sites (PS) level is presented, as well as analysis of all necessary input data and how they could be collected for FirEURisk Pilot Sites (PS). Well known software for wildfire behaviour simulation FlamMap has few 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
- **https://fireurisk.satways.net/collection/**
- **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 |
| Availability on FirEUrisk platform: | Yes, on FirEUrisk DataHub |

Product 32 Propagation potential indicators for Pilot Sites (PS)

## 3.5 Product 68. RESVI - Relative Societal Vulnerability Index (at community level)

- **Session:** Assess societal vulnerability to wildfires by involving local communities: the resvi tool. Ricardo Laterza, ISIG (Italy).
- **Developer:** Ricardo Laterza, ISIG (Italy).
- **Activity:** "1.2.2 – Societal vulnerability and resilience assessment".
- **Product description:** This product helps local communities (namely local institutions, stakeholders, and practitioners) in assessing their level of societal vulnerability *vis-à-vis* wildfire hazard. It also allows for the elaboration of resilience strategies tailored at the local community level. The RESVI comprises quantitative and qualitative data for five dimensions of societal vulnerability (social, economic, institutional, human capital and environmental) and elaborates a relative index based on the comparison among similar communities and/or their higher administrative tiers.
- **Methodology:** RESVI approach has been developed and implemented by ISIG in such projects: ECOSTRESS DG ECHO, RESILOC H2020, RESBA and RISKGEST. RESVI has been adapted within FirEUrisk project for the

assessment of social vulnerability to wildfires at community level that is based on both quantitative and qualitative methods and data. The index is built within a relative perspective, given the fact that there is no absolute threshold under or above which the vulnerability of a community may be considered (in absolute terms) high or low. This instrument is thus intended to support communities in assessing their own vulnerability against other areas of reference (e.g., higher administrative tiers, or same-level administrative units), ultimately contributing to a peer-to-peer learning process across local communities in the EU. Detailed description of algorithm of calculation available here:

1) ECOSTRESS Project, (2015). Relative Social Vulnerability Index and SWOT Analysis of Coastal Case Studies in the Upper Adriatic.

2) RESILOC Project, (2020). Analysis of Vulnerability. Performed by ISIG. Available on request.

- **FirEUrisk component of the integrated strategy:** Coping capacity
- **https://fireurisk.satways.net/collection/**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Database |
| Units: | Dimensions, indicators, and proxies composing a relative index on a 0-1 scale |
| Update Frequency: | Customisable (Yearly updates based on the availability of data) |
| Accuracy: | N/A |
| Output Format: | .xls |
| Fire risk component: | Coping capacity |
| Temporal coverage: | N/A |
| Spatial resolution: | Territorial administrative units in the area of analysis (e.g., for the Barcelona and Central region of Portugal Pilot Site analysis focus on Municipalities of the Province of Barcelona + the Province of Barcelona as a whole + the State and municipalities and intermunicipalities of Coimbra and Leiria, respectively) |
| Availability on FirEUrisk platform: | |

Product 68 RESVI - Relative Societal Vulnerability Index (at community level)

## 3.6 Product 55. Fuel Management Framework for Reducing Operation-based Ignitions (FuMaF_ROI)

- **Session:** Fuel management for reduction of operation-based ignitions. Vassiliki Varela, AUTH (Greece).
- **Developer:** Vassiliki Varela, AUTH (Greece).
- **Activity:** "A2.1.2 – Reducing operations-based fire ignitions".
- **Product description:** The Product is a document that implements a fuel management framework, including procedures, rules-of-thumb, methods, and spatial data layers specifications, for the reduction of operation-based ignitions.
- **Methodology:** The Product is built on top of a methodology developed in the PREFER project . Methodology is properly adapted to operation-based ignitions (critical infrastructures and essential networks (lifelines), such as power grid, road and railway networks, which are linked with several ignitions of wildfires). The methodology is elaborated by the partners involved in A2.1.2 (AUTH, SIA, ADAI, ARBO and CNR as the Leader of T2.1). The methodology includes 3 different steps:

A. On a larger scale, overlay the layers of the networks or point assets (installations, stations) on the vegetation layers (fuel map and / or satellite images) in order to identify the areas where the vegetation crosses a concrete buffer zone across the path of the network.
B. On a smaller scale, in the areas that have been identified in step A, which are the ones challenged by the presence of vegetation being very close to the operational network, use drone flights along the network line to identify the places that need fuel treatment.
C. The information derived from step B will be elaborated to prioritize the interventions and define the type of treatments that should be applied in different cases .
Although the activity focuses to ignition reduction, it will also consider the potential impact the fire would have to the envisaged infrastructure due to the landscape features, including the vegetation type and status.

- **FirEUrisk component of the integrated strategy:** Propagation/fuel
- **https://fireurisk.satways.net/collection/**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Document / Geospatial |
| Units: | Not applicable |
| Update Frequency: | Static (can be subsequently updated) |
| Accuracy: | Not applicable |
| Output Format: | .tiff |
| Fire risk component: | Propagation / Fuel |
| Temporal coverage: | The outputs will be valid until significant changes in the input data occur (e.g., significant changes in fuel types and/or load, infrastructure, land use etc.) in the area of interest. |
| Spatial resolution: | 1 ha < (1–20 m). |
| Availability on FirEUrisk platform: | Yes |

Product 55 Fuel Management Framework for Reducing Operation-based Ignitions (FuMaF_ROI)

## 3.7 Product 13. Maps of suitable areas for Land Management Strategy (LMS) use

- **Session:** Addressing fire risk through land management. Alex Neidermeier, VUA (Netherland).
- **Developer:** Alex Neidermeier, VUA (Netherland).
- **Activity:** "A2.2.4 Mapping & Guidelines for LMS".
- **Product description:** Our study explored the suitability of three land management strategies (LMS)—herbivory, mechanical fuel removal, and prescribed burn—which can create more heterogenous fuelscapes, thereby reducing an element of fire risk. We created suitability maps for each of the LMS using adoption factors identified in a systematic literature review (n = 123). We compared these maps with areas of historical fire occurrence to prioritize key areas for intervention. Please see publication below (Neidermeier et al. 2023) for further details and data download.
- **Methodology:** Spatial data proxies representing the LMS' suitability can be summarized as follows:
*Grazing/ herbivory suitability*: Areas with domesticated or wild grazers/ browsers; relatively high accessible; suitable pasture; and located outside major settlements.

*Mechanical fuel removal suitability:* Areas with forest biomass available for industry; which are closer to known biomass powerplants; are accessible for equipment and labour; and are not located on prohibitively steep slopes.

*Prescribed burn suitability:* Areas with a minimum number of prescribed burn days; adequate accessibility for equipment, labour, & emergency response; located outside of major settlements.

- **FirEURisk component of the integrated strategy:** Propagation/fuel
- **https://fireurisk.satways.net/collection/**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Geospatial |
| Units: | Suitable areas for LMS |
| Update Frequency: | Static |
| Accuracy: | N/A |
| Output Format: | .tiff |
| Fire risk component (accordingly to the Integrated Scheme of the FirEURisk project): | Propagation-Fuels |
| Temporal coverage: | Current |
| Spatial resolution: | 1 $km^2$ |
| Availability on FirEURisk platform: | - |

- ***Overview***

We found that over a quarter of Europe was suitable for multiple LMS within areas of higher historical fire occurrence, creating opportunities for concurrent and synergistic use of the strategies. Options were more limited in areas of southern Europe, where prescribed burn was found to be uniquely viable amongst the LMS evaluated. Opportunities were also restricted in some areas in northern Europe, where herbivory was found to be the only suitable LMS.

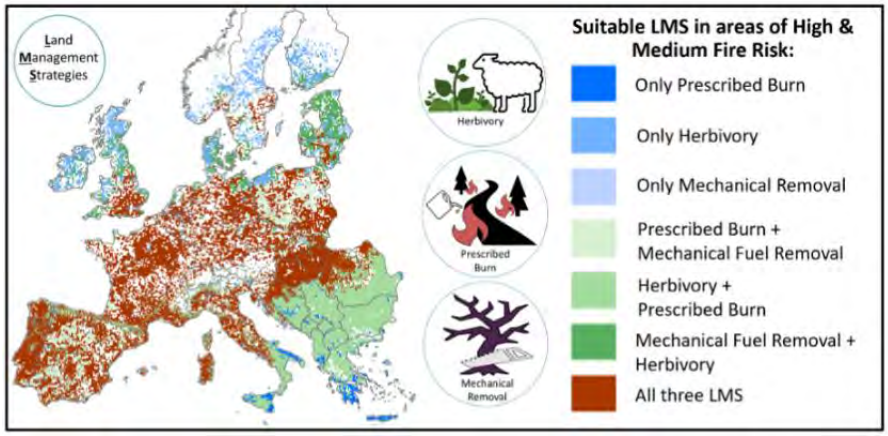


*Figure 12. Areas of high and medium (>33%) LMS suitability in areas of high and medium (>33%) historical fire occurrence. Areas in white had low LMS suitability and low fire occurrence. From: Neidermeier, A.N., Zagaria, C., Pampanoni, V., West, T.A.P., Verburg, P.H., 2023. Mapping opportunities for the use of land management strategies to address fire risk in Europe. Journal of Environmental Management 346, 118941. https://doi.org/10.1016/j.jenvman.2023.118941*

Product 13 - Maps of suitable areas for Land Management Strategy (LMS) use

## 3.8 Product 23. Extreme Fire Behaviour Modelling

- **Session:** Fire spread and smoke modelling. Domingos Viegas, ADAI (Portugal) and Ana Miranda, UAVR (Portugal).
- **Developer:** Domingos Viegas, ADAI (Portugal).
- **Activity:** "A2.3.1 Extreme Fire Behavior Modelling".
- **Product description:** The product allows to estimate the ROS of the head fire in some situations of Extreme Fire Behaviour, associated to the interaction between the atmosphere and the burning fire that induce a dynamic change of the ROS which is not considered in current fire behaviour simulators.
- **Methodology:** The product proposes a semiempirical method to estimate the dynamic behavior of a fire considering the interaction between the fire and the atmosphere that consists usually in a fire acceleration and deceleration, that may have one or more cycles, leading to the achievement of very high values of the ROS and time dependent fire spread properties that may have important implications in fire suppression and fire safety.
  The model is based on extensive analytical research supported by laboratory and field experiments, analysis of past fires and has a semi-empirical nature, with a set of differential equations to evaluate the positive or negative acceleration of the head fire as a function of parameters that are set or can be determined for common fuels and for a wide set of operational conditions.
  The model can be applied to three situations of dynamic fire behaviour that have been studied so far: (A) eruptive fires, (B) junction fires and (C) accelerating and decelerating fires.
  At present there are publications supporting Models A and B. Model C is being developed and has been tested in some cases in Portugal but must be extended to other cases.
  Detailed description of the Extreme Fire Behaviour Modelling available here: Deliverable D2.5 (M36).
- **FirEUrisk component of the integrated strategy:** Propagation
- **https://fireurisk.satways.net/collection/**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Mathematical Model |
| Units: | m/s |
| Update Frequency: | Depends on the situation being modelled |
| Accuracy: | 20 to 30% |
| Output Format: | Report/program |
| Fire risk component (according to the Integrated Scheme of the FirEUrisk project): | Fire propagation |
| Temporal coverage: | Duration of fire spread (1 to 10 hours) |
| Spatial resolution: | 10m |
| Availability on FirEUrisk platform: | Draft version of D2.5 |

Product 23. Extreme Fire Behaviour Modelling and Product 25. Smoke dispersion forecast

## 3.9 Product 25. Smoke dispersion forecast

- **Session:** Fire spread and smoke modelling. Domingos Viegas, ADAI (Portugal) and Ana Miranda, UAVR (Portugal).
- **Developer:** Ana Miranda, UAVR (Portugal).
- **Activity:** "A2.3.2 Smoke Modelling and Health Impacts".

- **Product description:** This product will estimate 3D air pollution concentrations (e.g., PM10, PM2.5, NO2, CO) at a local scale based on dispersion modelling. The final output will be the gridded time-dependent ground-level concentrations of relevant gases/aerosols (µg/m3) of each wildfire with a spatial resolution better than 1 km.
- **Methodology:** The methodology to estimate the gas/aerosol concentrations is based on the outputs of the smoke emission forecast. DISPERFIRE is a local lagrangean air-pollutant dispersion model and is being adapted and implemented for this purpose. It does not consider chemical reactions within the atmosphere allowing it to run in forecast mode even at finer scales. The simulation period will span the whole fire duration and eventually also the subsequent days (until only residual air-pollutant concentrations are found in the simulated region). Detailed description of algorithm of calculation and data sources available here: (Article or report):
- **FirEUrisk component of the integrated strategy:** Exposure
- **https://fireurisk.satways.net/collection/**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Geospatial |
| Units: | µg.m-3 |
| Update Frequency: | Near-real time after wildfire ignition |
| Accuracy: | Uncertainty: 50% to 100% |
| Output Format: | .shp, .tif |
| Fire risk component: | Exposure |
| Temporal coverage: | Fire duration (see Methodology) |
| Spatial resolution: | <1 km |
| Availability on FirEUrisk platform: | Under development |

- ***Overview***

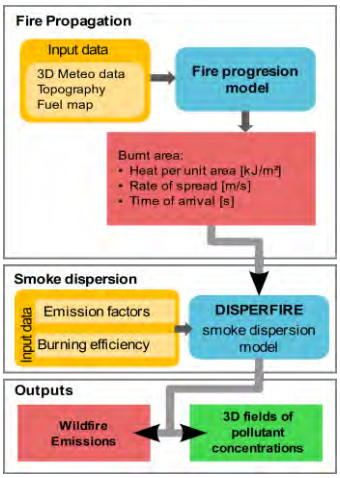


*Figure 13. Algorithm principal scheme.*

Product 23. Extreme Fire Behavior Modelling and Product 25. Smoke dispersion forecast

## 3.10 Product 19. Curricula for extreme fires and WUI

- **Session:** Curricula for extreme fires and WUI. Sébastien Lahaye, SAFE (France).
- **Developer:** Sébastien Lahaye, SAFE (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), elaborate on the way and context to use alternative techniques such as backburning, 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 & assets vulnerability
- **https://fireurisk.satways.net/collection/**
- **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 |

Curricula for extreme fires and WUI

## 3.11 Product 27. Guidelines to reduce communities' vulnerability to extreme fires and fires in WUI

- **Session:** Guidelines to reduce communities' vulnerability to extreme fires and fires in WUI. David Caballero, Meteogrid (Spain).
- **Developer:** David Caballero, Meteogrid (Spain).
- **Activity:** "A2.4.2 Strengthening resilience of WUI areas Deliverable".
- **Product description:** This product describes the best practices and guidelines to reduce vulnerability to extreme fires.
- **Methodology:** Identification of best practices and guidelines, including fuel treatments in the exterior, border plots, continuity, urban, exposure and WUIX index.
- **FirEUrisk component of the integrated strategy:** Exposure
- **https://fireurisk.satways.net/collection/**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Document |
| Units: | not applicable |
| Update Frequency: | not applicable |
| Accuracy: | not applicable |
| Output Format: | .pdf, .docx |
| Fire risk component (accordingly to the Integrated Scheme of the FirEURisk project): | Exposure |
| Temporal coverage: | not applicable |
| Spatial resolution: | not applicable |
| Availability on FirEURisk platform: | yes |

- ***Overview***

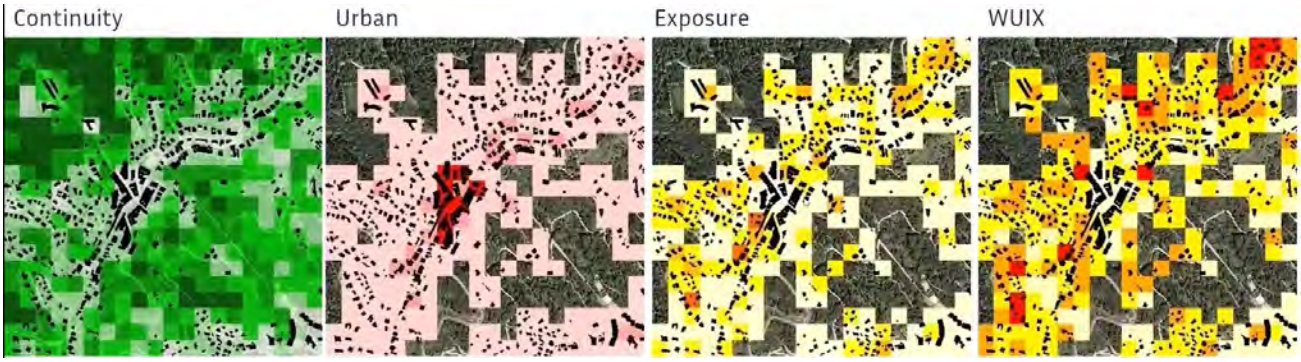


*Figure 14. The WUIX Index.*

[Product 27 Guidelines to reduce communities' vulnerability to extreme fires and fires in WUI]

## 3.12 Product 47. Citizens/scientist network and Engagement Plan

- **Session:** Participatory approaches in fire risk reduction. Ramona Velea, ISIG (Italy).
- **Developer:** Ramona Velea, ISIG (Italy).
- **Activity:** "A2.4.3 – Citizen's involvement in wildfire risk reduction".
- **Product description:** This product proposes a structured framework for establishing citizens networks/groups at local level. In this sense it supports the design and implementation of participatory and engagement strategies by mapping and analysing local stakeholders according to their level of relevance and interest towards the issue at stake (i.e., local strategies for wildfire risk reduction). It envisages the Elaboration of an Engagement Plan for the establishment and functioning of the network making use of several communication channels and tools, from face-to-face interaction in public events and initiatives, to social media, and capitalising the existing knowledge and resources within and outside the partnership (e.g., promote synergies with other networks of citizen-scientist, with events and initiatives dedicated to scientific promotion).
- **Methodology:** The tool suggests how to structure Citizens/scientist networks through the following steps: 1) Set the scope of inquiry (Elaborate a Community Evaluation, Elaborate a Stakeholder Evaluation); 2) Identify the most adequate participation strategies and tools in order to engage with stakeholders (following Information, Consultation, Dialogue, Partnership strategies). It also provides for guidelines for Monitoring and Evaluation activities, ensuring feedback on the effectiveness of implemented actions. The tool is based upon the following main sources: Council of Europe/ISIG. (2017; 2020). Toolkit for Civil Participation in decision making. Strasbourg: CoE; Council of Europe/CINGO. (2019). Code of Good Practice for Civil Participation in the Decision-Making Process. Strasbourg: CoE
- **FirEURisk component of the integrated strategy:** Coping capacity.
- **https://fireurisk.satways.net/collection/**

- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Document/Guidelines and training |
| Units: | N/A |
| Update Frequency: | Yearly |
| Accuracy: | N/A |
| Output Format: | .pdf |
| Fire risk component: | Coping capacity |
| Temporal coverage: | N/A |
| Spatial resolution: | N/A |
| Availability on FirEUrisk platform: | Yes |

Product 47 Citizens/scientist network and Engagement Plan

## 3.13 Product 8. Future climate information

- **Session:** Future climate information. Jaime Ribalaygua, Meteogrid (Spain).
- **Developer:** Jaime Ribalaygua, Meteogrid (Spain).
- **Activity:** "A3.1.1 Climate change scenario data".
- **Product description:** The product provides information on the expected future climate over the EU territory. It provides projections obtained from Climate Models and climate scenarios of future greenhouse gasses concentrations. The final outputs: – document with projection graphs and geospatial product.
- **Methodology:** High resolution climate scenarios using downscaling methods were provided using existing climate scenarios available in the COPERNICUS-C3S (AR6) platform, using ERA5-Land re-analysis as a reference (9 km x 9 km) and interpolated to a 1 km x 1 km grid. A set of at least 20 combinations (ten Earth System Models and two emission scenarios, RCP4.5 and RCP8.5) were statistically downscaled for a better estimation of the uncertainty. NCSR was develop a methodology (based on advanced extreme value and statistical tools) for specific extreme fire events. The climate scenarios were used to identify changes in meteorological drivers and teleconnections under future conditions (FMI).
- **FirEUrisk component of the integrated strategy:** Vulnerability (Ecological values)
- **https://fireurisk.satways.net/collection/**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Geospatial product, document with projection graphs |
| Units: | Expected changes (ºC, mm, number of days or events) |
| Update Frequency: | Provided once |
| Accuracy: | Variable uncertainty |
| Output Format: | Geospatial product: raster (.tif), vector (.shp) Document: .pdf |
| Fire risk component (accordingly to the Integrated Scheme of the FirEUrisk project): | Vulnerability (Ecological values) |
| Temporal coverage: | 30 years averages (30 years around 2050 and for the end of the century (2070-2100) |
| Spatial resolution: | 12.5 $km^2$ for ET, can be downscaled to 1 $km^2$ |
| Availability on FirEUrisk platform: | Yes |

Product 8. Future climate information




## 3.14 Product 75. Continental land-use change scenarios and stylised fuel management scenarios

- **Session:** How will our present land management affect out future risk? Alex Neidermeier, VUA (Netherland).
- **Developer:** Alex Neidermeier, VUA (Netherland).
- **Activity:** "3.1.2 LUC scenarios for policy implementation and fuel management".
- **Product description:** Historic land use (LU) reconstructions (1960 to 2010) and future land system scenarios (2015-2050) were linked as data inputs for the fire enabled Dynamic Global Vegetation Models (DGVM). The integrated 1960-2050 dataset incorporates variables critical to fuel distribution across European landscapes, such as afforestation, forest fragmentation, and land abandonment, which will in turn improve the ability of the DGVMs to forecast future fire regimes.
- **Methodology:** Historic data was provided from the HILDA+ dataset (Winkler et al., 2021), which combines several open data streams (remote sensing, reconstructions and statistics) to estimate past LU change. The future LU scenarios were simulated using CLUMondo, a spatially explicit and dynamic land system change model (full model details available in (Asselen and Verburg, 2013)). We adopted Shared Socioeconomic Pathways (SSP) 1 ("Sustainability") and SSP3 ("Regional rivalry") to explore the effects on LU of divergent developmental paths for Europe. Detailed description of algorithm of calculation and data sources available here: Asselen and Verburg, 2013.
- **FirEUrisk component of the integrated strategy:** Propagation-Fuels
- **https://fireurisk.satways.net/collection/**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Geospatial |
| Units: | Land cover classes |
| Update Frequency: | Static |
| Accuracy: | N/A |
| Output Format: | .tiff |
| Fire risk component: | Propagation-Fuels |
| Temporal coverage: | 1960-2050 (decadal) |
| Spatial resolution: | 9 $km^2$ |
| Availability on FirEUrisk platform: | All data can be found on: DataverseNL |
| Key contact for questions | Alex Neidermeier a.neidermeier@vu.nl |

- ***Overview***

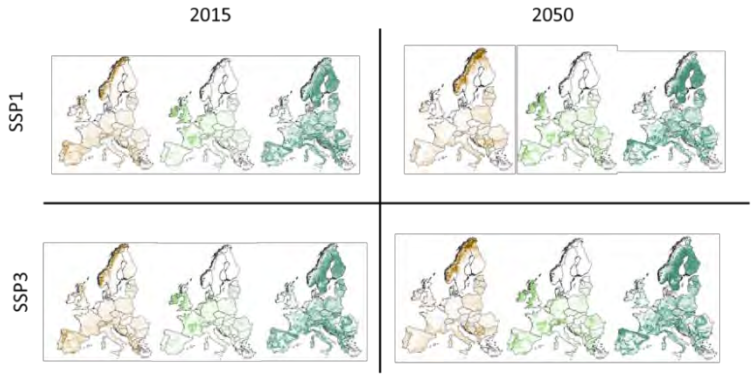


*Figure 15. Comparison of changes in land cover in SSP 1 & 3 between 2015 and 2050.*

Product 75. Continental land-use change scenarios and stylised fuel management scenarios

## 3.15 Product 36. Future fire regime data base

- **Session:** Future fire regime data base. 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
- **https://fireurisk.satways.net/collection/**
- **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) |
| Availability on FirEUrisk platform: | Yes |

- ***Overview***

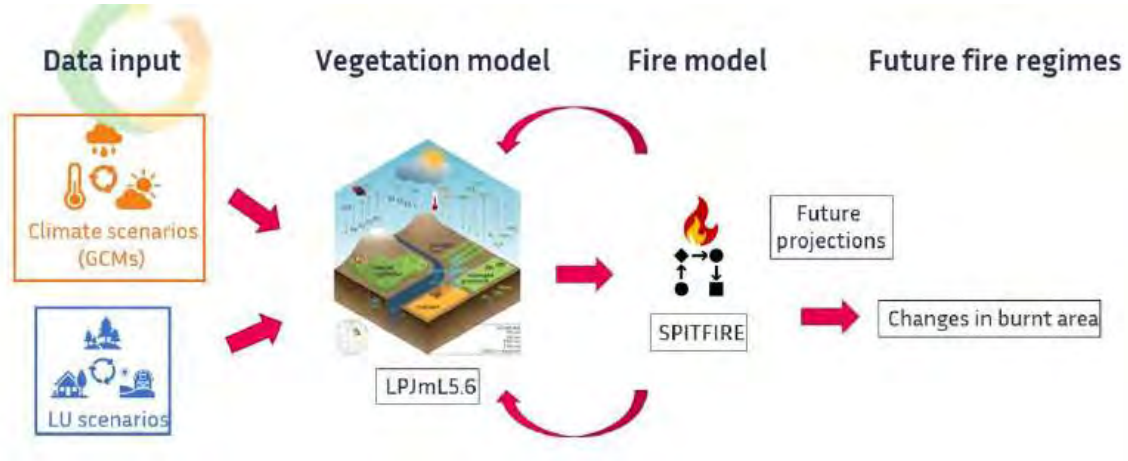


*Figure 16. Future fire regimes.*

[Product 36 Future fire regime data base]

## 3.16 Product 44. Tool for displaying outputs from the internal platform and external platforms customised for the FirEURisk needs

- **Session:** FirEURisk project viewer. Alejandro Barrios, Arbaunaut (Island).
- **Developer:** Alejandro Barrios, Arbonaut (Island).
- **Activity:** "A4.3.1 Integrating FirEURisk resources with other EU platforms and legacy systems".
- **Product description:** The tool allows visualizing pre-defined spatial datasets though a WebGIS interface. It gives a possibility for providing access to the same datasets through an Android app interface. The mobile datasets can be used in offline mode when the selected layers have been downloaded to the device in advance.
- **Methodology:** WebGIS interface tool that allows to view multiple layers of FirEURisk products applied to PS3.
- **FirEURisk component of the integrated strategy:** Several
- **https://fireurisk.satways.net/collection/**
- **Technical characteristics:**

| Characteristics | Description |
|---|---|
| Type of products: | Software / Web application / Mobile application |
| Units: | not applicable |
| Update Frequency: | not applicable |
| Accuracy: | not applicable |
| Output Format: | Online read-only access |
| Fire risk component (accordingly to the Integrated Scheme of the FirEURisk project): | not applicable |
| Temporal coverage: | not applicable |
| Spatial resolution: | not applicable |
| Availability on FirEURisk platform: | not applicable |

- ***Overview***



*Figure 17. Example of the product interface.*

# 4 Validation Protocol – Immediate Feedback

One of the main objectives of the event was to present FirEURisk's products and gather feedback for further improvement whenever possible. To facilitate this, interactive surveys were introduced during the event using the Mentimeter tool (https://www.mentimeter.com) to capture individual perspectives on each product. In addition, a dedicated debriefing meeting was scheduled afterwards. This meeting included key and experienced representatives from the main entities managing wildfires in Portugal, particularly at the PS3 region.

The questions posed to the audience in the questionnaires were aligned, as much as possible, with those used in the previous DE held in Barcelona, June 7th, 2023 (cf. deliverable 5.9). This approach will also be followed for future DEs, allowing for an overarching perspective across all DE events. The questions focused on high-level aspects, avoiding technical specifications, and aimed to gather key information to assess:

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

The questions posed through Mentimeter are available in Annex B.

## 4.1 Results of the immediate feedback

In this section, we present the responses to the questionnaires collected during the event. The responses directly obtained from the Mentimeter tool are presented in Annex C. The questions were presented in Portuguese and English, allowing the respondent to choose the language in which they felt most comfortable.

### Initial assessment:

1. What is your organisation's name? (n= 105 responses completed) – please see the list of acronyms where the organization names are described.

| Organisation's name | | |
|---|---|---|
| FEPC | Coimbra municipality | University of Coimbra |
| ISIG | Bombeiros | Faculty_of_Medicine_Coimb |
| ISEC | Castanheira de Pera Firefighters | USTO Mb |
| EFI | Oleiros Municipality | ADAI |
| ADAI | Sardoal SMPC | Vila Real (Cruz Verde) Firefighters |
| ADAI | ANEPC | Civil protection (Mafra) |
| GNR | ADAI | AGIF |
| ISIG | ADAI | Coruche Municipality |
| CCDRC | University of Aveiro | ISEC |
| ICNF | ANEPC_GAUF | GNR SEPNA |
| ADAI | Pombal Firefighters | Tábua Municipality |
| ICNF | ADAI | University of Aveiro |
| Mangualde Firefighters | IPMA | NCSRD |
| Municipality | GMV | Condeixa Firefighters |
| AquaForm | ISEC | FEPC |
| Carnaxide Firefighters | ISEC | ANEPC |
| EVOLSAR | ISEC | ADAI |
| ADAI | Municipality | Leiria Municipality |
| AGIF | Alcabideche Firefighters | Algés Firefighters |
| GNR | Tecnosylva | Junta_de_Castilla y León |
| ADAI | CoLAB ForestWISE | Faro Firefighters |
| University of Coimbra (Economy) | University of Coimbra | Tecniquitel |
| Municipal Civil Protection | ADAI | Castanheira de Pera (Municipal C. P.) |
| ICNF | Pedrógão Grande Municipality | Castanheira de Pera Municipality |
| ANEPC | Coimbra Municipality | University of Porto |
| ISEC | ADAI-IPV | ISEC |
| University of Coimbra | CIM | Góis Municipality (Civil Protection) |
| ICNF | Figueira da Foz Municipality | ICNF |
| IPMA | Nazaré Firefighters | Góis (Municipal Civil Protection) |
| CoLAB ForestWISE | University of Coimbra | Águeda Municipality |
| GNR | ADAI | GTF |
| UAH | Ministry of Culture | CoLAB ForestWISE |
| University of Aveiro | Coruche Municipality | Ferreira Municipality |
| Bravo Mundo (NGO) | GNR | USTO (Algeria) |

| Organisation's name | | |
|---|---|---|
| UEPS-GNR | Arouca Municipality | Municipal Civil Protection |

2. What aspect of wildfire risk assessment is most important in your activity? (n= 112 responses)

| Choices | Votes |
|---|---|
| Ignition causes (natural/human) | 52 – [18%] |
| Fire propagation (fuels, terrain, weather) | 84 – [29%] |
| Population | 67 – [23%] |
| Ecosystem exposure | 19 – [6%] |
| Potential losses (ecological/socio-economic assets) | 26 – [9%] |
| Resistance and response capacity | 38 – [13%] |
| Other | 7 – [2%] |

3. What other fire risk components do you deal with in your activity? (e.g., land 37 management plans, fighter's training, residents' education) (n=153 responses)

| Fire risk components identified | | |
|---|---|---|
| Smoke | Topography, smoke, heat | Firefighting |
| Research | Health and safety | Interoperability |
| Smoke | Fire spread | Smoke, physical fatigue |
| None | Prevention | Environmental impacts |
| Smoke | Fuel manager | Fire spread |
| Research | Fire safety | Slope |
| Fuel parametrization | Safety WUI | Slope |
| Biomass and fuel management | Slope | Fuel management |
| None | Slope | Meteorology, slope and mostly firefighting difficulties |
| Smoke | Fuel Management | Fire safety |
| None | Mitigation | Fuel management, |
| Research | Fuel management | Fire Suppression |
| Research | Cascading effects | Crew safety |
| Weather | Human | Citizens' protection |
| Fumo | Fuels physical parameters | Fuel management |
| High res. Fuel maps | Fuel management and landscape management | Firefighting |
| Burned areas recovery | Policies and regulation | Preserving the environment |
| Human | Human factors | Fuel management optimization |
| Fire safety | Smoke, social risks, fire safety | Missing land / fuel management |
| Fire safety engineering in the WUI. | Changes in health; health risks | Trees on private land, near houses |
| Community resilience | Fire Spread | CFD fire modelling |

| Fire risk components identified | | |
|---|---|---|
| Prevention, investigation and causes of fires | Lack of management | Fire safety |
| Radiation, smoke | Meteorology | Rate of spread |
| Human health | Smoke, radiation, fear | Prevention |
| None | Research and innovation | Fuel management |
| Weather | Security | Fuel management |
| Fuel moisture content | Wildlife | Fuel management |
| Ignition | Fuel management | Compatible land uses |
| Population's level of resilience | Fire danger | Fuel management |
| Society awareness | Population safety | Effect of fire severity on ecosystems (flora, fauna, and habitats), fuel management |
| Fire propagation | Fite spread | Prevention |
| Exposure, slope | Firefighting | Effect on population (from evacuation to social risks) |
| Smoke | Slope | Controlled burning |
| Post-fire restoration | Aviation firefighting | Fuel management, public awareness, protecting settlements |
| Slope | Criminal investigation | Topography, population centers, trees in spaces |
| Smoke | Social risks | Forest fuels |
| Human | None | Wildfire governance |
| Rate of spread | Human | Building areas |
| Smoke | Fire spread | Meteorology |
| None | Landscape resilience (ecosystems and communities) | Interaction between entities |
| Fuel loss | Fire fighting | Isolated buildings |
| Fuel flammability | Forest losses, fuel planning optimization | Prevention |
| Social risks | Fire safety | Fire event potential |
| Topography, meteorology | Extinction accidents | Building protection and evacuation |
| Rescue | Fuel management | Public policy |
| Construction vulnerability | Fire event potential | Fuel management, firefighting, management of human and material resources, effect of fire (such as severity), consequences of fires |
| Fumo | Communities | Fumo |
| Fuel management | Operational planning | Controlled burning |
| Information systems weather propagation | Smoke, fear | Socio economy vulnerability |
| Weather and smoke | Prevention | Weather and smoke |
| Combat | Management of human resources | Materials |

## FirEURisk's products on fire risk assessment:

1. Has the explanation of the fire risk assessment products sufficient? (n=104 responses)

| Choices | Votes (0-5) |
|---|---|
| Human ignition probability map | 4.28 |
| Fuel type and model map | 4.33 |
| Wildland Urban Interface (WUI) map | 4.38 |
| Wildfire spread and behavior outputs, "basic mode" propagation potential | 4.18 |
| Socio-economic vulnerability | 4.09 |

2. How suitable are these risk assessment products for your territory (n=105 responses)

| Choices | Votes (0-5) |
|---|---|
| Human ignition probability map | 4.29 |
| Fuel type and model map | 4.47 |
| Wildland Urban Interface (WUI) map | 4.49 |
| Wildfire spread and behavior outputs, "basic mode" propagation potential | 4.32 |
| Socio-economic vulnerability | 4.01 |

3. What other information for fire risk assessment would you need? (n=63 responses)

| Additional fire risk assessment information required | | |
|---|---|---|
| Smoke propagation | Fuel models updates | Safety |
| Results | None | Impact on communities |
| - | Evacuation | Current fire behavior |
| - | Weather | Fuel model variation along the year |
| None | Weather | 0 |
| Return period | fuel load | Location near roads and settlements, density of vegetation |
| Weather | Risk awareness and information to communities | Legislation |
| Fuel parameters | Fire danger | Census population<br>Weather data |
| Evacuation in villages | Downburst probability, pyrocumulonimbus | Study of social behavior. Human-caused ignitions are the most relevant. |
| Fire severity | Places where and how information can be found | fire severity |
| Nothing | Evacuation | meteorology |
| Live fuel moiture content | Agua | None |
| None | Severity | population exposure |
| Precise meteorological assessment | Natural causes information | Fuel parameters |

| Additional fire risk assessment information required | | |
|---|---|---|
| Local culture | Environmental impact at critical points | More study and research into the type of fuels that exist in this case in Portugal. |
| Last fires | Coordination | FIREFIGHTER CAPABILITY |
| Smoke dispersion | Weather | How to actually apply it in the field |
| Arson profile | Human behavior | Community fire 'readiness' capturing local attitudes and knowledge levels |
| Smoke propagation | Detailed characterization of the built environment. Individual vulnerability of infrastructure remains a critical aspect to be assessed and included in the global picture | Specification of the fire danger indices used |
| Water for firefighting | Humidity | Protection of isolated communities |
| Detailed assessment of smaller areas | Population, meteorological data | Smoke |
| Amount of fuel removed | Firefighting difficulties | Behavior of structures and infrastructures to fire. |
| Fuel parameters | Innovative fuel treatment methodologies | Lower troposphere conditions, fire behavior |
| Severity | Water | Dispersal of the population, Road network, means of combat, Availability of means and resources |
| Evacuation | Fuel models updates | Safety |
| Smoke propagation | None | Impact on local communities |
| Results | Evacuation | Current fire behavior, given the type of fuels present |
| - | Weather | Fuel model variation along the year |
| - | Weather | - |
| None | Fuel load | Location near roads and settlements, density of vegetation |
| Return period | Risk awareness and information to communities | Legislation |
| Weather | Fire danger | Census population<br>Weather data |
| Fuel parameters | Downburst probability, pyrocumulonimbus | Study of social behavior. Human-caused ignitions are the most relevant |
| Evacuation in villages | Places where I can find information about the municipality of Vidigueira and how | Fire severity |
| Fire severity | Evacuation | Meteorology |
| Nothing | Water | - |
| Live fuel moisture | Severity | Population exposure |

| Additional fire risk assessment information required | | |
|---|---|---|
| None | Natural causes information | Fuel parameters |
| Precise meteorological assessment | Environmental impact at critical points | More study and research into the type of fuels that exist in this case in Portugal. |
| Cultura local | Coordination | FIREFIGHTER CAPABILITY |
| Last fires | Weather | How to actually apply it in the field |
| Smoke dispersion | Human behavior | Community fire 'readiness' capturing local attitudes and knowledge levels |
| Arson profile | Detailed characterization of the built environment. Individual vulnerability of infrastructure remains a critical aspect to be assessed and included in the global picture | Specification of the fire danger indices used |
| Smoke propagation | Humidity | Protection of communities |
| Water for firefighting | Population and meteorological data | Smoke |
| Detailed assessment of smaller areas | Firefighting difficulty | Behavior of structures and infrastructures to fire. |
| Amount of fuel removed | Innovative fuel treatment methodologies | Lower troposphere conditions Behavior of fire |
| Fuel parameters | Water | Dispersal of the population, Road network, means of combat, Availability of means and resources |
| Severity | Fuel models updates | Risk awareness and information to communities |
| Evacuation | None | Fire behavior |
| Smoke propagation | Evacuation | Downburst probability, pyrocumulonimbus |
| Water for firefighting | Weather | Fuel parameters |
| Detailed assessment of smaller areas | Weather | Severity |
| Amount of fuel removed | Fuel load | Evacuation |

4. Is the approach to fire risk assessment products comprehensive? (n=104 responses)

| Choices | Votes (0-5) |
|---|---|
| Human ignition probability map | 4.05 |
| Fuel type and model map | 4.21 |
| Wildland Urban Interface (WUI) map | 4.32 |
| Wildfire spread and behaviour outputs, "basic mode" propagation potential | 4.19 |
| Socio-economic vulnerability | 3.90 |

5. How interesting are these products? Would you use them in your activities? (n=100 responses)

| Choices | Effort (0-10) | Impact (0-10) |
|---|---|---|
| Human ignition probability map | 7.94 | 7.56 |
| Fuel type and model map | 8.28 | 8.04 |
| Wildland Urban Interface (WUI) map | 8.53 | 7.87 |
| Wildfire spread and behaviour outputs, "basic mode" propagation potential | 8.55 | 8.31 |
| Socio-economic vulnerability | 7.19 | 6.65 |

## FirEURisk's products on fire risk reduction:

1. Has the explanation of the fire risk reduction products sufficient? (n=67 responses)

| Choices | Votes (0-5) |
|---|---|
| Fuel Management Framework for Reducing Ignitions | 4.36 |
| Maps of suitable areas for land management strategies use | 4.30 |
| Fire behaviour and smoke dispersion predictive models | 4.24 |
| Curricula for extreme fires and WUI | 4.09 |
| Guidelines to reduce communities' vulnerability to extreme fires | 4.30 |

2. How suitable are these risk reduction products for your territory (n=66 responses)

| Choices | Votes (0-5) |
|---|---|
| Fuel Management Framework for Reducing Ignitions | 4.19 |
| Maps of suitable areas for land management strategies use | 4.00 |
| Fire behaviour and smoke dispersion predictive models | 4.04 |
| Curricula for extreme fires and WUI | 4.13 |
| Guidelines to reduce communities' vulnerability to extreme fires | 4.31 |

3. Is the approach to fire risk reduction products comprehensive? (n=66 responses)

| Choices | Votes (0-5) |
|---|---|
| Fuel Management Framework for Reducing Ignitions | 3.93 |
| Maps of suitable areas for land management strategies use | 3.87 |
| Fire behaviour and smoke dispersion predictive models | 3.84 |
| Curricula for extreme fires and WUI | 3.87 |
| Guidelines to reduce communities' vulnerability to extreme fires | 3.98 |

4. How interesting are these products? Would you use them in your activities? (n=66 responses)

| Choices | Effort (0-10) | Impact (0-10) |
|---|---|---|
| Fuel Management Framework for Reducing Ignitions | 8.27 | 7.72 |
| Maps of suitable areas for land management strategies use | 7.93 | 7.10 |
| Fire behavior and smoke dispersion predictive models | 7.89 | 7.63 |
| Curricula for extreme fires and WUI | 7.89 | 7.00 |
| Guidelines to reduce communities' vulnerability to extreme fires | 8.00 | 7.51 |

## FirEURisk's products on fire risk adaptation:

1. Has the explanation of the fire risk adaptation products sufficient? (n=37 responses)

| Choices | Votes (0-5) |
|---|---|
| Future climate information | 4 |
| Future fire regime database | 4.21 |
| Continental land-use change and fuel management scenarios | 4.13 |

2. How suitable are these risk adaptation products for your territory (n=39 responses)

| Choices | Votes (0-5) |
|---|---|
| Future climate information | 4 |
| Future fire regime database | 4.20 |
| Continental land-use change and fuel management scenarios | 4.05 |

3. Is the approach to fire risk adaptation products comprehensive? (n=66 responses)

| Choices | Votes (0-5) |
|---|---|
| Future climate information | 2.92 |
| Future fire regime database | 3.19 |
| Continental land-use change and fuel management scenarios | 3.09 |

4. How interesting are these products? Would you use them in your activities? (n=66 responses)

| Choices | Effort (0-10) | Impact (0-10) |
|---|---|---|
| Future climate information | 7.48 | 6.51 |
| Future fire regime database | 8.04 | 7.16 |
| Continental land-use change and fuel management scenarios | 7.79 | 7.06 |

### FirEURisk's products on multi-level integration:

1. Please, value the following characteristics of FirEURisk Display (n= 39 responses)

| Choices | Votes |
|---|---|
| Platform design | 4.34 |
| Complete product description | 4.00 |
| Accessibility (easy to navigate) | 4.26 |
| Product mapping display | 4.21 |
| Clear legends | 3.86 |
| Clear metadata | 3.66 |

2. To what extent do you agree with the following statements? (n= 38 responses)

| Choices | Votes |
|---|---|
| Was FirEURisk project well presented at the start of the demonstration? | 3.91 |
| Were products described in sufficient detail for your needs? | 3.75 |
| Did you understand the use of the products? | 3.62 |
| Did you understand the questions about the product(s)? | 3.56 |
| Were questions answered satisfactorily? | 3.86 |
| The on-line experience was sufficient to validate the product | 3.47 |

# 5 Validation Protocol – Aftermath Debriefing

The preceding section delineated the outcomes derived from on-site inquiries posed to various participants during the Demonstration Event. This methodology facilitated the participants' expression of viewpoints in a straightforward manner accessible to all and resulted in a large number of responses with statistical analytical potential. These responses provided broad understanding of the quality and usability of FirEURisk products from the perspective of their application in the PS3 Pilot Site area. However, notwithstanding its merits, the "Mentimeter" methodology, grounded

in multiple-choice and immediate responses, affords limited freedom of expression and insufficient time for reflection. In pursuit of a more comprehensive analysis of participant feedback, a debriefing meeting was convened with a select group of the DE participants, allowing for free and reflective expression.

The debriefing meeting occurred remotely on November 13, 2023, ten days after the Demonstration Event, with a pre-determined list of questions disseminated in advance to facilitate thoughtful responses. The invited participants comprised representatives of key stakeholders within the Portuguese fire management system, serving as potential users of FirEURisk products. The participants in this meeting included:

- Julia from GMV and Miguel Almeida from ADAI, who moderated the session.
- Francisco Peraboa, Regional Commander for the Centre of the National Emergency and Civil Protection Authority (ANEPC), acting as coordinator of the rural fire response phase.
- João Santos, Eduardo Marques, and Marco Lucas from the ANEPC's Fire Utilization and Analysis Group, acting as decision support information managers during fires.
- João Fernandes, Major of the National Republican Guard (GNR), which is the organization coordinating wildfire surveillance and alert system as well as the enforcement of compliance with risk management regulations.
- Luís Paulo Pita, Head of the Sub-Regional Coordination Center for the Coimbra Region of the National Forestry Institute (ICNF), representing the coordinating body for the wildfire prevention phase.
- Yannick Le Page, Knowledge and Innovation Advisor at the Agency for Integrated Rural Fire Management (AGIF), the umbrella organization for Portugal's rural fire management system.
- Ana Sá, Senior Researcher at the CoLab ForestWISE collaborative laboratory, contributing with an academic and scientific perspective.
- Luís Filipe Mano, a citizen and forest owner, providing a non-institutional user's viewpoint.

## 5.1 Summary of Questions and Responses

### 5.1.1 Key Questions Raised

During the meeting, several objective questions were raised, focusing on fundamental aspects of the FireUrisk project's risk assessment products. These questions included:

- How can the effectiveness of the risk assessment products be optimized in practical scenarios?
- What enhancements can be implemented to improve the accuracy and relevance of the products?
- In what manner can the products be seamlessly integrated into current fire management and prevention strategies?

### 5.1.2 Discussion on Product Utility

The debate underscored the pivotal role of the project's products in pinpointing high-risk regions through maps detailing anthropogenic ignition probability and vegetation types. Attendees recognized the potential of these tools to notably enhance risk assessment efforts by furnishing comprehensive, actionable insights into the underlying factors influencing fire hazards.

### 5.1.3 Feedback and Improvement Suggestions

Feedback orbited around improving the precision of risk assessment models and the necessity for timely updates to the data supporting the project's products. Participants recommended that updates should occur regularly, at a minimum, to account for alterations in land use, vegetation, and climate conditions. Furthermore, there was

unanimous agreement on the requirement for enhanced spatial resolution and more frequent temporal updates to maintain the products' relevance and utility for efficient risk management.

### 5.1.4 Insightful answers and comments

The responses provided by attendees were enlightening, offering diverse perspectives on the application and enhancement of the FirEURisk project's outputs. Key insights included:

- The importance of aligning the products with the specific needs and capabilities of various fire management entities.
- The necessity of continuous updates and improvements to the data models to accurately reflect the dynamic nature of fire risks and vegetation changes.
- Suggestions for incorporating user feedback into the development process to ensure the products remain user-centric and practically valuable.

The attendees' responses underscored the significance of customizing the FirEURisk project's risk assessment products to meet the distinct requirements and capacities of different fire management entities, acknowledging the varied needs across different regions and scenarios. Continuous updates and enhancements to the models were deemed critical for accurately capturing the evolving dynamics of fire risks and vegetation patterns, thereby ensuring the continued relevance of the products. Additionally, integrating user feedback into the development process was proposed as a pivotal strategy for maintaining the user-centric and practical value of these tools, fostering a collaborative approach to enhancing fire risk management practices.

### 5.1.5 Lessons Learned and Conclusion

***Consensus and feedback integration***

The meeting emphasized the importance of viewing the FirEURisk project's products as indispensable tools for fire risk assessment and management. There was unanimous agreement on the necessity of integrating the feedback and suggestions gathered during this session to further enhance the effectiveness of these products. By closely aligning the tools with the evolving needs of fire management professionals, their practical utility and impact in real-world scenarios can be significantly enhanced.

***Strategic recommendations***

To capitalize on the insights gleaned, several strategic recommendations were formulated:

- Regular updates: establish a schedule for regular updates to the risk models, ensuring they accurately reflect the latest environmental and climatic conditions.
- User-centric design: integrate a mechanism for continuous user feedback, facilitating iterative improvements that address the changing needs of users.
- Future engagements: coordinate follow-up meetings or workshops to review progress, share updates, and sustain the dialogue among stakeholders

# 6 Conclusions and Lessons Learnt from the Demonstration Event

Throughout this report, we have provided a comprehensive account of the Demonstration Event, which served as a platform primarily for showcasing various products developed under the FirEURisk project. These products were demonstrated within the context of their application to the intermunicipal communities of Coimbra and Leiria in the Central Region of Portugal, serving as the focal area for pilot site PS3.
Beyond the dissemination and promotion of FirEURisk project activities and products, the event aimed to seek valuable feedback from potential users of FirEURisk outputs. Additionally, it provided an opportunity for stakeholders to offer suggestions aimed at enhancing the effectiveness and applicability of these tools. Two distinct methodologies were employed: one involving real-time collection of responses via Mentimeter tool, and the other comprising a more restricted gathering with a smaller group of stakeholders from the Portuguese fire management system, allowing in-depth discussions.
Among the main indicators of the event, the following stand out:

- 18 presentations delivered by 20 speakers.
- Active participation from 13 consortium partners.
- Presentation of 15 FirEURisk products, distributed across fire risk assessment (5), reduction (6), adaptation (3), and the FirEURisk Platform (1).
- 85 in-person attendees and 265 remote participants.
- In-person participants from 6 different nationalities: 3 EU countries and 3 non-EU countries.
- Remote participants from 18 different nationalities: 12 EU countries and 6 non-EU countries.
- Representation from 62 entities in-person.
- 2,051 responses to the 23 Mentimeter questions (89.2 R/Q ratio).
- 7 invited participants in the debriefing session, moderated by 2 members of the FirEURisk team.
- Participation of the Minister of Internal Administration of the Portuguese Government, who oversees forest fires.

Overall, the feedback received was extremely encouraging, with unanimous interest expressed by participants in the products showcased. Products showcased under the first panel focusing on fire risk assessment (WP1) garnered particular enthusiasm. Given their advanced development status as per the project timeline, it's understandable that they resonated strongly with participants. These products, especially maps and related tools developed in WP1, were perceived as more accessible compared to those from WP2 (risk reduction) and WP3 (risk adaptation), which rely on guidelines and future estimations, respectively. Furthermore, the direct applicability of first-panel products to the pilot site area was appreciated, distinguishing them from the more general applications of products from the subsequent panels.
Among the strengths highlighted by participants was the scalability of the products, particularly those related to risk assessment. The concentration of information provided by these tools was also admired. Equally noteworthy was the positive reception of risk reduction products, with emphasis placed on the need for their widespread dissemination and training of all fire management actors, including citizens.
Lastly, a shared desire to continue tracking the progress of the project's results beyond its completion was expressed, underlining the anticipation for ongoing evolution and refinement of the FirEURisk products.

The conclusions and lessons learnt can be synthesised in three main components:

1. **Action plan and logistics**

From a technical and organizational perspective, no relevant flaws were detected, with the following decisions standing out as key contributors to the successful outcome of the event:

- All speakers and moderators strictly adhered to the schedule, which greatly pleased the participants.

- Providing lunch and coffee breaks facilitated networking among in-person participants, in addition to facilitating follow the planned schedule.
- The excellent quality of the facilities and technical services offered by the Regional Development Coordination Commission of the Centre (Portugal) ensured that the event run smoothly and comfortably, contributing significantly to the participants' positive experience.
- Professional translation from English to Portuguese and vice versa was essential for ensuring all participants understood the content, as well as enabling participation for those who only understood one of the languages, thereby increasing the event's attractiveness.
- Sending product cards to participants in advance allowed them to familiarize themselves with the products to be presented beforehand. It is uncertain whether they read them, but regardless of that, it was a good practice because it provided them with that opportunity.
- The presence of the Minister of Internal Administration of the Portuguese Government added credibility and attractiveness to the event and the FirEUrisk project.

## 2. Program Structure

It was important for participants to be able to follow the strategy and developments of the FirEUrisk project and the Demonstration Event itself. Therefore, the agenda structure comprised three main blocks:

- Explanation of the program sequence and presentation of the project, its integrated vision, and the strategy followed, accompanied by a description of the pilot site – this allowed for framing the logic and objectives of the subsequent presentations regarding FirEUrisk products.
- Individual description of the products divided into the project's technical components (assessment, reduction, and adaptation) that had been previously explained. The Q&A session at the end of each group allowed for continuous follow-up of the presentation sequence.
- Final presentation with a live demonstration of the FirEUrisk Platform, once again allowing participants to envision the integration of the products presented in a unified FirEUrisk view.

## 3. Product Validation

- The use of Mentimeter was useful for the collection of many responses from the attendees and bringing dynamism to the event. The gathered feedback could be analysed quantitatively.
- The debriefing session was very productive due to the qualitative value it brought. It is considered that the number of seven participants was appropriate because it allowed everyone to express themselves freely without extending the duration of this session too much (~2 hours). Sending the questions to be asked in advance allowed participants to reflect beforehand on their answers, and consequently provide better responses.

# 7 References

To facilitate the reading, the following references are also presented in Chapter 3, next to the description of the respective product.


- Bar-Massada, A., Alcasena, F., Schug, F., & Radeloff, V. C. (2023). The wildland-urban interface in Europe: Spatial patterns and associations with socioeconomic and demographic variables. Landscape and Urban Planning, 235, 104759. https://doi.org/10.1016/j.landurbplan.2023.104759
- ECOSTRESS Project, (2015). Relative Social Vulnerability Index and SWOT Analysis of Coastal Case Studies in the Upper Adriatic.
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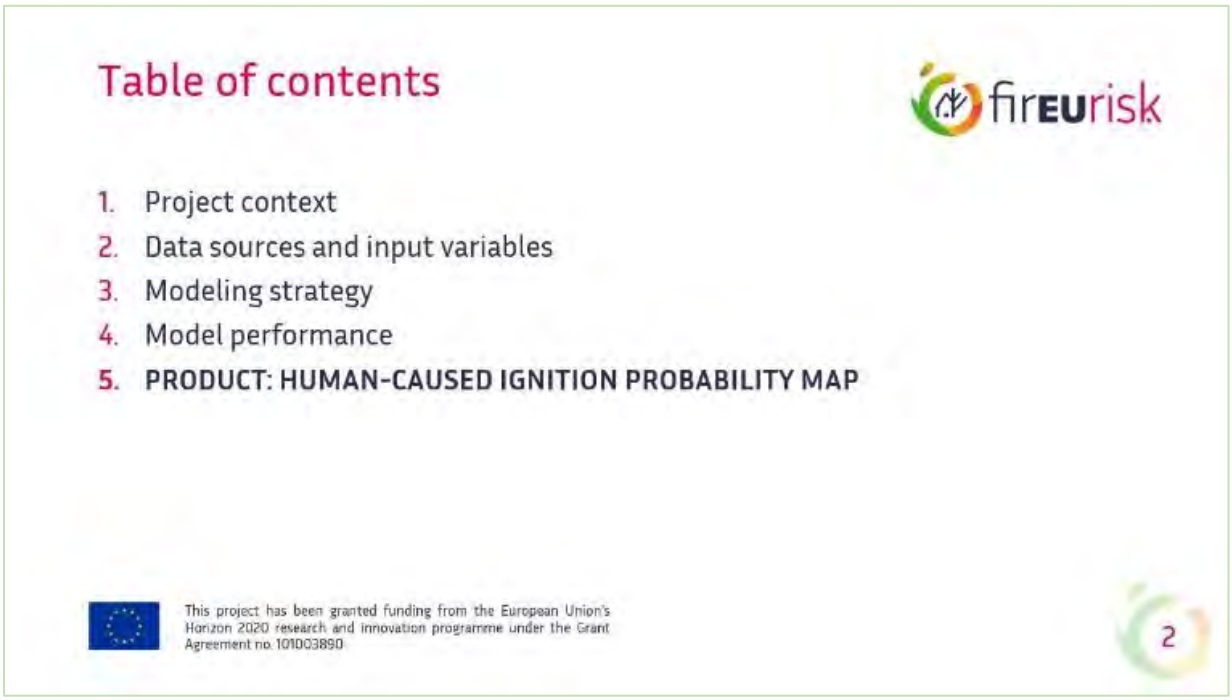
- Neidermeier, A. N., Zagaria, C., Pampanoni, V., West, T. A. P., & Verburg, P. H. (2023). Mapping opportunities for the use of land management strategies to address fire risk in Europe. Journal of Environmental Management, 346, 118941. https://doi.org/10.1016/J.JENVMAN.2023.118941
- RESILOC Project, (2020). Analysis of Vulnerability. Performed by ISIG. Available on request.
- Van Asselen, S., & Verburg, P. H. (2013). Land cover change or land-use intensification: simulating land system change with a global-scale land change model. Global Change Biology, 19(12), 3648–3667. https://doi.org/10.1111/GCB.12331

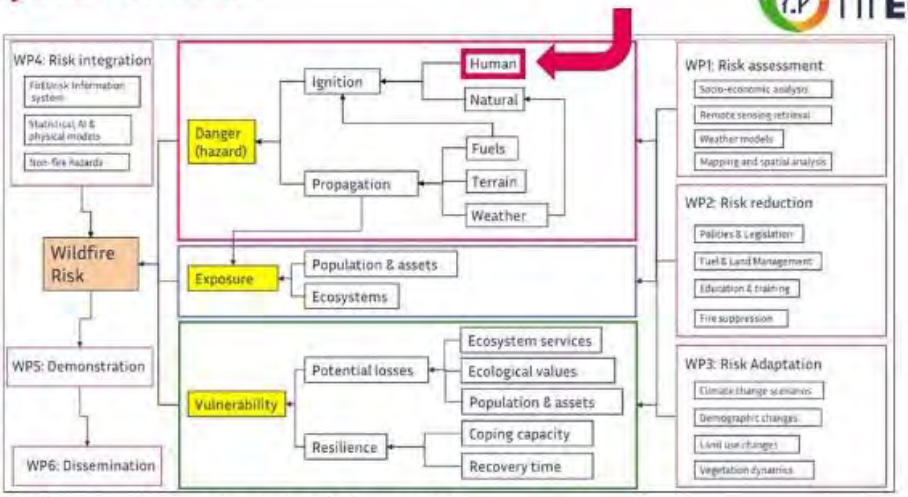
## Annex A: PS3 Demonstration Event presentations

### Product 63. Human ignition probability.



# Project context

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# Data sources and input variables

- Fire data – DECIF Database (2001-2015); 24625 recorded ignitions

| 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 municipal 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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# Model performance

| Pilot site | AUC | Top four fire drivers |
|---|---|---|
| **Central Portugal** | **0.87** | **Fuel types, Percentage wildland coverage, Population density, Distance to WGI** |
| Central Europe | 0.84 | Population density, Fuel types, Distance to WUI, Distance to roads |
| Barcelona | 0.85 | Population density, Distance to WUI, Distance to roads, Fuel types |
| Attica region | 0.89 | Population density, Percentage agricultural coverage, Percentage wildland coverage, Percentage urban coverage |
| Northern Europe | 0.69 | Distance to WUI, Distance to WAI, Distance to roads, Percentage wildland coverage |

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# Model performance

| Pilot site | AUC | Top fire drivers |
|---|---|---|
| **Central Portugal** | **0.87** | **Fuel types, Percentage wildland coverage, Population density, Distance to WGI and WUI** |
| Central Europe | 0.84 | Population density, Fuel types, Distance to WUI, Distance to roads |
| Barcelona | 0.85 | Population density, Distance to WUI, Distance to roads, Fuel types |
| Attica region | 0.89 | Population density, Percentage agricultural coverage, Percentage wildland coverage, Percentage urban coverage |
| Northern Europe | 0.69 | Distance to WUI, Distance to WAI, Distance to roads, Percentage wildland coverage |

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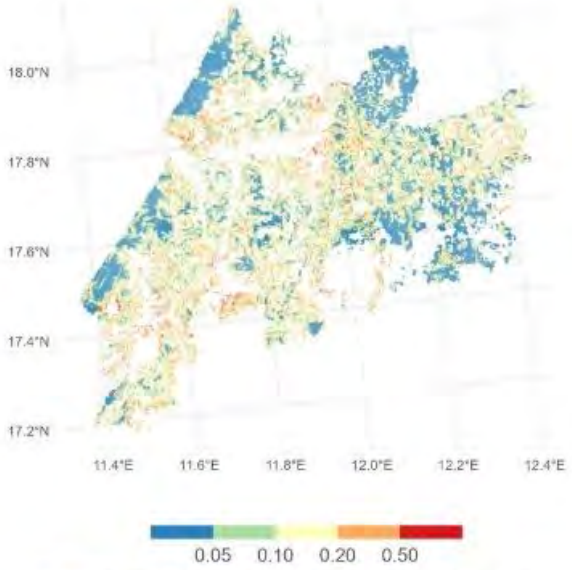


## HUMAN-CAUSED IGNITION PROBABILITY

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fireEUrisk

Thanks for your attention

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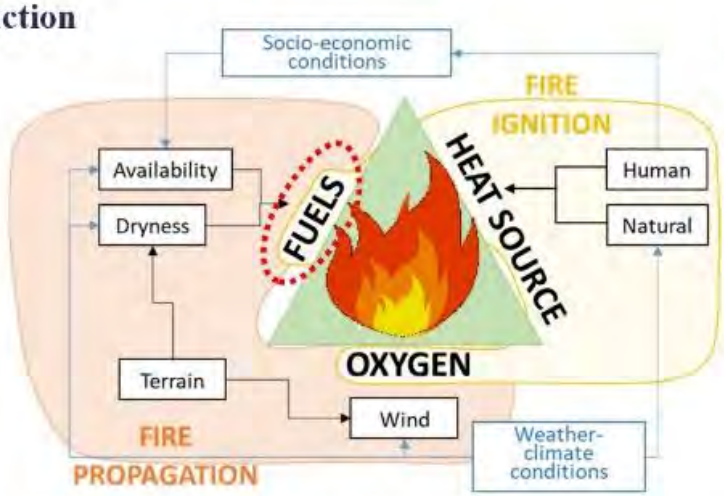
## Product 2. Fuel type and model map






## Introduction




Chuvieco, E.; Yebra, M.; Martino, S.; Thonicke, K.; Gómez-Giménez, M.; San-Miguel, J.; Oom, D.; Vélea, R.; Mouillot, F.; Molina, J.R.; et al. Towards an integrated Approach to Wildfire Risk Assessment: When, Where, What and How May the Landscapes Burn. *Fire* **2023**, 6, 215. https://doi.org/10.3390/fire6050215

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## Introduction



### Forest Fuel Management

**The single most important adaptation in response to climate change**

**The essential need for detailed vegetation mapping**

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## Problem

- Climate Change
- More frequent and severe wildfires
- Need to act on fire prevention
- Need to do forest fuel management
- Lack of detailed and quality data regarding vegetation cover
- Lack of decision support tools to analyze available remote sensing data



03/11/2023 PS3 Demonestration Event in Coimbra

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## Solution




- Satellite data selection and acquisition
- Data processing and fusion
- Fuel classification and characterization
- Fuel management plan based on multicriteria optimization
- Integration to digital platform and validation

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# Study Area

03/11/2023 | PS3 Demonestration Event in Coimbra

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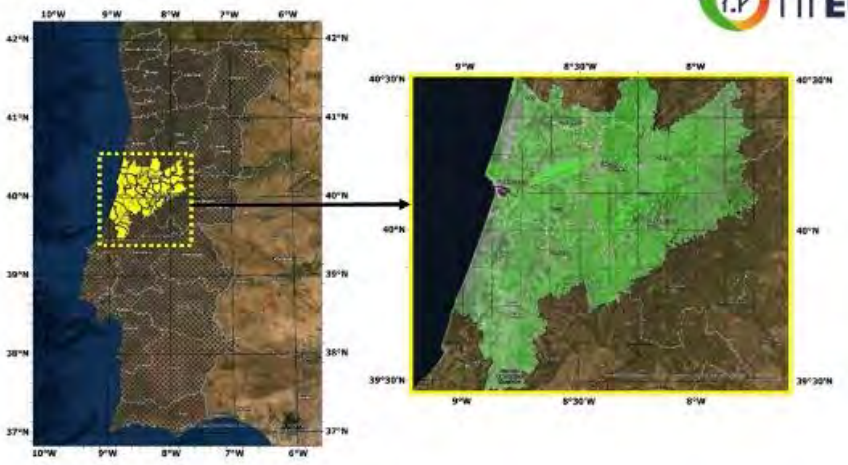
## Portuguese Pilot Site (PS3)

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# Methodology & Data

03/11/2023 | PS3 Demonestration Event in Coimbra

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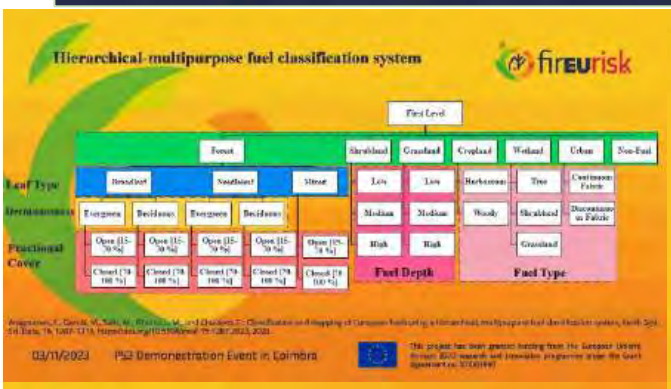


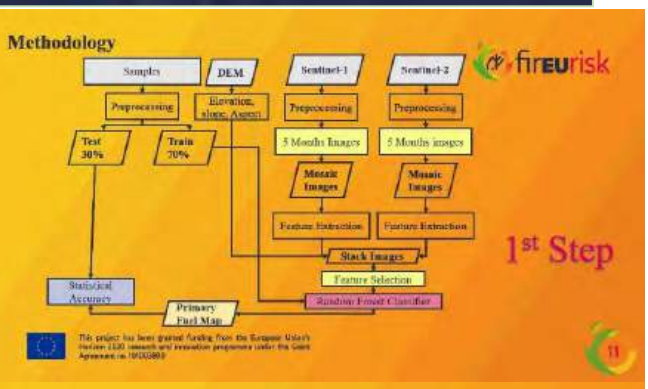


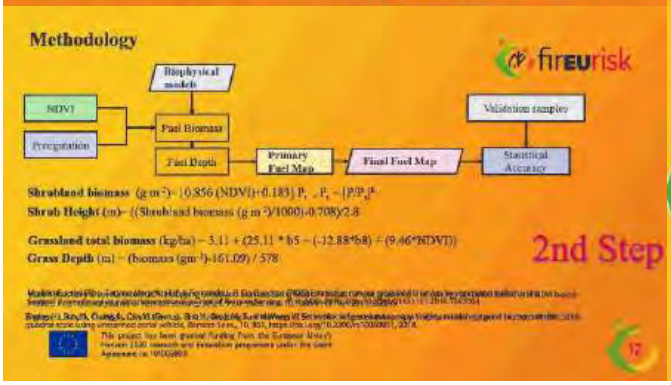




# Results



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## Results-Band Selection

Selection of **35 bands** based on Recursive Feature Extraction (RFE) and Random Forest built-in feature importance measures

| | |
|---|---|
| **Topography** | • Elevation |
| **SAR band** | • VH |
| **GLCM textures** | • Mean<br>• Correlation<br>• Variance |
| **Vegetation Indices** | • GNDVI<br>• TCW<br>• MSAVI |
| **Spectral bands** | • Band 11<br>• Band 8A<br>• July & January |

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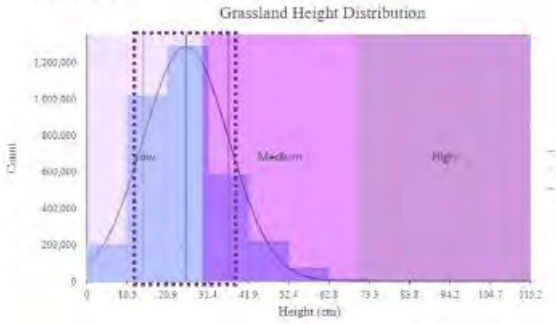
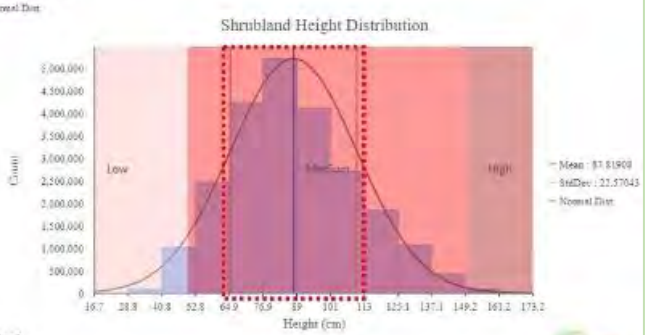
## Results-Height Estimation

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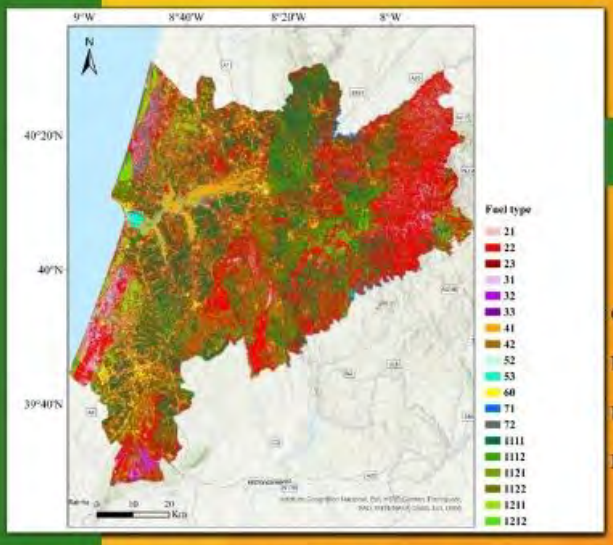


## III Results

| | Primary map | Final map |
|---|---|---|
| Overall Accuracy | 88.94% ±1 | 83.62% ±1 |
| Min Producer Accuracy | 72.13% | 64.51% |
| Min User Accuracy | 60% | 50% |
| Mean F1 score | 87.65% | 83.45% |

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## Results-Confusion Matrix

fireurisk

**Reference**

| Classification | 20 | 30 | 41 | 42 | 52 | 53 | 60 | 71 | 72 | 1111 | 1112 | 1121 | 1122 | 1211 | 1212 | PA (%) | F1-Score (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | 100 | 5 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 6 | 0 | 3 | 0 | 85.5 | 86.6 |
| 30 | 5 | 44 | 6 | 2 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 72.1 | 77.9 |
| 41 | 0 | 3 | 87 | 6 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 89.7 | 87.9 |
| 42 | 5 | 0 | 8 | 105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 89.0 | 90.9 |
| 52 | 0 | 0 | 0 | 0 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.0 | 77.1 |
| 53 | 0 | 0 | 0 | 0 | 13 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 80.9 | 85.3 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 87 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 97.8 | 92.1 |
| 71 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 53 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100.0 | 100.0 |
| 72 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 | 79 | 0 | 0 | 0 | 0 | 0 | 0 | 89.8 | 93.5 |
| 1111 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 13 | 0 | 0 | 0 | 1 | 79.7 | 85.3 |
| 1112 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 50 | 0 | 0 | 0 | 0 | 98.0 | 87.7 |
| 1121 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 1 | 0 | 0 | 92.3 | 72.7 |
| 1122 | 0 | 0 | 0 | 0 | 3 | 4 | 0 | 0 | 0 | 0 | 0 | 2 | 43 | 0 | 0 | 82.7 | 89.6 |
| 1211 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 75 | 0 | 97.4 | 94.9 |
| 1212 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 43 | 86.0 | 91.5 |
| UA (%) | 87.7 | 84.6 | 86.1 | 92.9 | 62.8 | 90.2 | 87 | 100 | 97.5 | 91.7 | 79.4 | 60 | 97.7 | 92.6 | 97.7 | | |
| OA (%) | 88.94 | | | | | | | | | | | | | | | | |



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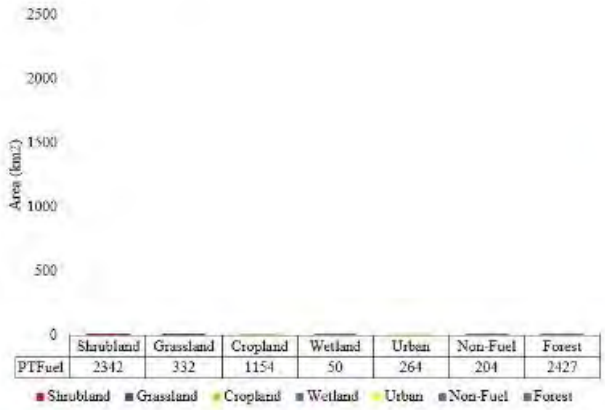
## Results-Occupied Area




**Causes**

- Lack of up-to-date
- Complex and heterogeneous
- Wildfires and burnt area
- Cutting tree and new plantation
- Fragmented species distribution
- Tree age differences
- Resolution and class differences

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# Conclusion & Future Works

03/11/2023 | PS3 Demonestration Event in Coimbra

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## Conclusion & Future Works




### Future Works

- Using GEDI data for fuel parametrization
- Calibrating GEDI with airborne LiDAR
- Expanding the study area to mainland Portugal

Pegah Mohammadpour
pegah@adai.pt

fireurisk

pegah@adai.pt



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## Product 18. Wildland - Urban Interface map






# Why are we so worried about the WUI?




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# 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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# Intermix vs. interface WUI

**Intermix WUI: settlements are within vegetation**



**Interface WUI: settlements adjoin vegetation**



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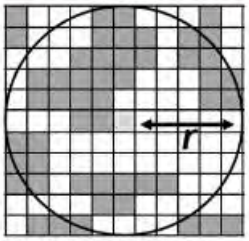
# Identifying intermix WUI

**Flammable vegetation raster**




For each pixel calculate flammable cover within a buffer *r*

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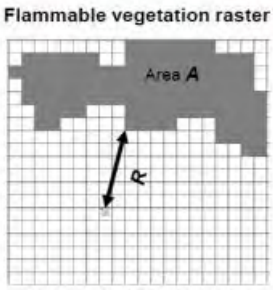
# Identifying interface WUI







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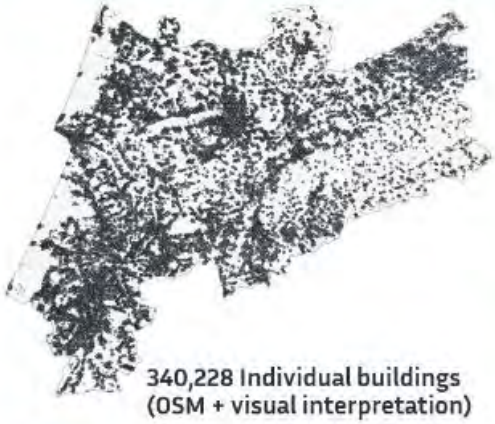
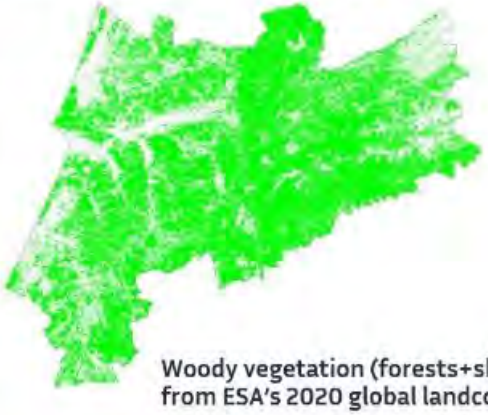
# Inputs (10m spatial resolution)



340,228 Individual buildings
(OSM + visual interpretation)



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

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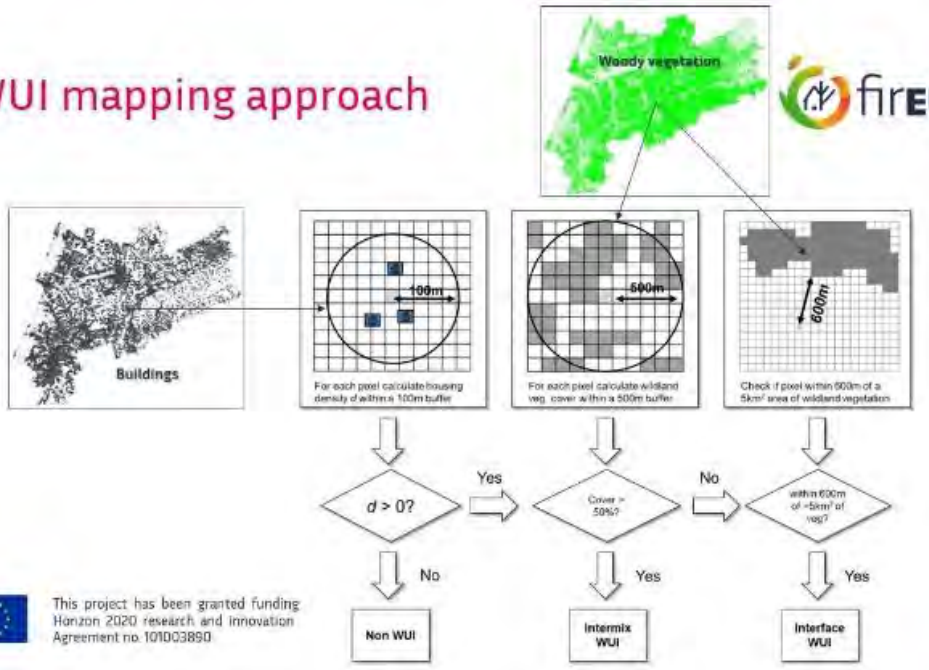
# WUI mapping approach

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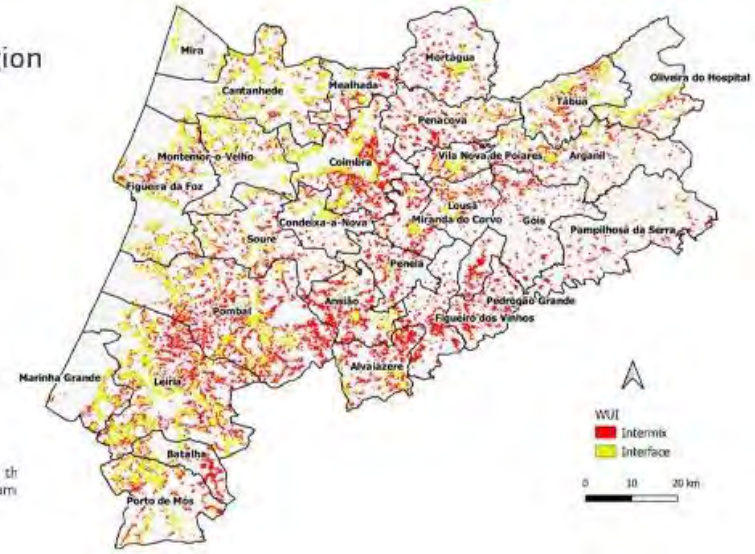
# How much WUI?

136,119 ha, or ~**20.0%** of the region

81,706 ha (60%) intermix WUI
54,408 ha (40%) interface WUI

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# How much WUI area? (municipal level)

Top 5 municipalities in terms of percent are:

Leiria (32.1% WUI)
Alvaiázere (29.4%)
Coimbra (29.2%)
Ansião (28.6%)
Pombal (27.9%)

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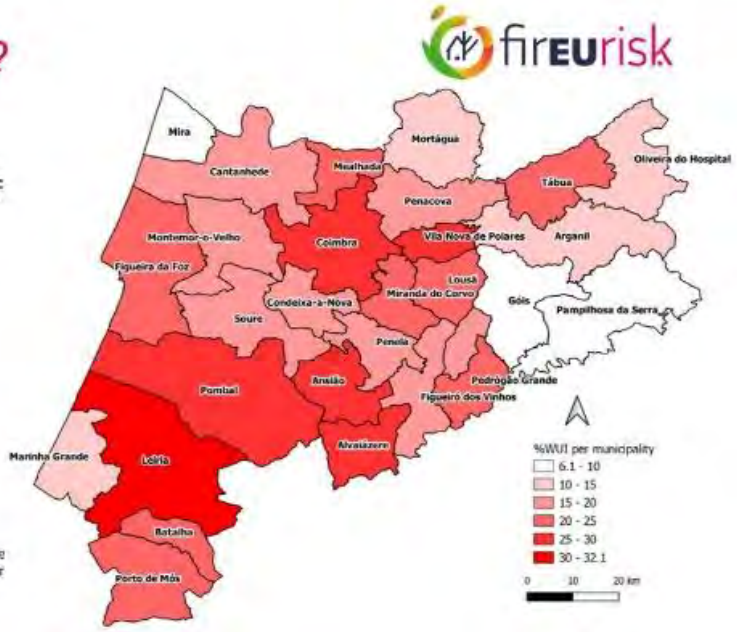


# Buildings in the WUI

There are **275,084** buildings in the WUI, which represent **80.9% of the buildings in the entire region**

**Four** municipalities have **100% of their buildings in the WUI**:
Penacova, Pedrógão Grande, Góis, Castanheira de Pêra

**17** have **more than 90%**

(**71.7%** of Coimbra's buildings)

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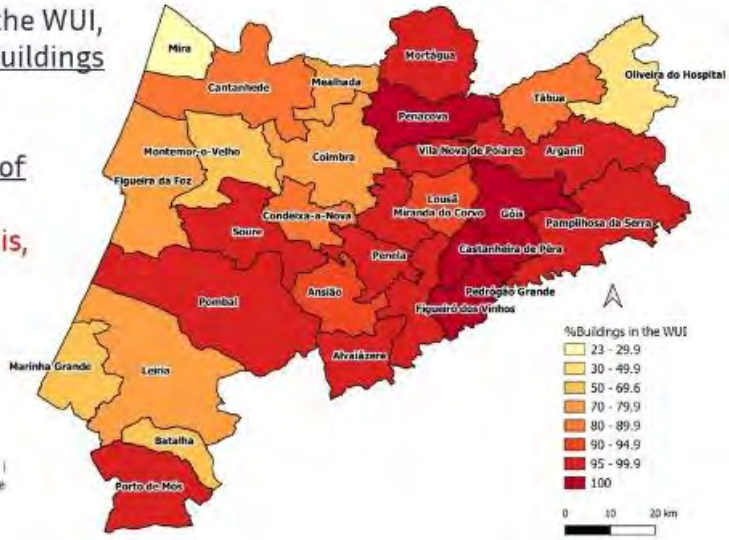
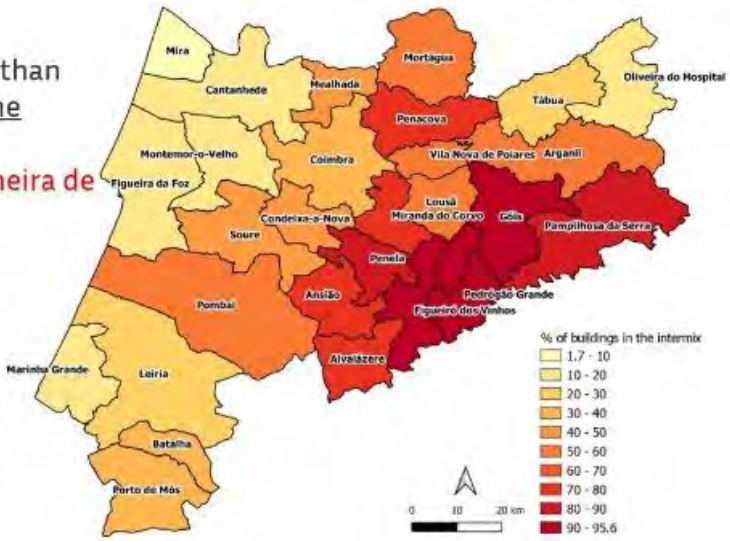


# Buildings in the WUI (intermix only)

**Four** municipalities have more than 90% of their buildings inside the intermix WUI
Pedrógão Grande, Góis, Castanheira de Pêra, Figueiró dos Vinhos

**Six** more have more than 70% buildings in the intermix WUI

(**35.9%** of Coimbra's buildings)

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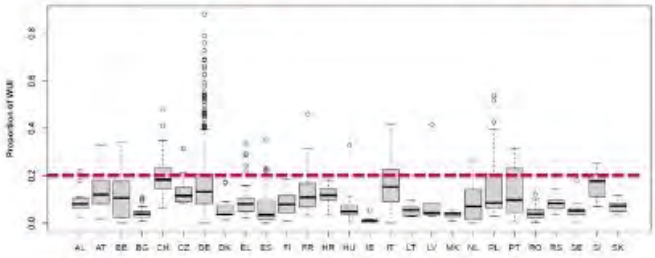
Agreement no 101003890

# European context

WUI covers 7.4% of the European territory, 9.1% of Portugal [Central Portugal 20%]

46.6% intermix [60%], 53.4% interface [40%]







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## Insights

The region of central Portugal represents an extreme case of wildfire exposure to human settlements

(if it were a European country, it would rank **second** in total WUI cover and **first** in intermix WUI cover)

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

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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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## Product 32 Propagation potential indicators for Pilot Sites (PS)

# Propagation Potential in Pilot Site 3 - Central Portugal

**Luís Mário Ribeiro**, ADAI-CEIF, University of Coimbra
[luis.mario@adai.pt]

3/11/2023

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## Propagation potential

Developed in WP1, A1.1.5, for all the Pilot Sites and the European Territory

Marin Bugarić[1], Fermin Alcasena[2], Marcos Rodrigues Mimbrero[3], Darko Stipaničev[1], **Luis Mario Ribeiro**[4], Vassiliki Varela[5], Luis Torres[6], David Caballero[6], Emilio Chuveco[7], Pere J. Gelabert[2]

[1] Fac. Electrical Eng, Machine Eng Naval Arch, University of Split, Croatia
[2] University of Lleida, Catalunya, Spain
[3] Universidad de Zaragoza, Spain
[4] ADAI-CEIF, University of Coimbra, Portugal
[5] Aristotle University of Thessaloniki, Greece
[6] MeteoGRID, Madrid, Spain
[7] University of Alcalá, Alcalá de Henares, Spain



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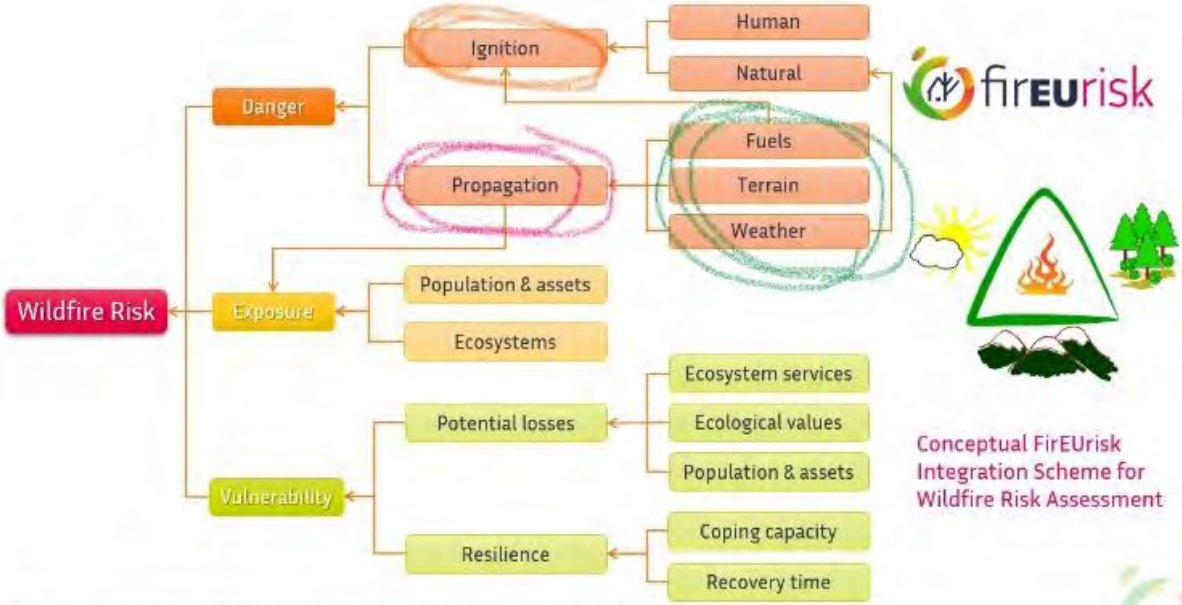
# What is propagation potential?

- The likelihood of a wildfire spreading in a particular area, as determined by the vegetation, weather conditions and topography.

- Calculating propagation potential allows for the generation of several maps, useful for prevention and preparedness planning:



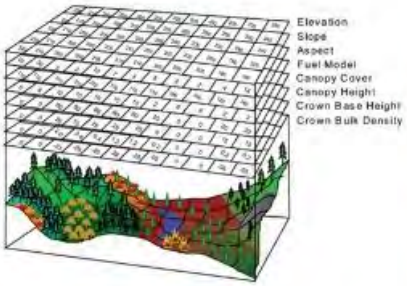




Conceptual FirEURisk Integration Scheme for Wildfire Risk Assessment

Chuvieco et al. (2023). **Towards an Integrated Approach to Wildfire Risk Assessment: When, Where, What and How May the Landscapes Burn**. *Fire*, 6(5), 215. https://doi.org/10.3390/fire6050215

# Propagation potential in PS3 PT

Using **FlamMap** with a set of input layers:







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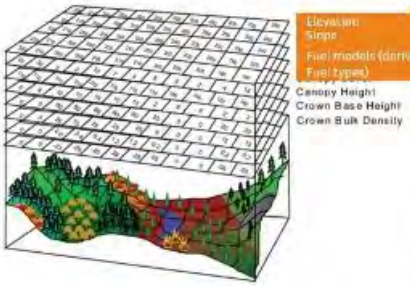
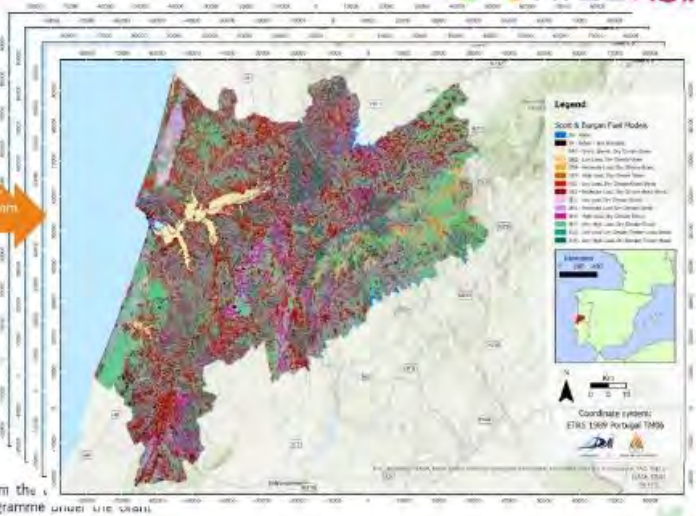
# Flammap input layers

Using FlamMap with a set of input layers:

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# FirEURisk Fuel type map

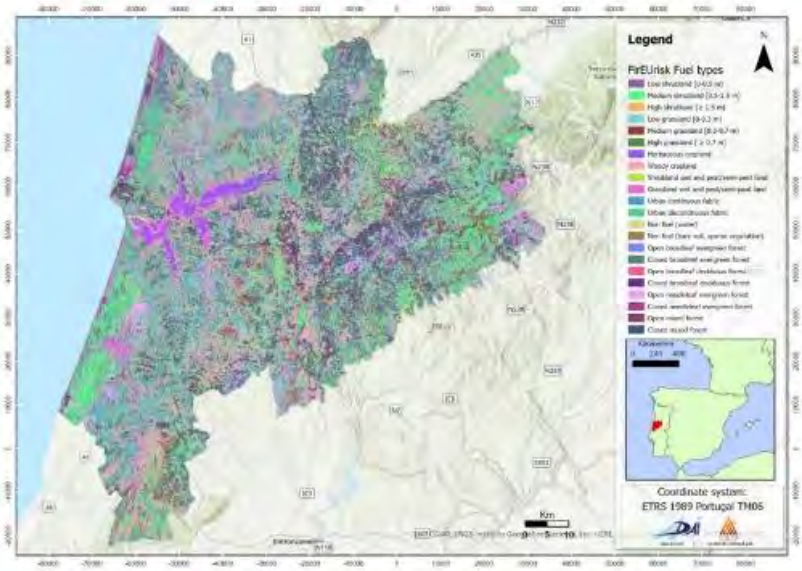



Table 5. Suggested attribution of the first-level FirEURisk fuel types to the FBFM standard fuel models in Europe.

| FirEURisk fuel type | Crosswalk A* | Crosswalk H* | FirEURisk fuel type | Crosswalk A* | Crosswalk H* |
|---|---|---|---|---|---|
| 1111 | SH7 | SH8 | 23 | SH5 | SH9 |
| 1112 | TU1 | TU2 | 31 | GR2 | GR5 |
| 1121 | SH5 | SH9 | 32 | GR4 | GR8 |
| 1122 | TU5 | TU3 | 33 | GR7 | GR9 |
| 1211 | SH7 | SH8 | 41 | GR4 | GR6 |
| 1212 | TU1 | TU2 | 42 | GR2 | GR6 |
| 1221 | SH5 | SH9 | 51 | SH7 | SH8 |
| 1222 | TU5 | TL3 | 52 | SH5 | SH9 |
| 1301 | SH7 | SH8 | 53 | GR7 | GR9 |
| 1302 | TU5 | TL3 | 61 | NB | NB |
| 21 | SH2 | SH3 | 62 | SH2 | SH3 |
| 22 | SH7 | SH8 | 7 | NB | NB |

* A is the arid/semi-arid region, and H is the sub-humid/humid region. See Table 1 for the fuel type code identification and Table C2 in Appendix C for the FBFM descriptions and parameters.

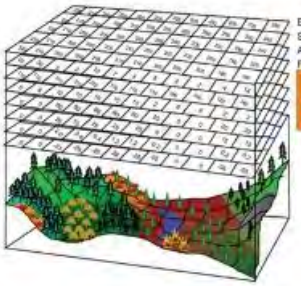

Aragoneses, E., García, M., Salis, M., Ribeiro, L. M., & Chuvieco, E. (2023). **Classification and mapping of European fuels using a hierarchical, multipurpose fuel classification system**. *Earth System Science Data*, 15(3), 1287–1315. https://doi.org/10.5194/essd-15-1287-2023

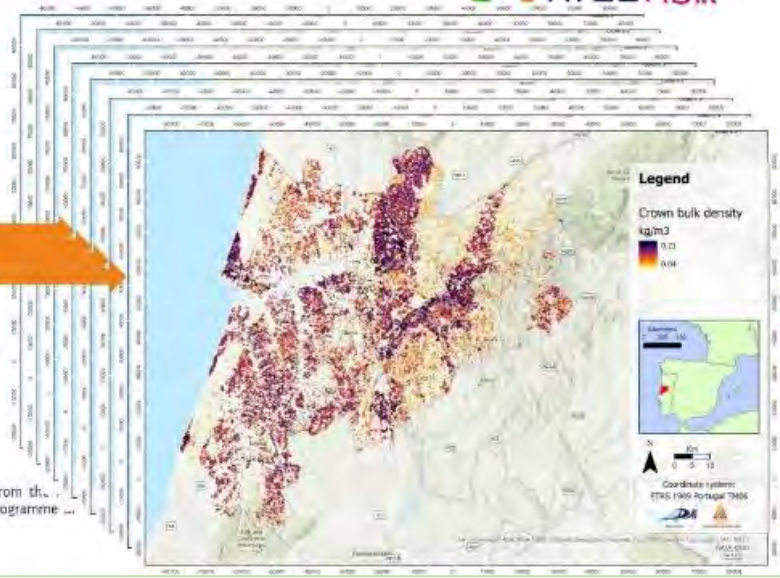
Scott & Burgan (2005). **Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model**. https://doi.org/10.2737/RMRS-GTR-153




# Flammap input layers

Using FlamMap with a set of input layers:

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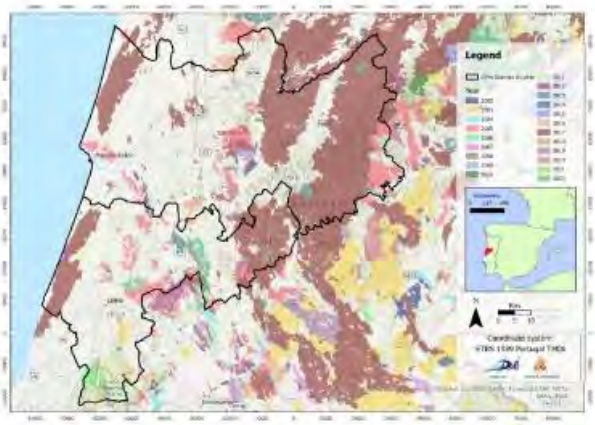
# Weather scenarios

1. Historical fire records (20 years)
2. For every fire in the database, larger than 1 ha, we obtained:
   - *burned area*
   - *wind direction*
   - *wind speed and gust*
   - *1h dead fuel moisture*
   - *10h dead fuel moisture*
   - *100h dead fuel moisture*
   - *live woody fuel moisture*
   - *live herbaceous fuel moisture*

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# Weather scenarios

1. Initially 8 directions (N, NE, E, SE, S, SW, W, NW), but in PS3 PT only 3 were representative
2. Average conditions scenario, represented by percentile 50
3. Extreme conditions scenario, represented by percentile 95
4. Scenarios that influence <10% overall burned area were ignored

| ID | Scenario | Percentile | Wind direction (°) | Wind speed (gust - km/h) | Live herb fuel moisture | Live woody fuel moisture | 1h dead fuel moisture | 10h dead fuel moisture | 100h dead fuel moisture | Burned area | Number of fires | Average fire size |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Northeast | 95 | 45 | 12.8 | 46 | 32 | 63 | 6 | 7 | 28235 | 39 | 724 |
| 2 | | 50 | 45 | 7.7 | 28 | 52 | 78 | 8 | 9 | 39147 | 208 | 188 |
| 3 | Southeast | 95 | 135 | 14.3 | 51 | 32 | 64 | 6 | 7 | 18105 | 47 | 385 |
| 4 | | 50 | 135 | 8.1 | 29 | 59 | 89 | 8 | 9 | 99060 | 126 | 786 |
| 5 | Northwest | 95 | 315 | 12.3 | 44 | 31 | 63 | 7 | 8 | 54916 | 124 | 443 |
| 6 | | 50 | 315 | 8.7 | 31 | 53 | 80 | 12 | 13 | 7273 | 353 | 21 |

# Propagation potential in PS3 PT

1. Individual simulations were made with Flammap for each of the scenarios, weighting them according to the ratio of fire occurrence to get the final result.
2. FlamMap basic runs
   - Fireline intensity
   - Rate of spread
   - Flame length
   - Heat released
3. FlamMap MTT runs
   - Burn probability
   - Conditional flame length
   - Fire intensity level

Table 3. Wildfire events classification based on fire behavior and capacity of control.

| Fire Category | Real Time Measurable Behavior Parameters: FLI* (kW·m⁻¹) | ROS (m/min) | FL (m) | Real Time Observable Manifestations of FBB: PyroCb | Dimensions | Spotting Activity | Spotting Distance (m) | Type of Fire and Capacity of Control** |
|---|---|---|---|---|---|---|---|---|
| Normal Fires | <500 | <0.5 / <1.0 | <1.5 | Absent | Absent | Absent | 0 | Surface fire. Fairly easy |
| | 500–2000 | <1.5 / <2.0 | <2.5 | Absent | Absent | Low | <100 | Surface fire. Moderately difficult |
| | 2000–4000 | <2.0 / <3.0 | 1.5–2.5 | Absent | Absent | High | <400 | Surface fire, torching possible. Very difficult |
| | 4000–10,000 | <3.0 / <10.0 | 2.5–3.5 | Unlikely | In some localized cases | Possible | 400–1000 | Surface fire, crowning likely depending on vegetation type and dead/live fuel. Extremely difficult |
| Extreme Wildfire Events | 10,000–30,000 | >3.0 / <25.0 | 3.5–5.0 | Possible | Present | Prolific | <1500 | Crown fire, either active or plume-driven. Spotting prevalent near or far from the ground. Possible fire breaching across or extended obstacle without apparent. Chaotic and unpredictable fire spread. Virtually impossible |
| | 30,000–50,000 | >3.0 | 5.0–6.0 | Probable | Present | Medium Spotting | <2000 | Plume-driven. Highly convective fire. Chaotic and unpredictable fire spread. Spotting, including long distance, plays a relevant role in fire growth. Possible fire breaching across or extended obstacle without apparent. Impossible |
| | >50,000 (possible) | >3.0 (possible) | >6.0 (possible) | Present | Present | Massive Spotting | >2000 | Plume-driven. Highly convective fire. Same as the previous, but with additional fire-induced atmospheric circulation. Fire whirls, gusts and firestorm development are originated. Fuel matrix because of extreme turbulence is unstable and massive spotting. Impossible |

Note: * Direct and whole flame; ** generalized; *** abandoned and guidance. *FLI classes I–6 follow the classification by Alexander and Cruz (2013).

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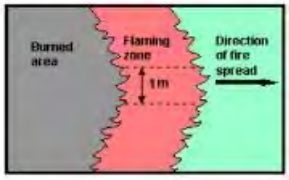
Tedim et al. (2018). **Defining Extreme Wildfire Events: Difficulties, Challenges, and Impacts**. Fire, 1(1), 9. https://doi.org/10.3390/fire1010009

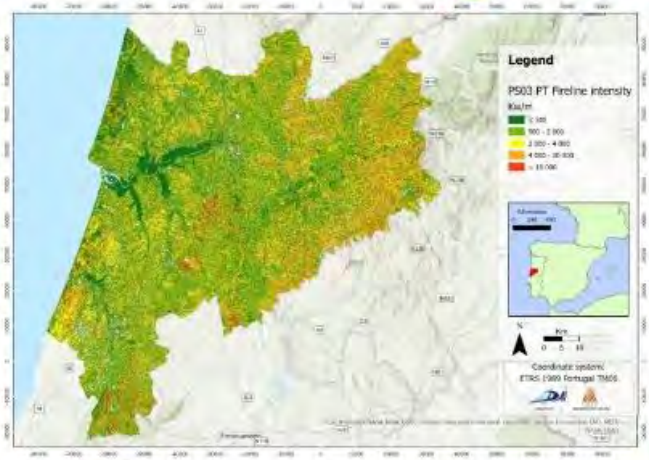


# FlamMap basic runs

## 1. Fireline intensity

Fireline Intensity is the heat energy release per unit time from 1-meter wide section of the fuel bed extending from the front to the rear of the flaming zone.

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# FlamMap basic runs

1. [illegible]
2. Rate of spread

Surface Rate of Spread is the "speed" the fire travels through the surface fuels. Surface fuels include the litter, grass, brush, and other dead and live vegetation within about 1.8 m of the ground.




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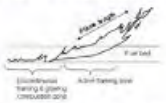
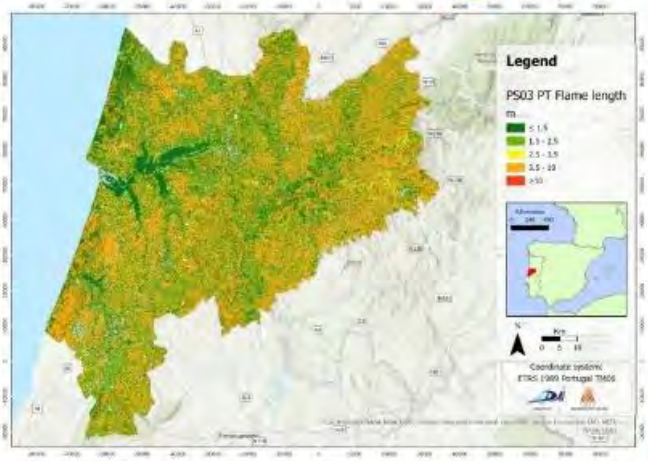
# FlamMap basic runs

1. [illegible]
2. [illegible]
3. Flame length

The Flame Length of a spreading surface fire within the flaming front is measured from midway in the active flaming combustion zone to the average tip of the flames



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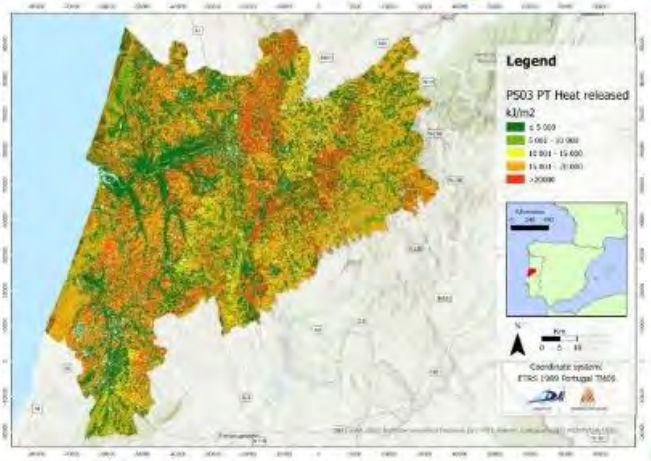
# FlamMap basic runs

1. [illegible]
2. [illegible]
3. [illegible]
4. Heat released

Heat per Unit Area is the heat energy release per area (square meter) within the flaming front of the surface fuel

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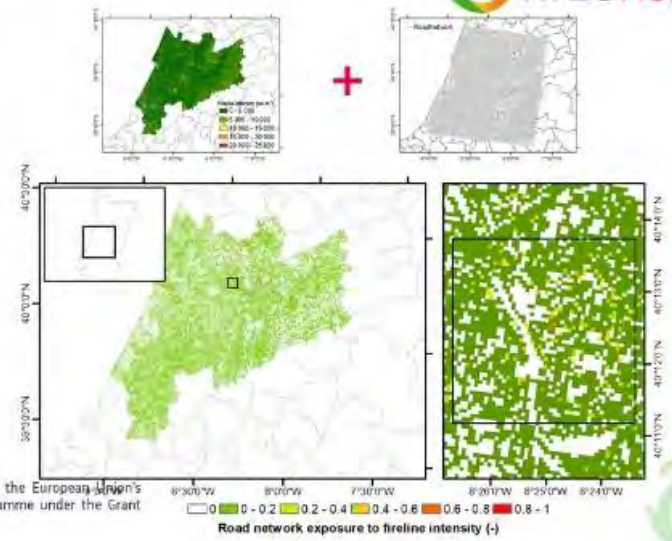
# FlamMap basic runs

Applying the results to obtain fire exposure metrics:

*Example of road network exposure (from University of Aveiro)*

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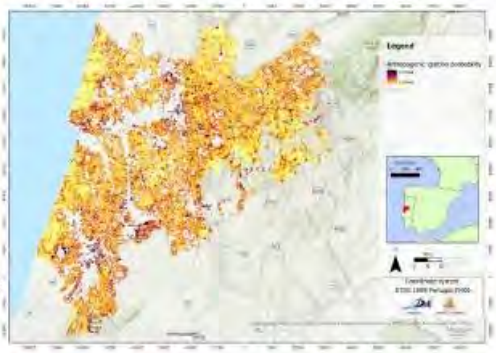
## FlamMap MTT runs

1. Minimum Time Travel module relies on the execution of multiple fire propagation simulations, according to ignition scenarios.
2. Ignition scenarios were created with the help of the human ignition probability map for the PS.



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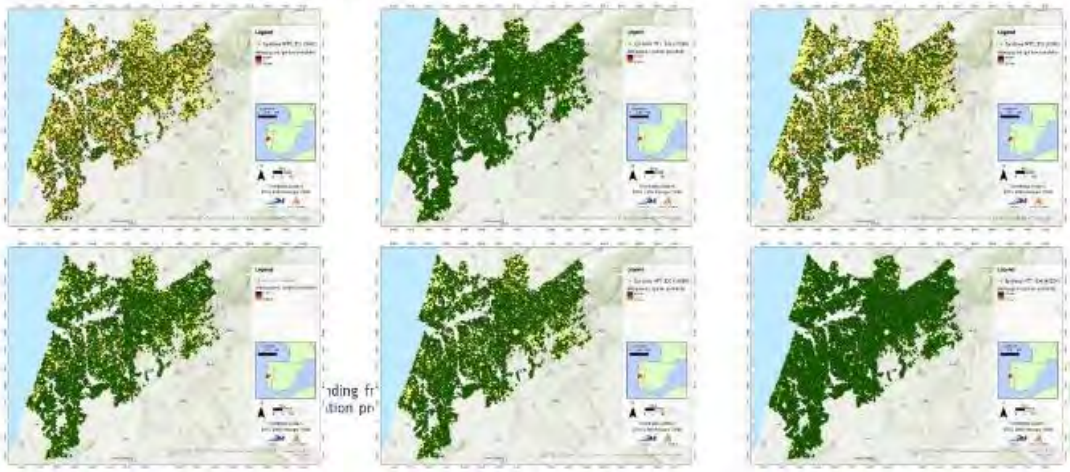
## FlamMap MTT runs – ignition scenarios

Thousands of ignitions were generated (proportional to the number of fires in each weather scenario) to saturate the area with fire



# FlamMap MTT runs

1. Calibration stage was required to determine "simulated fire durations" for each weather scenario
2. Three outputs:
   - Burn probability
   - Conditional flame length
   - Fire intensity level

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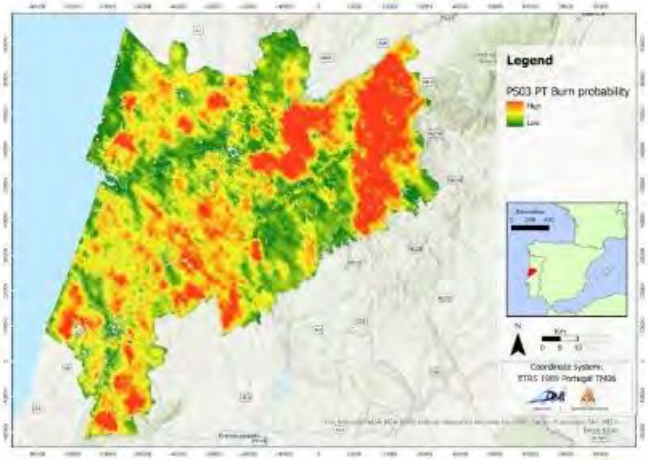
# FlamMap MTT runs

1. Burn probability
   - The fraction of the number of fires that encountered each node (0.0 to 1.0).
   - 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 a region, the higher the probability

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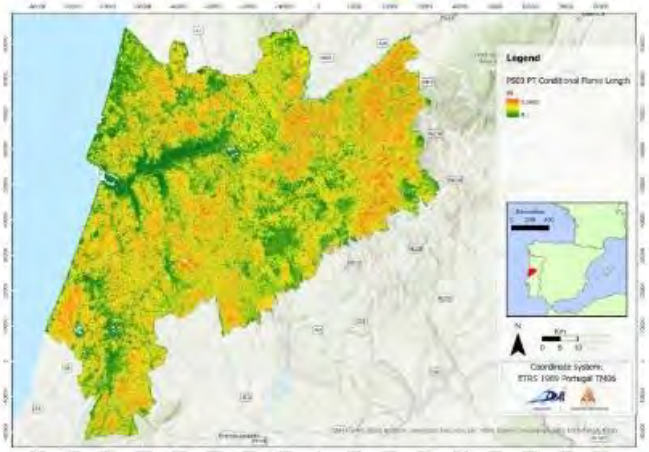
# FlamMap MTT runs

## 2. Conditional flame length

- Represents the most likely flame length at a given location if a fire occurs.
- It is an average measure of expected wildfire intensity.

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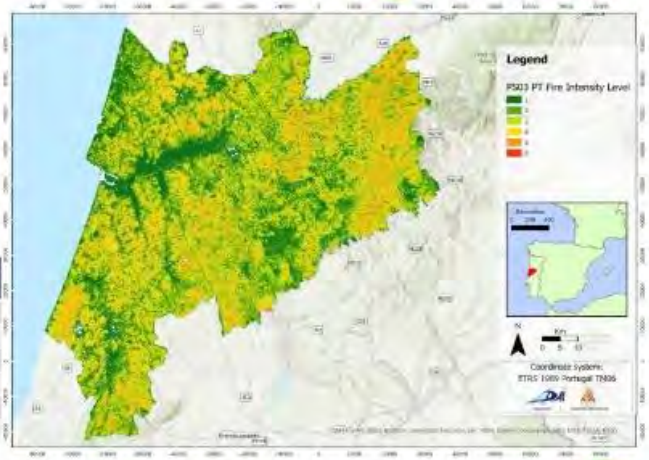
# FlamMap MTT runs

## 3. Fire intensity level

- Represented by classes of flame length ranges.
- FIL can be related to fireline and crown fire intensity.

| Fire Intensity Level | Flame length (m) | Fireline intensity (kW/m) | Crown fire intensity (kW/m) |
|---|---|---|---|
| FIL1 | < 0,6 | < 88,6 | < 108 |
| FIL2 | 0,6–1,2 | 88,6–400 | 108–303 |
| FIL3 | 1,2–1,8 | 400–965 | 303–554 |
| FIL4 | 1,8–2,4 | 965–1803 | 554–851 |
| FIL5 | 2,4–3,7 | 1803–4354 | 851–1559 |
| FIL6 | > 3,7 | > 4354 | > 1559 |

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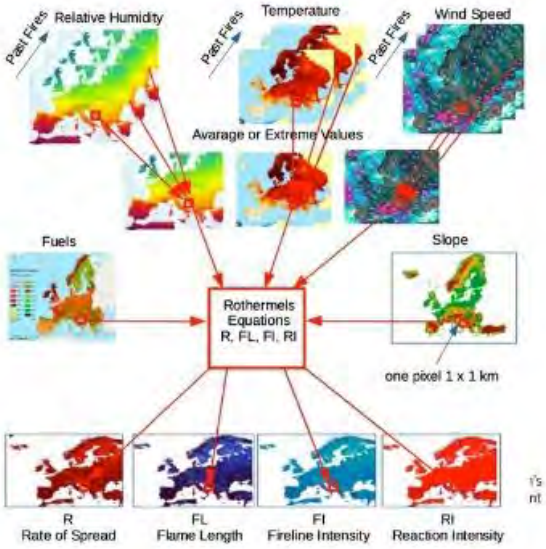
# Propagation potential – European territory




- 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.**
- A similar approach was followed



# Propagation potential – European territory

1. Fireline intensity

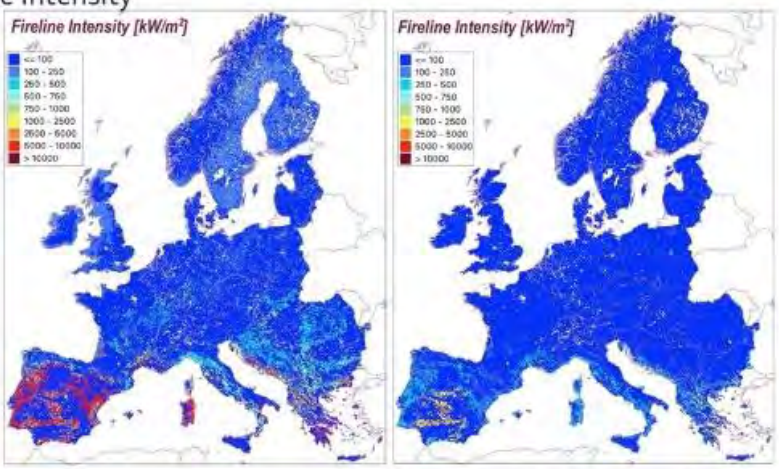



*Figure 27: Comparison of Fireline Intensity (FI) [kW/m²)] for extreme and average wind speed and fuel moisture(left – extreme, right – average)*

# Propagation potential – European territory

1. Rate of spread

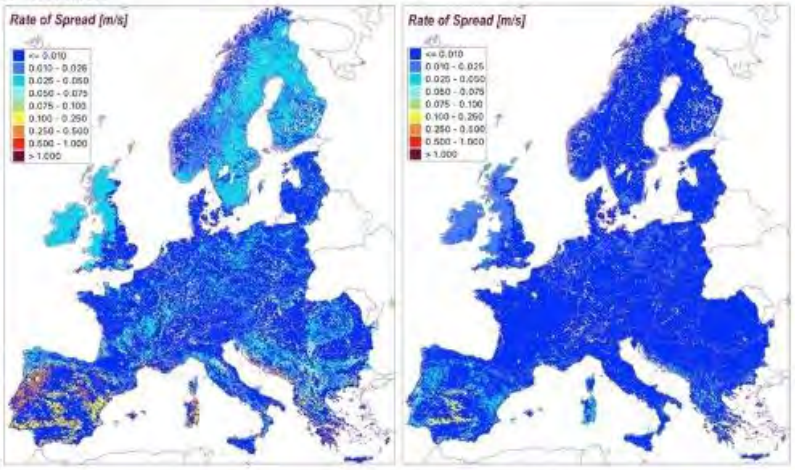



Figure 25: Comparison of Rate of Spread (ROS) [m/s] for extreme and average wind speed and fuel moisture (left – extreme, right – average)



# Propagation potential – European territory

1. Flame length

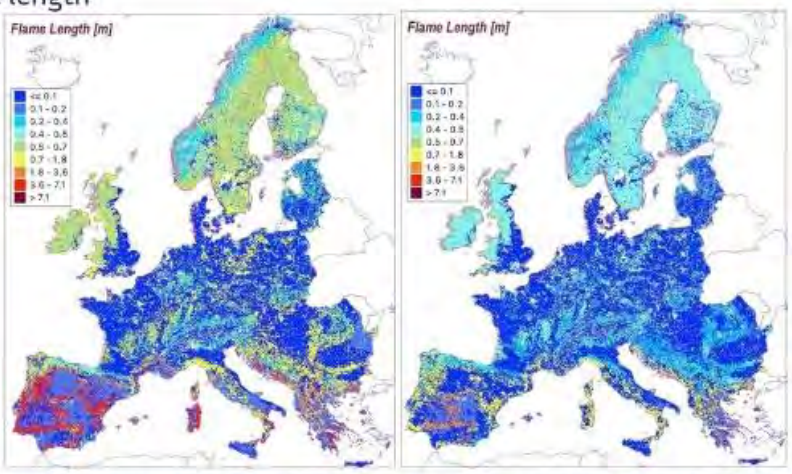



Figure 28: Comparison of Flame Length (FL) [m] for extreme and average wind speed and fuel moisture (left – extreme, right – average)

# Propagation Potential in Pilot Site 3 - Central Portugal

**Luís Mário Ribeiro**, ADAI-CEIF, University of Coimbra
[lmr.mario@adai.pt]

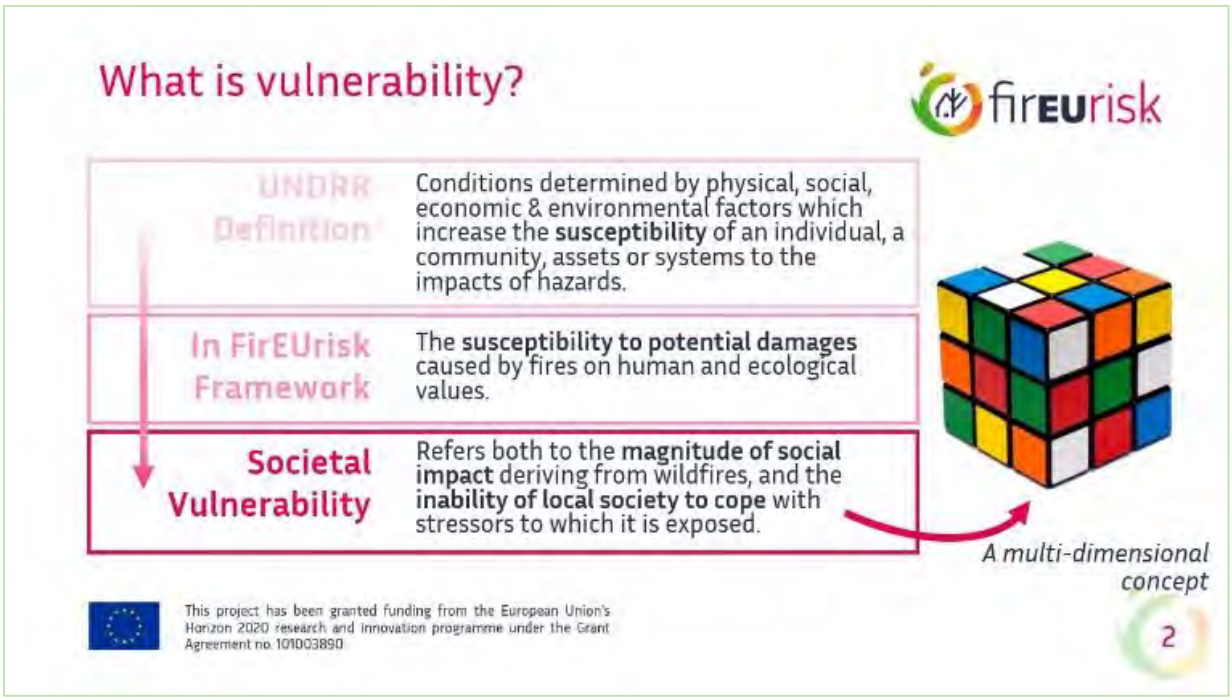
adai.pt/ceif | facebook.com/ceif.adai

3/11/2023

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

## Product 68 RESVI - Relative Societal Vulnerability Index (at community level)



## Why is social vulnerability relevant for wildfire risk prevention activities?

- ✓ To better understand social vulnerability of a given community means to **better understand** its **strengths** and **weaknesses** when facing wildfires
- ✓ It means being able to **integrate relevant features** (e.g., volunteering forces, trust towards institutions etc.) **in** risk prevention, risk communication, and resilience-making **local policies**
- ✓ It means to gain **more instruments to engage local societies** in "peace periods" to find them more prepared during wildfire seasons
- ✓ It means being able to **learn from other communities** on how to prevent and prepare for wildfires, in a peer-to-peer process



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



## How to assess social vulnerability

**Pure measurement approaches** tend to be very limited, because of unavoidable differences between contexts and because vulnerability is a dynamic feature.

### ASSESSMENT PERSPECTIVE

Understand vulnerability within a **socially, spatially and temporally perspective**

In the absence of universally defined standard and tresholds, analyse vulnerability in **comparative terms**

Consider the **community perspective** by prioritizing **participatory approaches** and gathering local knowledge



This project has been granted funding from the Europ Horizon 2020 research and innovation programme unde Agreement no. 101003890



# ReSVI

## RElative Social Vulnerability Index

03/11/23 | FirEUrisk Demonstration Event – Portugal

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

## ReSVI Goals

1. Elaborating a **self-assessment guided tool** for social vulnerability to wildfires at community level
2. Highlighting **major areas of vulnerability** at (local) community level
3. Supporting relevant actors (e.g., Local Authorities, decision-makers, relevant practitioners) in **vulnerability-reducing and resilience-enhancing strategies**
4. Supporting **strategic planning**

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

# ReSVI Dimensions

| Social | Economic | Institutional | Human cap. | Environmental |
|---|---|---|---|---|
| Demography, identity, vitality (e.g. socio-demographic characteristics, local activism, access to information, etc.) | Overall resources and assets within a community that ensure wellbeing (e.g., average income, distribution of resources, occupational related aspects, etc.) | Institutional and political resources, as well as participation frameworks fostering citizens' engagement in decision-making processes | Knowledge, skills, and capacities, as well as the potentiality to deploy those skills and capacities (e.g., educational level, health-related variables) | Tangible assets, understood both as natural and infrastructural/built, that shape the context within which the community develops |
| 9 Indicators | 4 Indicators | 7 Indicators | 3 Indicators | 12 Indicators |
| 46 Proxies | 36 Proxies | 31 Proxies | 26 Proxies | 116 Proxies |

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



# ReSVI Operational Steps

| Units of analysis | Review of indicators/proxies | Data collection | ReSVI elaboration | Participatory analysis |
|---|---|---|---|---|
| Units of analysis are selected to be horizontally (e.g., same administrative level), vertically (e.g., hierarchically related levels), or mixed compared | Indicators and proxies are assessed according to their relevance (yes/no, and weight) and availability. The preliminary list can be also integrated with new indicators/proxies | Data are collected through international, national, and local repositories, as well as by conducting qualitative and quantitative on field data collection (e.g., workshops, surveys) | Normalised Z-score $Z = \frac{X - \mu}{\sigma}$ $\frac{(Z - m_z)}{M_z - m_z}$ | ReSVI, represented as an overall index as well as split up in its 5 Dimensions and 35 Indicators, serves as a basis for a participatory review of community vulnerability against wildfires |
| 1 | 2 | 3 | 4 | 5 |

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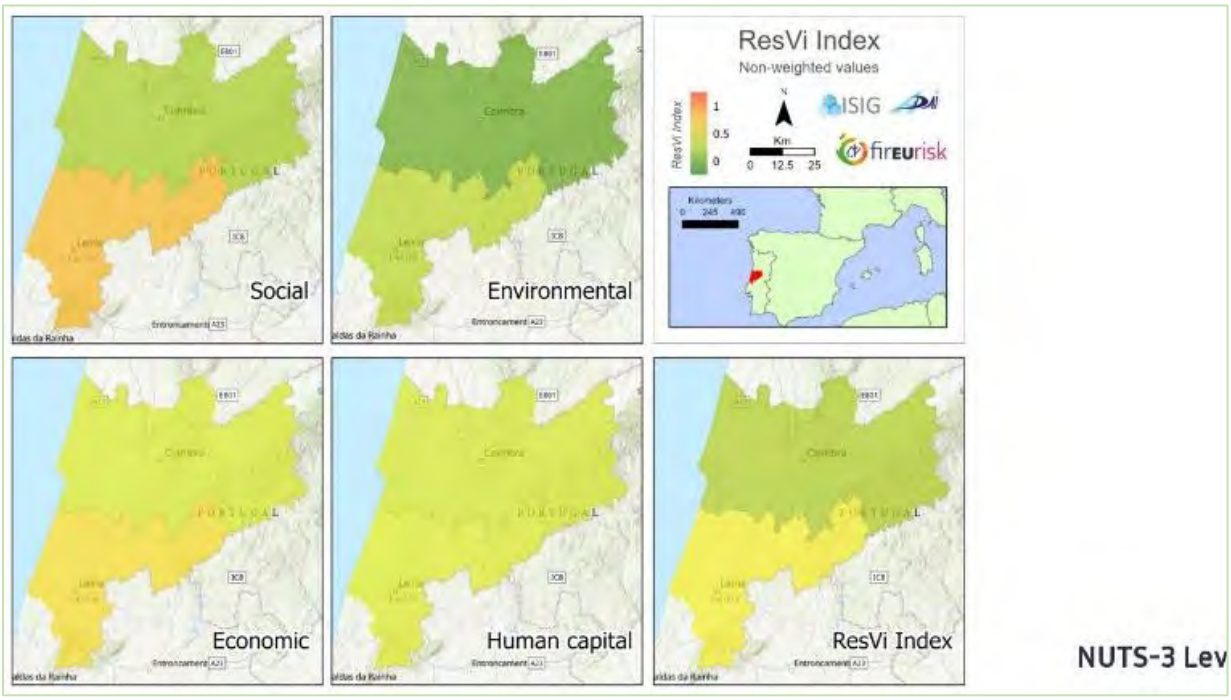
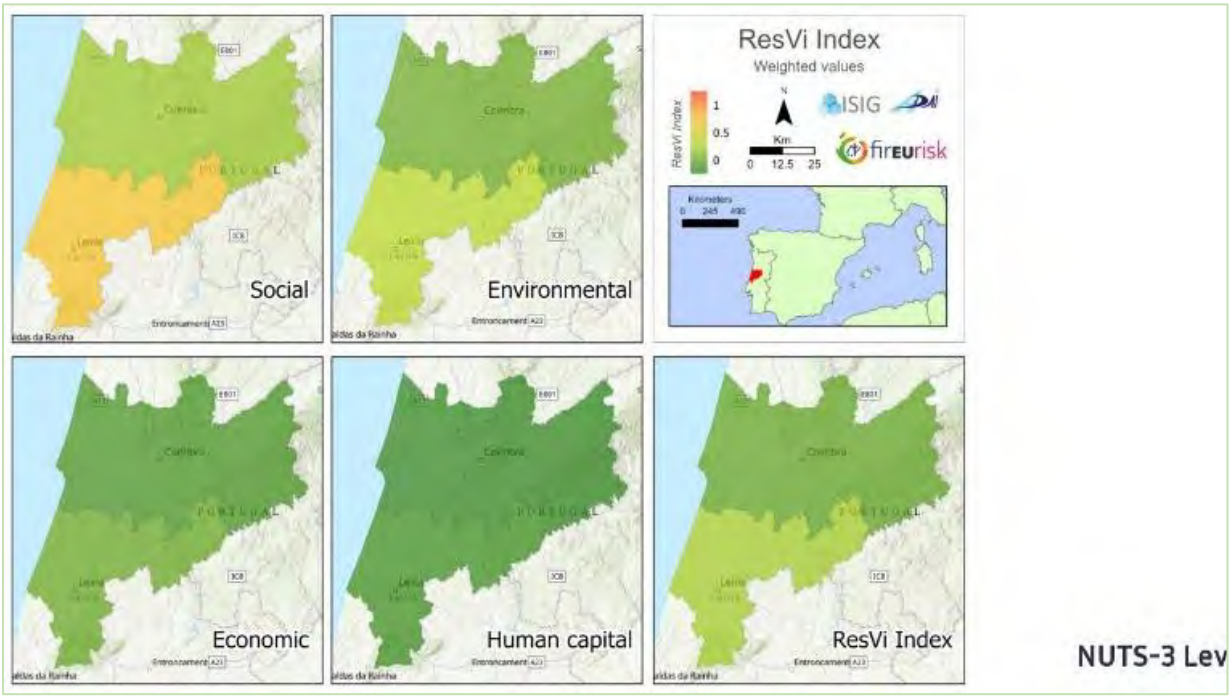

Social
Environmental
ResVi Index
Non-weighted values
ResVi Index
1
0.5
0
N
Km
0 12.5 25
ISIG
firEURisk
Kilometers
0 245 490
Economic
Human capital
ResVi Index
NUTS-3 Lev


Social
Environmental
ResVi Index
Weighted values
ResVi Index
1
0.5
0
N
Km
0 12.5 25
ISIG
firEURisk
Kilometers
0 245 490
Economic
Human capital
ResVi Index
NUTS-3 Lev

## Municipality Level

| Non-weighted | Lousã | Castanheira de Pêra | Figueiró dos Vinhos |
|---|---|---|---|
| Social | 0.38 | 0.63 | 0.59 |
| Economic | 0.46 | 0.50 | 0.51 |
| Institutional | 0.76 | N/A | N/A |
| Human Capital | 0.47 | 0.49 | 0.49 |
| ReSVI | 0.52 | 0.54 | 0.53 |

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| Wighted | Lousã | Castanheira de Pêra | Figueiró dos Vinhos |
|---|---|---|---|
| Social | 0.35 | 0.54 | 0.51 |
| Economic | 0.14 | 0.11 | 0.12 |
| Institutional | 0.38 | N/A | N/A |
| Human Capital | 0.05 | 0.06 | 0.05 |
| ReSVI | 0.23 | 0.54 | 0.23 |

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# Steps after the ReSVI Assessment

*Just some ideas on what you might be able and keen to do after completing ReSVI analysis*

Highlight vulnerable areas upon which to prioritise, as well as resilient areas to be exploited to their fullest



Define resilience enhancing strategies in a participatory way, building upon knowledge and relationships of trust generated by the self-assessment process



Engage stakeholders and citizens in a long-term perspective



Establish new peer-to-peer learning connections among different communities



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Thank you for your attention!

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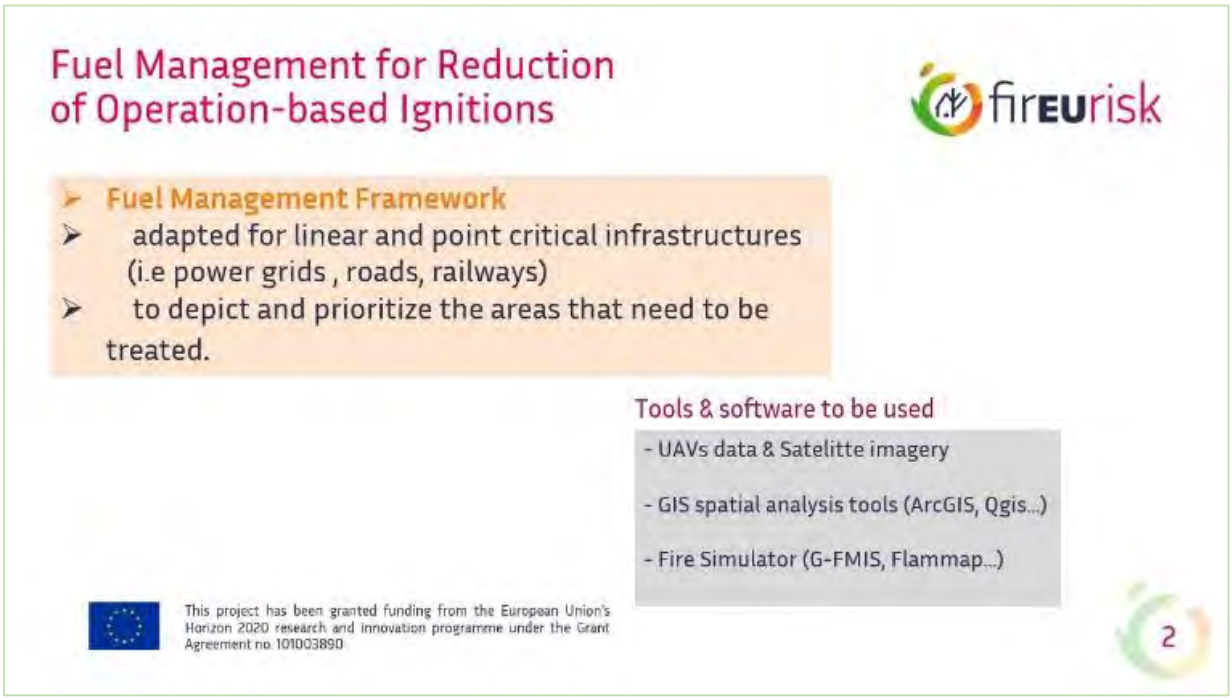
## Product 55 Fuel Management Framework for Reducing Operation-based Ignitions (FuMaF_ROI)



## Input thematic layers

- Power grid (lines) .. (High-Medium-Low voltage)
- Power substations/pylons/transformers (WUI areas) (points) ..
- Railway network (lines)
- Road network (lines) ... (National, Provincial, Municipal .. and Unpaved)
- Other installations related to road and railway networks (points)
- Topography (elevation, slope, aspect)
- Fuel Type map based on FirEURisk fuel types
- Climatic characteristics/ Zone (...Dry, Mild, Wet)
- Ignition points of past fires caused by accident due to the existence or usage of the above infrastructure
- Fire Simulation for a selected weather scenario (prevailing or worst case for the PS/AOI)



## Output/resulting map

**Fuel Reduction** map with three (3) priority classes (low, medium, high) of fuel treatment.

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



## Steps of Analysis

a. Zone of analyses around networks & point assets
b. Acceptable Safety Distance (ASD) for each type of network & asset

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## Steps of Analysis

### c. definition of Homogeneous Territorial Classes (HTCs)

| Elevation | Slope | Aspect | Fuel | Climate | Classes |
|---|---|---|---|---|---|
| < 100 m | < 5° | Zenith | Grassland Low | Lauretum hot subzone | 1 |
| 100 – 500 m | 5°-25° | North | Grassland high | Lauretum intermediate subzone | 2 |
| 500 – 1000 m | > 25° | East | Shrubs low | Lauretum cold subzone | 3 |
| > 1000 m | | South | Shrubs high | | 4 |
| | | West | Forest closed | | 5 |
| | | | Forest open | | 6 |
| | | | Crops | | 7 |
| | | | Urban & vegetation | | 8 |

4 x 3 x 5 x 8 x 3 = 1440 HTC (theoretical value)



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## Steps of Analysis

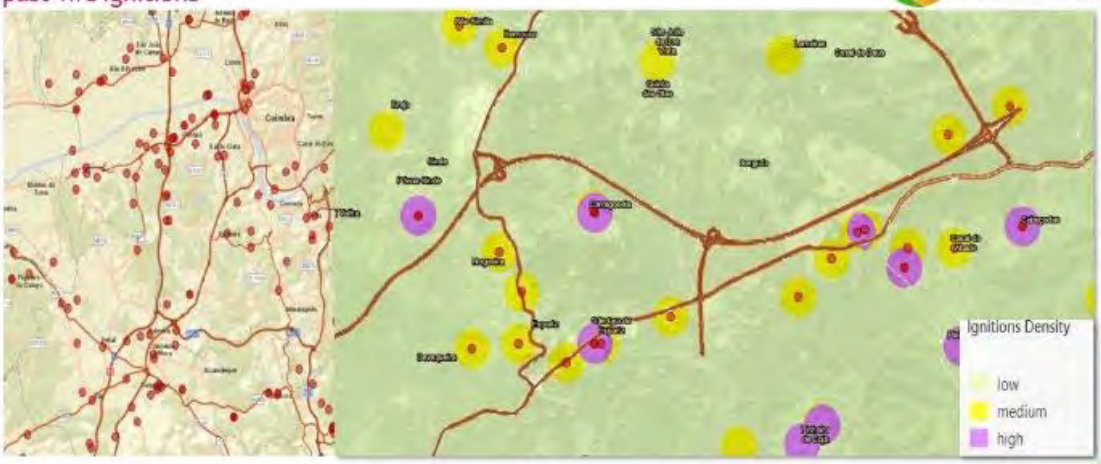
### d. Estimation of Rate of Spread under a selected weather scenario for the PS
### e. Estimation of Mean Rate of Spread (ROS) for each HTC and classification in five (5) classes (ROScl)




| mROS (m/min) | -> class |
|---|---|
| 0-5 | 1 v.low |
| 5-15 | 2 low |
| 15-25 | 3 medium |
| 25-60 | 4 high |
| >60 | 5 extreme |

## Steps of Analysis

### f. creation of Past Ignitions Density map (PID) based on operations-based past-fire ignitions

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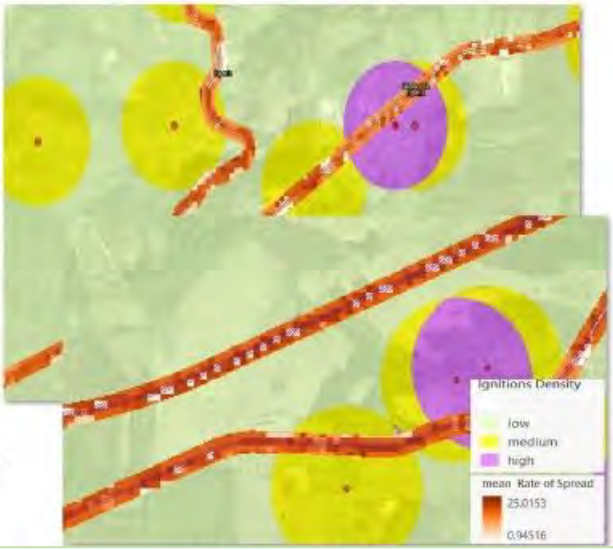
## Steps of Analysis

### g. Combination of Acceptable Safety Distance (ASD), HTC-ROScl & ID maps for the estimation of Fuel Reduction Danger (FRD) map

| HTC_ROSd | PID | ASD (m) | danger value |
|---|---|---|---|
| 1 | low | > X (outside the buffer zone defined for each type of Infra) | 1 |
| 2 | medium | < X (in the zone defined for each type of infra | 2 |
| 3 | high | | 3 |
| 4 | | | 4 |
| 5 | | | 5 |
| ? | | | ? |

Maximum Fuel Reduction Map (FRM) danger value = 5 + 3 + 2 = 10
Minimum Fuel Reduction Map (FRM) danger value = 1+ 1 + 1 = 3

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## Steps of Analysis

g. Combination of Acceptable Safety Distance (ASD), HTC-ROScl & ID maps for the estimation of Fuel Reduction Danger (FRD) map




## Steps of Analysis

h. Classification of FRd map for the creation of final Fuel Reduction map

Maximum Fuel Reduction danger (FRd) value = 5 + 3 + 2 = 10
Minimum Fuel Reduction danger (FRd) value = 1+ 1 + 1 = 3

Three classes of FR priority
Low (3-4)
Medium (5-6)
High (7-10)




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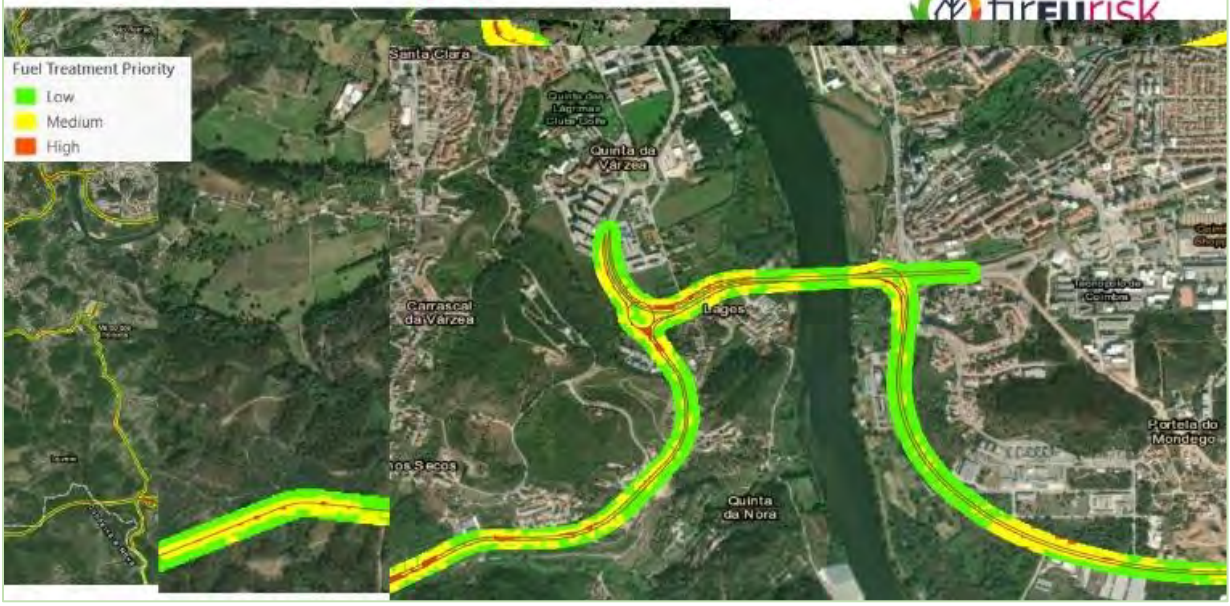
# Fuel Reduction map (priority classes)




## Fuel Management for Reduction of Operation-based Ignitions Framework

- The Framework is under development and will be finalized by February of 2024.
- ASD values for each type of Critical Infrastructure
- Calibration of the threshold values of classes of the parameters
- Integration of very high resolution data from UAVs
- Application/improvements of the final product in PS3 (Portugal) and PS5 (Greece)

### for operational purposes....

- Mapping of Fuel Treatment Priority around Critical Infrastructures
- Area (hectares) covered by each Fuel Treatment priority class in total or/and per forest management unit
- Combination of physical characteristics (topography, fuel conditions) in the Homogeneous Territorial Classes (HTCs) for the facilitation of the selection of Fuel Treatment methods
- Fire behaviour characteristics (ROS, FLIN) for each HTC and/or forest management unit

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# fireurisk

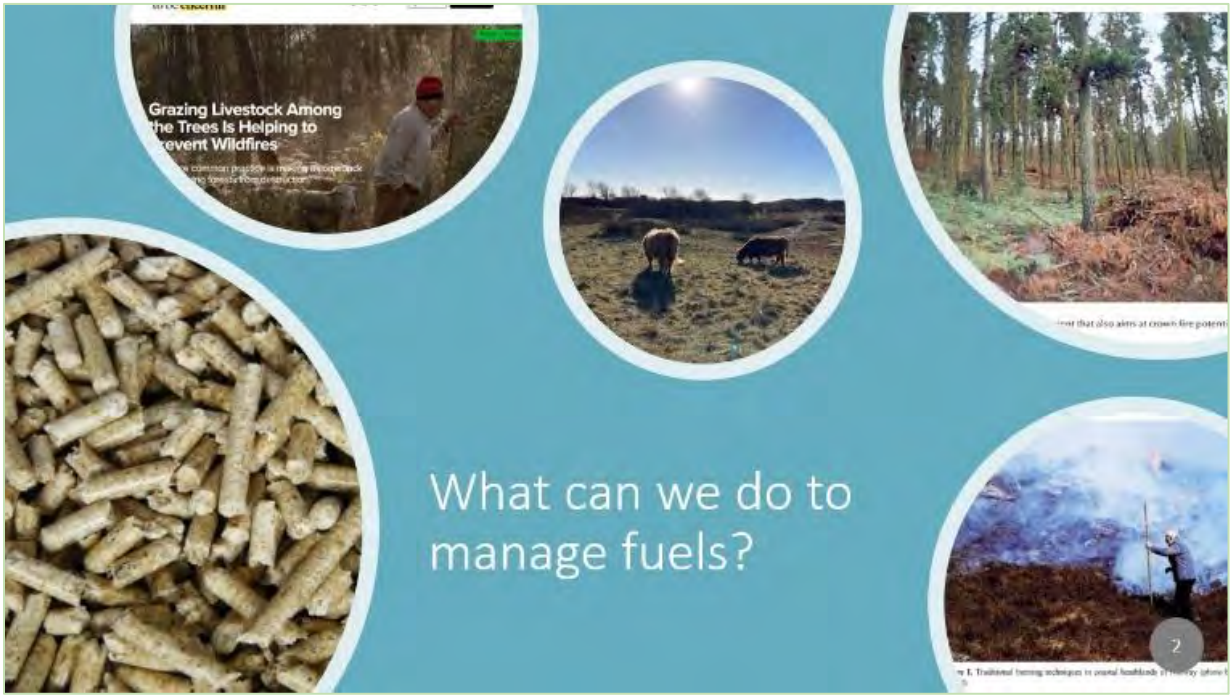
## Thank you!

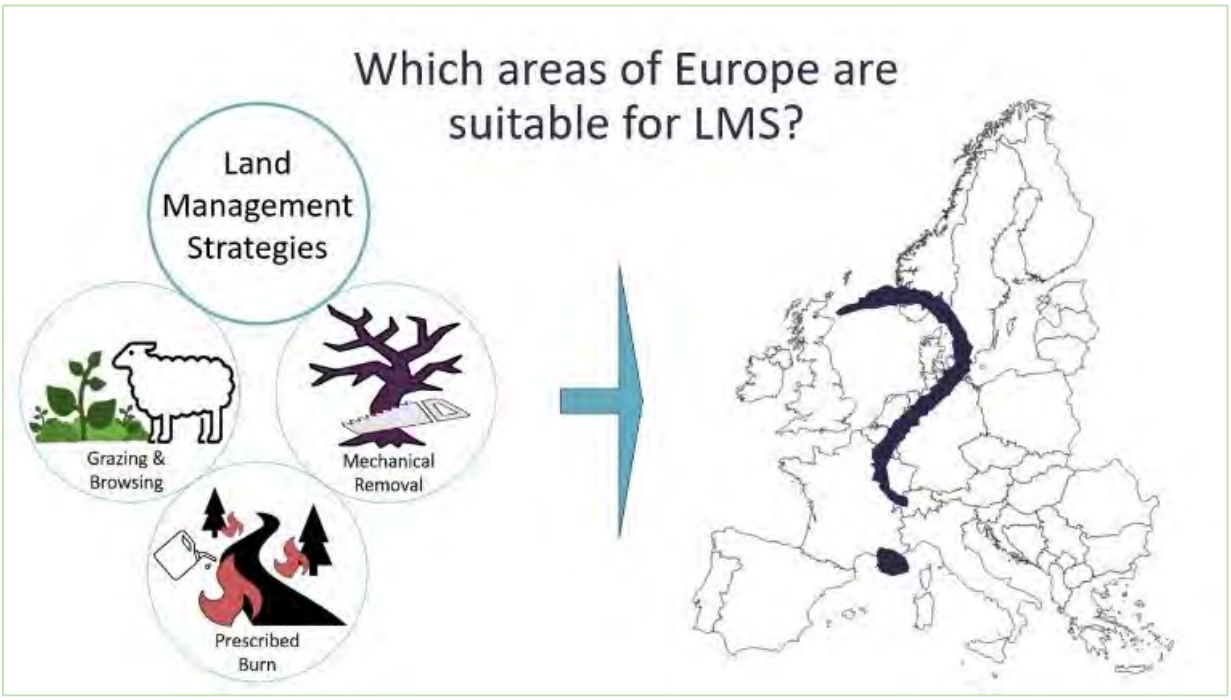
Vassiliki Varela
(vvarela@for.auth.gr)

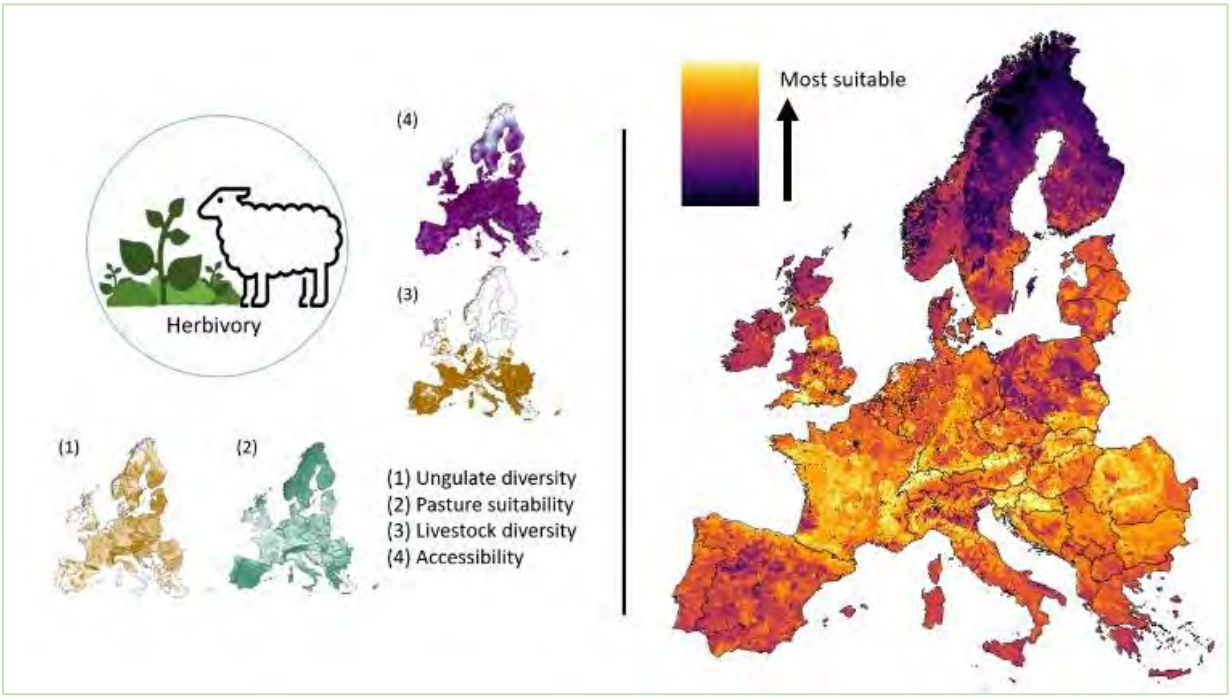
This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

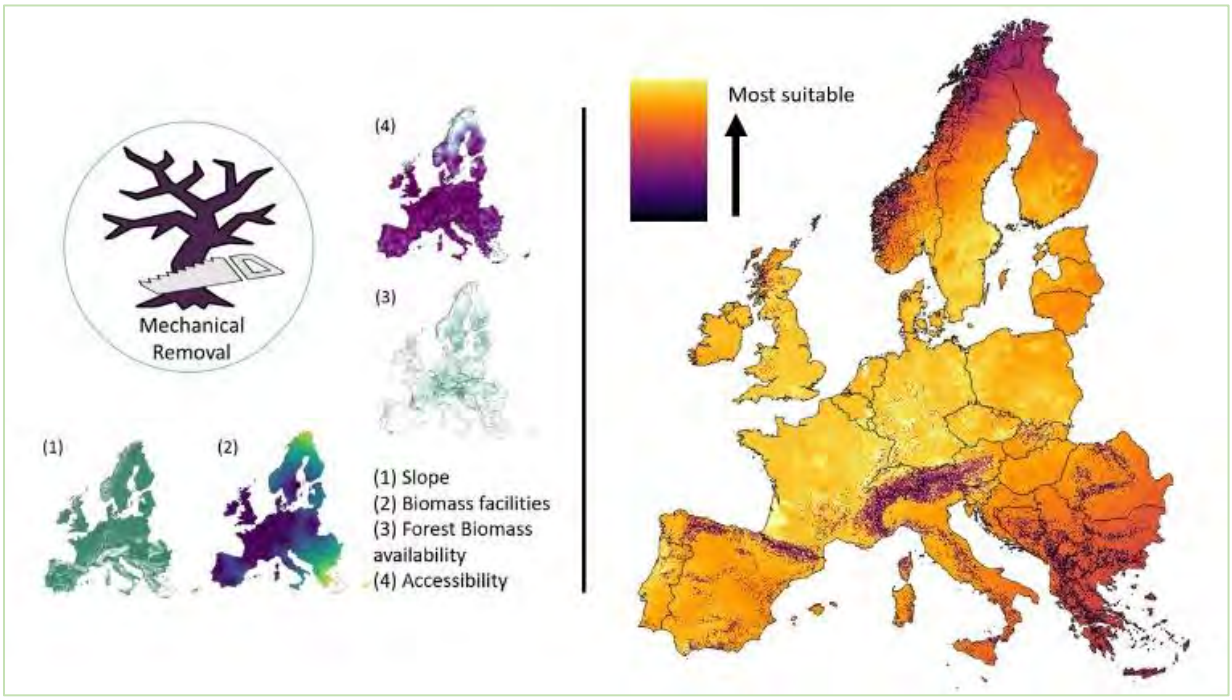
## Product 13 - Maps of suitable areas for Land Management Strategy (LMS) use

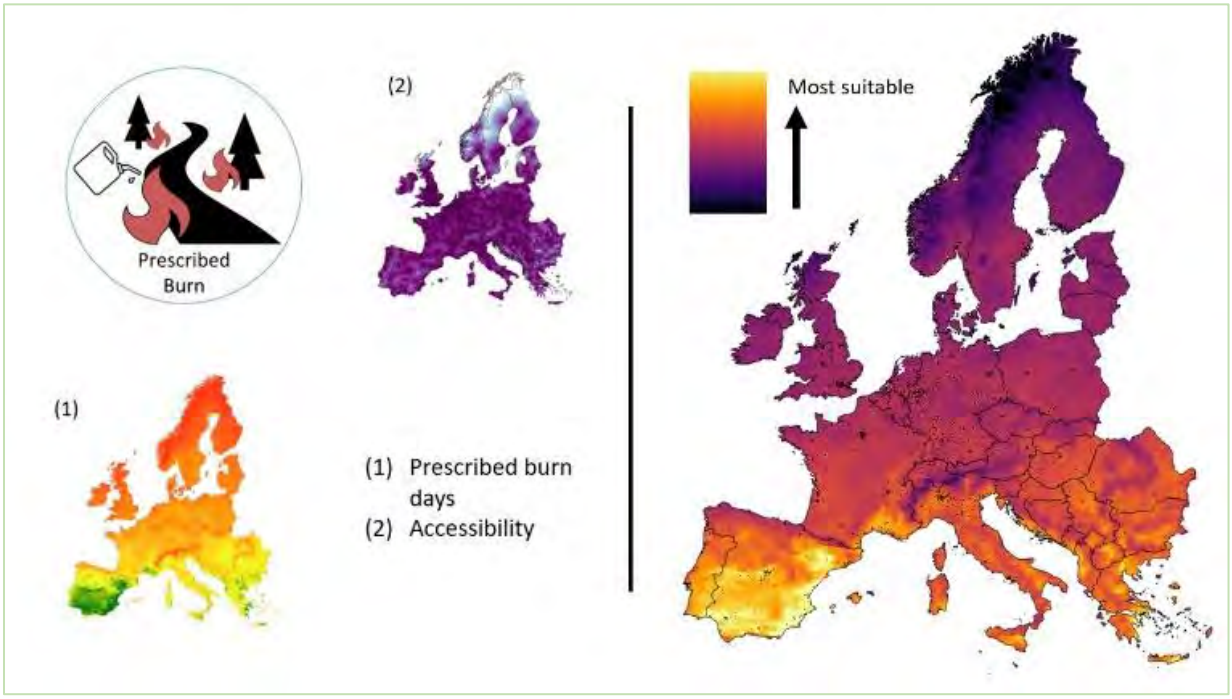


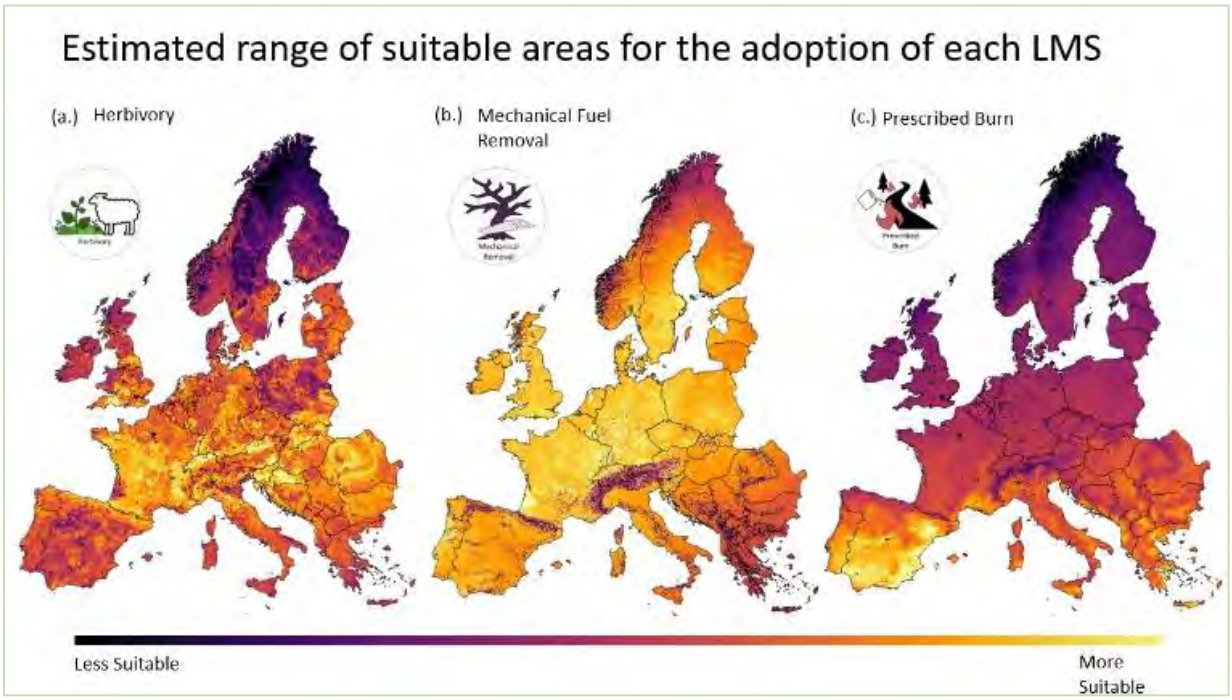



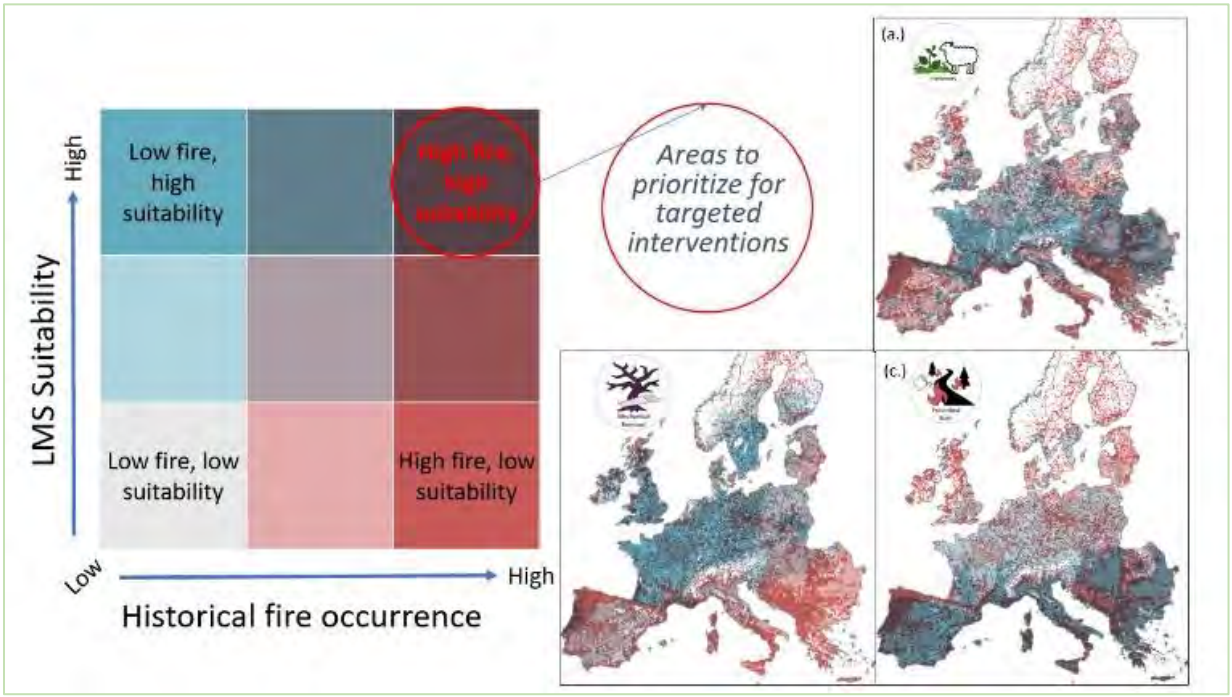

Which areas of Europe are suitable for LMS?
Land Management Strategies
Grazing & Browsing
Mechanical Removal
Prescribed Burn

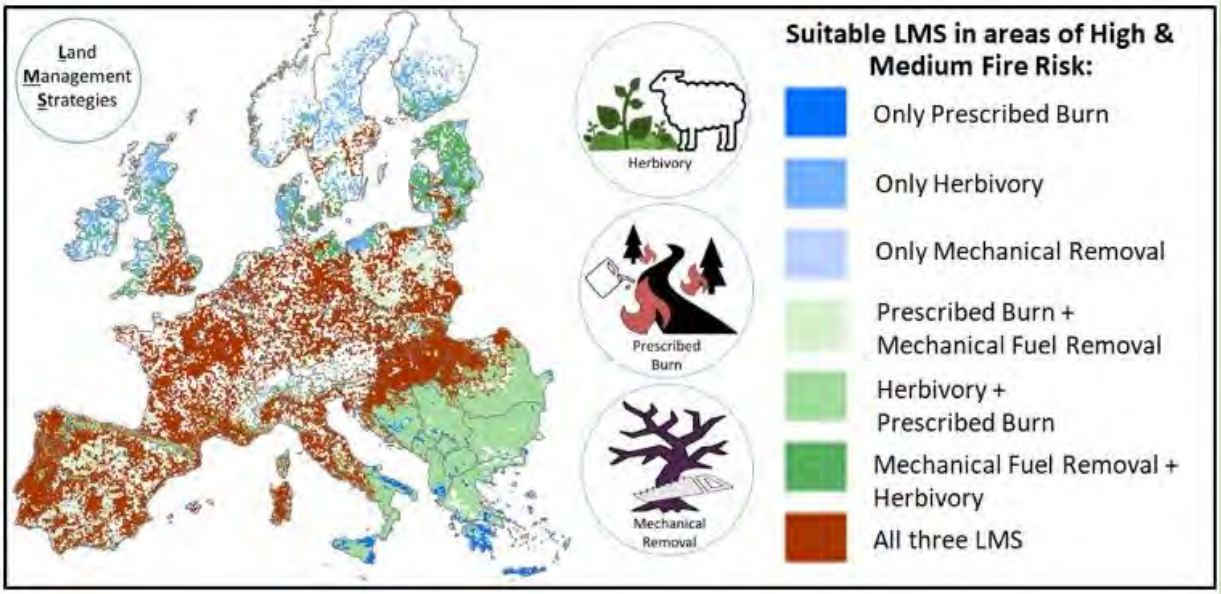

Herbivory
(1)
(2)
(3)
(4)
(1) Ungulate diversity
(2) Pasture suitability
(3) Livestock diversity
(4) Accessibility
Most suitable


Mechanical Removal
(1)
(2)
(3)
(4)
(1) Slope
(2) Biomass facilities
(3) Forest Biomass availability
(4) Accessibility
Most suitable


Prescribed Burn
(1)
(2)
(1) Prescribed burn days
(2) Accessibility
Most suitable


Estimated range of suitable areas for the adoption of each LMS
(a.) Herbivory
(b.) Mechanical Fuel Removal
(c.) Prescribed Burn
Less Suitable
More Suitable


LMS Suitability
High
Low
Low fire, high suitability
High fire, high suitability
Low fire, low suitability
High fire, low suitability
Low
High
Historical fire occurrence
Areas to prioritize for targeted interventions
(a.)
(b.)
(c.)







## Limitations of Mapping

1. Data for all of EU is limited
2. Data needs to have a spatial element
3. Difficult to include certain critical data aspects, such as socioeconomic drivers/ enablers/ barriers
4. Scale of 1km

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

Research article

# Mapping opportunities for the use of land management strategies to address fire risk in Europe

A.N. Neidermeier [a,*], C. Zagaria [a], V. Pampanoni [b], T.A.P. West [a], P.H. Verburg [a,*]

[a] Environmental Geography Group, Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam, the Netherlands
[b] Earth Observation Satellite Images Applications Lab (EOSIAL), University of Rome School of Aerospace Engineering, Rome, Italy
[c] Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland

ARTICLE INFO

Handling Editor: Jason Michael Evans

Keywords:
Prognography
Herbivory
Mechanical fuel removal
Prescribed burn
Fuel treatment strategies

ABSTRACT

Many parts of Europe face increasing challenges managing wildfires. Although wildfire is an integral part of certain ecosystems, fires in many places are becoming larger and more intense, driven largely by climate change, land abandonment, and changes in fuel management with important socioeconomic, environmental, and ecosystem services consequences for Europe. In order to envision a comprehensive fire risk mitigation strategy for Europe, a spatial assessment of opportunities to manage fuels at the landscape-scale is needed. Our study explored the suitability of three land management strategies (LMS)—herbivory, mechanical fuel removal, and prescribed burn—which can create more heterogenous fuelscapes, thereby reducing an element of fire risk. We created suitability maps for each of the LMS using adoption factors identified in a systematic literature review (n = 123). We compared these maps with areas of historical fire occurrence as a proxy for fire risk to prioritize key areas for intervention. We found that over a quarter of Europe was suitable for multiple LMS within areas of greater fire risk, creating opportunities for concurrent and synergistic use of the strategies. Options were more limited in areas of southern Europe, where prescribed burn was found to be uniquely viable amongst the LMS evaluated. Opportunities were also restricted in some areas of high fire risk in northern Europe, where herbivory was found to be the only suitable LMS. Our findings take a wide-view of fuel management to target landscape-scale decision making focused on reducing fire risk. However, many other factors must be taken into account to successfully manage fuels at local scales, including the socio-cultural appropriateness of the LMS, the viability of incentive schemes, and possible trade-offs with other management goals, such as carbon storage and biodiversity.

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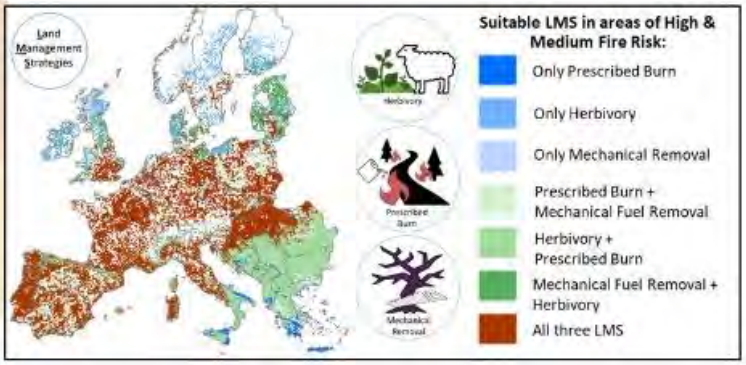
# Thank you!

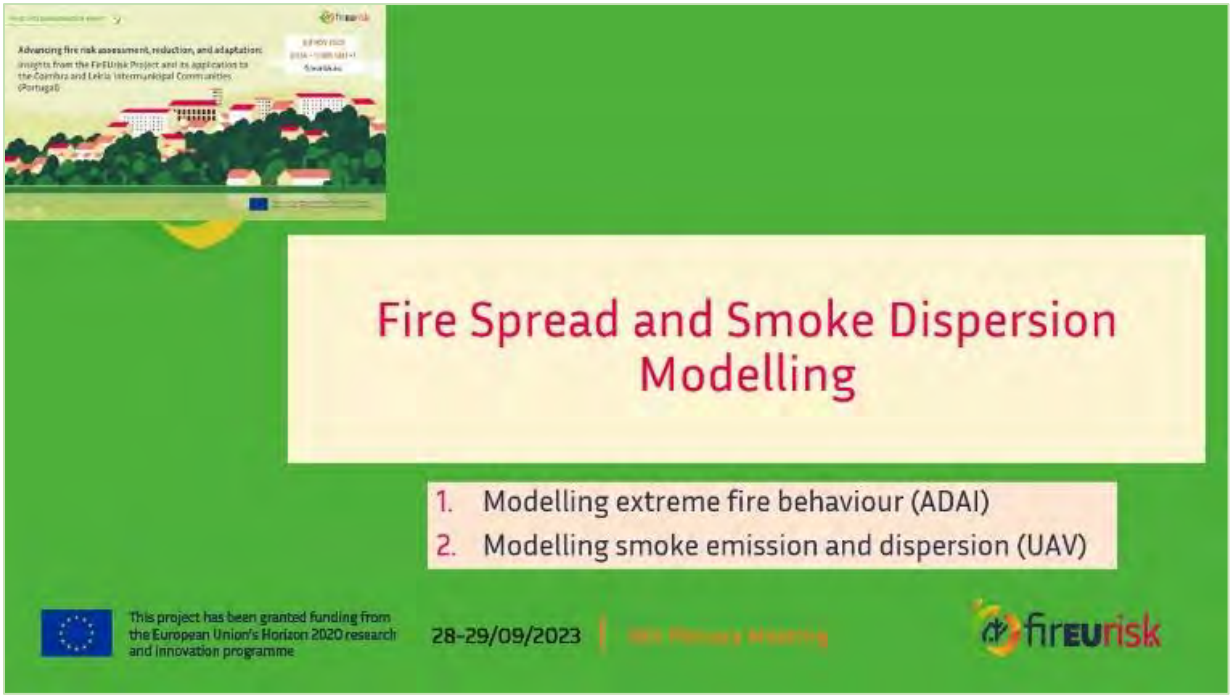
**Alex Neidermeier**
Vrije Universiteit, Amsterdam
a.Neidermeier@vu.nl




Nov. 3rd, 2023 | Demonstration Event, Portugal

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

## Product 23. Extreme Fire Behaviour Modelling and Product 25. Smoke dispersion forecast

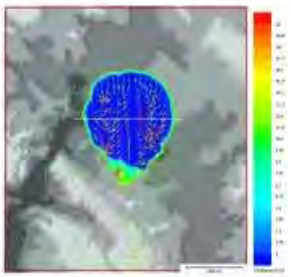




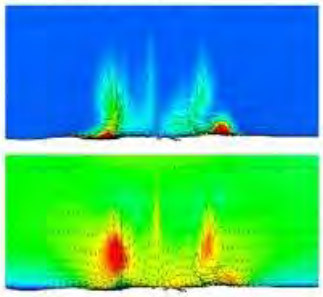

3

### 3D Wind Field Models

- Fire and wind field interact in a complex manner, due to buoyancy effects created by the fire heat release
- Navier-Stokes solvers are the way to capture the influence that fire plays on the wind field.
- The two-way coupling between wind and fire should be wisely managed to keep calculation times amenable



Fire shape and wind field 10m above ground. Fire region is coloured according to rate of heat release. White line represents the transect used.



**Temperature and Velocity Magnitude Field** on a vertical plane perpendicular to incident wind direction, passing though fire shape centre

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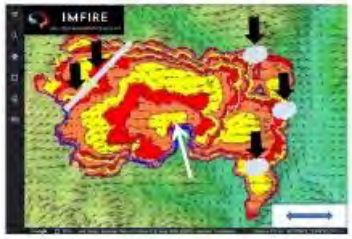
## Fire Spread Simulation for Decision Support in the Operational Context

### MTT – Minimum Travel Time

- Simulate the fire suppression using a network optimization process.
- Minimum Travel Time Fire Spread (MTT) displays the most significant fire spread pathways across your burned area.
- Act on most significant fire spread pathways, considering real time assessment of fire fighting means, efficiency and risk.



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3/11/2023 | Demo Event Coimbra

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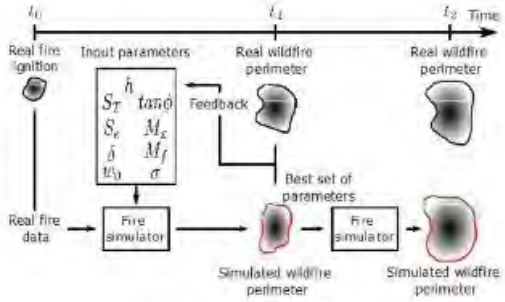
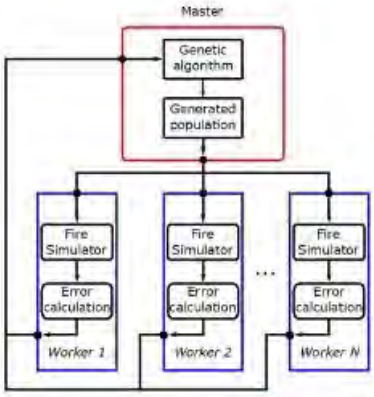
## Use of Artificial Intelligence for Increased Prediction Accuracy

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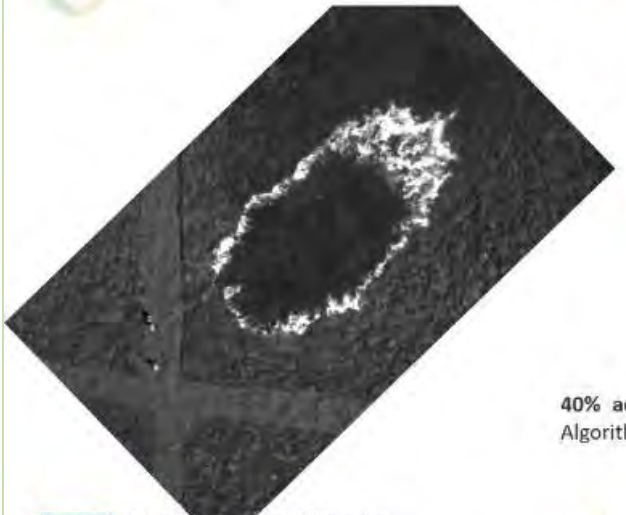
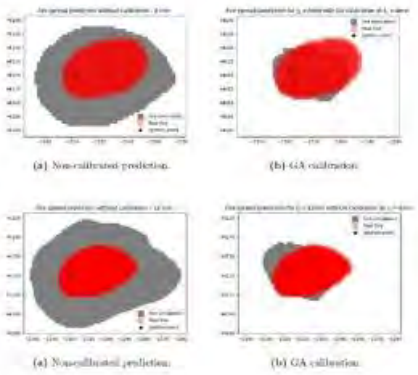
## Simulation of field experiment fires





(a) Non-calibrated prediction. (b) GA calibration.

(a) Non-calibrated prediction. (b) GA calibration.

**40% accuracy increase** on fire spread results using Genetic Algorithms and parameter fine-tuning

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

28-29/09/2023 | 6th Plenary Meeting

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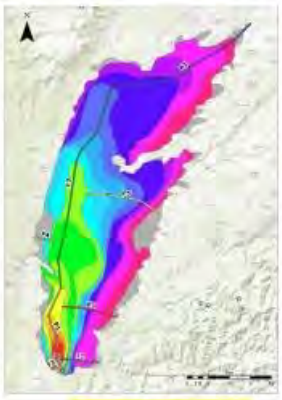
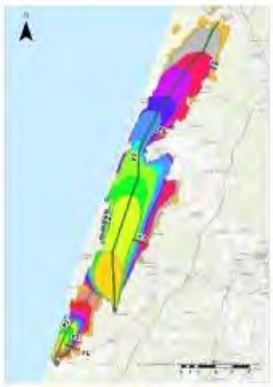
# Prediction of Extreme Fire Behaviour

- For fire spread modelling we consider <u>two parts</u>:
  - Prediction of the Head Fire ROS in the case of Extreme Fires.

    Knowledge of R(t); $R'(t)=R(t)/R_0$
    Basic ROS, used as a reference.
  - Prediction of the evolution of fire perimeter.



Lousã Fire (2017)



Leiria Fire (2017)

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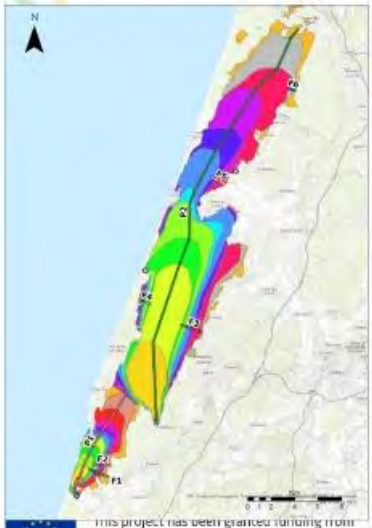
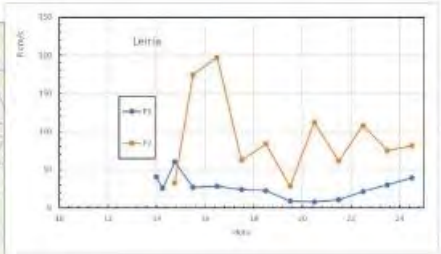
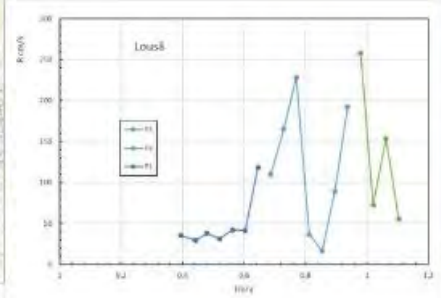
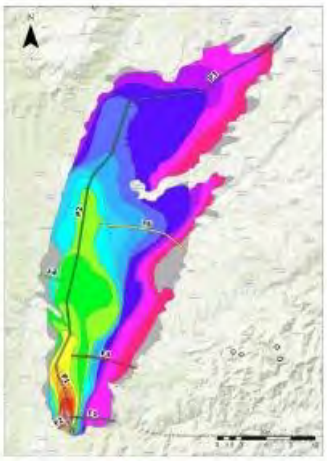
# Application cases





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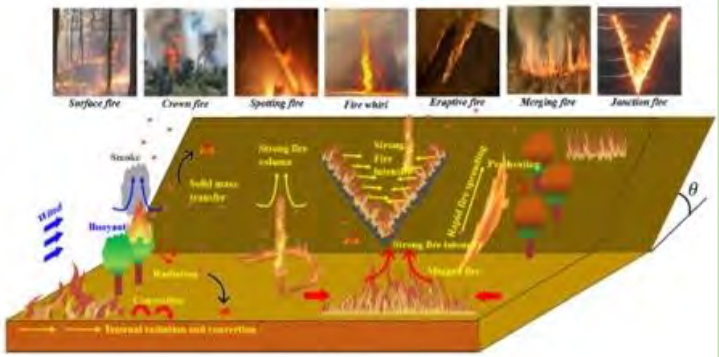
## 9 ROS of Extreme Fires

- We consider the following problems:
  - Eruptive fires
  - Junction fires
  - Oscillatory fire behaviour
  - Acceleration and deceleration of a fire.

- The following problems are being addressed:
  - Crown fires
  - Spot fires
  - Fire whirls
  - Peat fires

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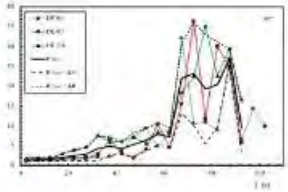
## 10 Eruptive fire behaviour

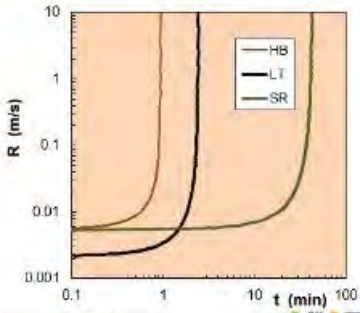
- It occurs in canyons and in steep slopes and is characterised by an acceleration that is induced by the fire itself.

- It is well described by the following mathematical equation:

$$\frac{dR'}{dt'} = a'_1{}^{\frac{1}{b_1}} . b_1 . a'_2 \, (R' - 1)^{1-\frac{1}{b_1}} . R'^{b_2}$$



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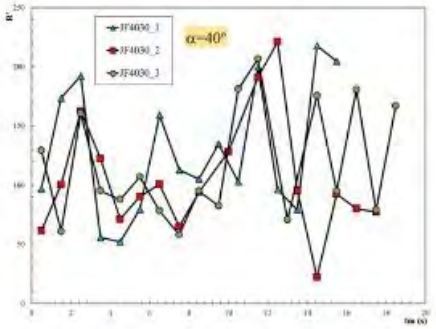
## 11 Junction Fire

- It occurs when two fire lines, making a small angle between them, join.
- The intersection point moves with the highest ROS values that we have registered in forest fires at various scales.





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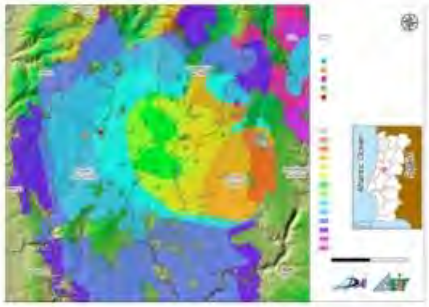
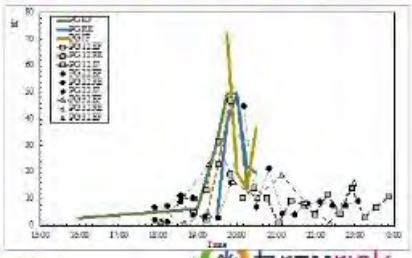
## 12 Junction Fire at the Pedrógão Grande Fire (17 June 2017)

- In the analysis of the Pedrógão Grande Fire (17 June 2017, with 66 fatalities), we found that the merging of two fires produced the "Junction Fire" process and originated its huge ROS.
- We studied it at laboratory scale and were able to replicate and model this behaviour.





Viegas DX, et al., 2023. Field and laboratory analysis of the junction fire process in the catastrophic fire of Pedrógão Grande in 17 June 2017, Int. J. Wildland Fire. https://doi.org/10.1071/WF22160.

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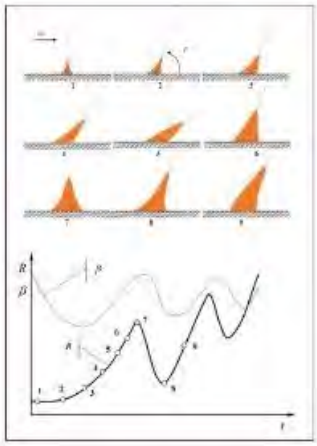
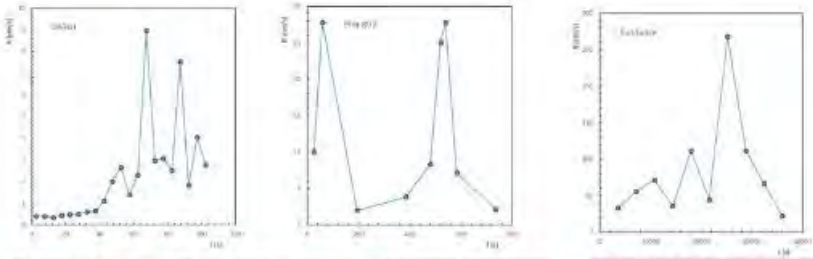
## 13 Oscilatory Fire behaviour

- We observe that the behaviour of the head fire is oscilatory in the course of time due to the interaction between the fire and the environment.
- This effect is observed at all scales of analysis. The amplitude and frequency of the oscillations depend on the size of the fire and increase with the ROS.





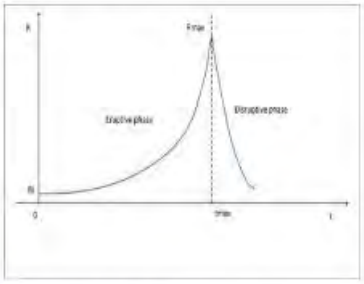
Viegas DX, et al., 2021. On the non-monotonic Behavior of Fire Spread, Int. J. Wildland Fire. https://doi.org/10.1071/WF21016.

Viegas DX, et al., 2022. On the intermittent nature of forest fire spread- Part 2, Int. J. Wildland Fire. https://doi.org/10.1071/WF21098.



## 14 Fire acceleration and deceleration

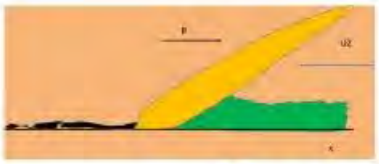
- The evolution of the head fire is a succession of acceleration and deceleration processes.
- In some extreme fires this has occurred with dramatic consequences.
- We are studying this process.



Acceleration (Eruptive phase)



Deceleration (Disruptive phase)



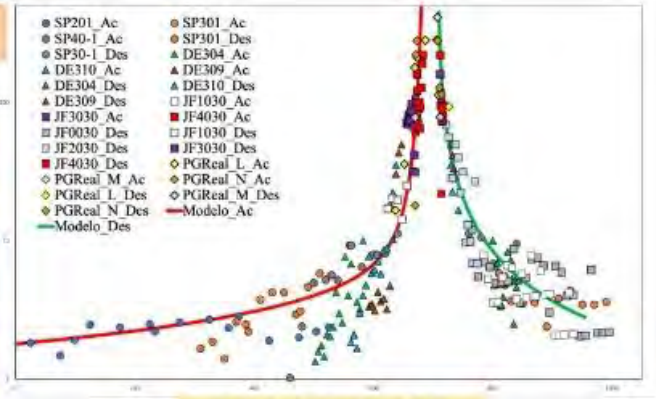
# Mathematical model

## Acceleration

$$\frac{dR'}{dt'} = a'_1{}^{\frac{1}{b_1}} b_1 a'_2 (R'-1)^{1-\frac{1}{b_1}} R'^{b_2}$$

## Deceleration

$$\frac{dR'}{dt'} = -a'_1{}^{\frac{1}{b_1}} b_1 a'_3 (R'-1)^{1-\frac{1}{b_1}} R'^{b_3}$$




$a'_1 = 0.83$, $a'_2 = a'_3 = 0.24$
$b_1 = 0.95$, $b_2 = b_3 = 1.3$

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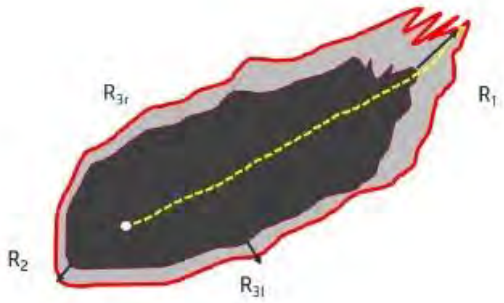
# Modelling the Fire Perimeter

We assume that the value of the ROS of the head fire, the back and the flanks is known:

- $R_1$
- $R_2$
- $R_{3r}$
- $R_{3l}$

The movement of each element of the fire perimeter is modeled according to the concepts of:

- Fireline rotation
- Fireline extension.

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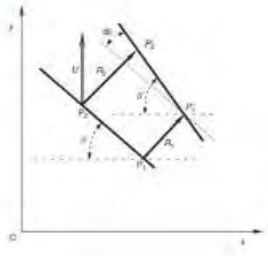
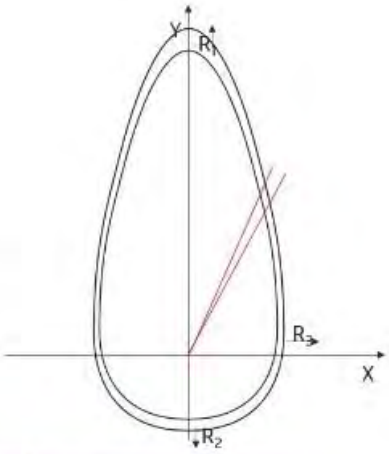
## Fireline rotation and extension



SC 311
40° 10°
Dt 10s






$$\omega = \frac{d\beta}{dt} \qquad \omega = A.\sin\beta.(cos\beta)^B \qquad ds = \int_{\theta_i}^{\theta_{i+1}} f_s(m_x, m_y)\, d\theta$$

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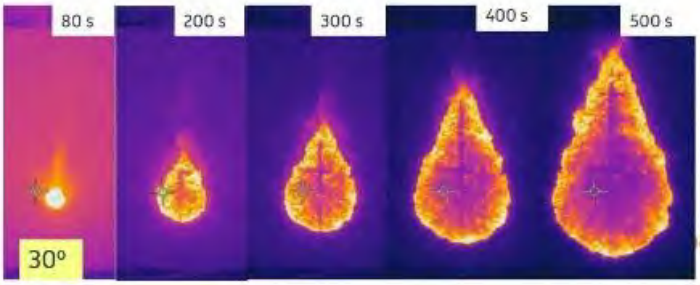
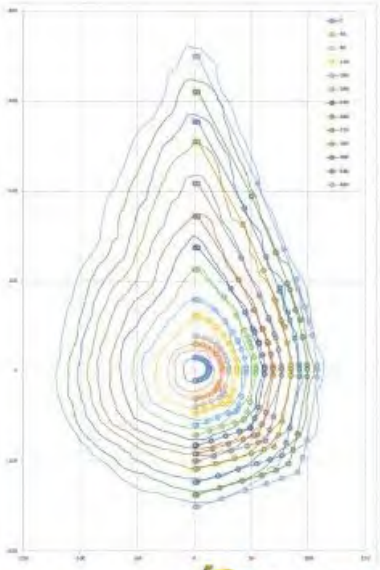
## Test cases



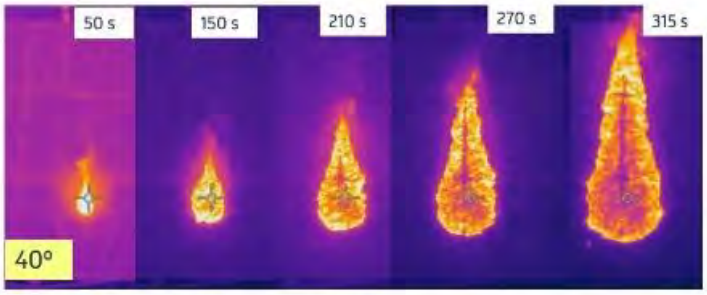
30° slope

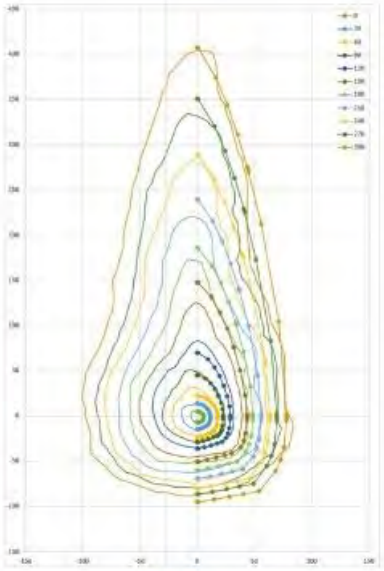




40° slope



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# Smoke emissions and dispersion

**Ana Miranda, Tobias Osswald, Carla Gama and Diogo Lopes**
Department of Environment and Planning,
University of Aveiro
Portugal

28-29/09/2023

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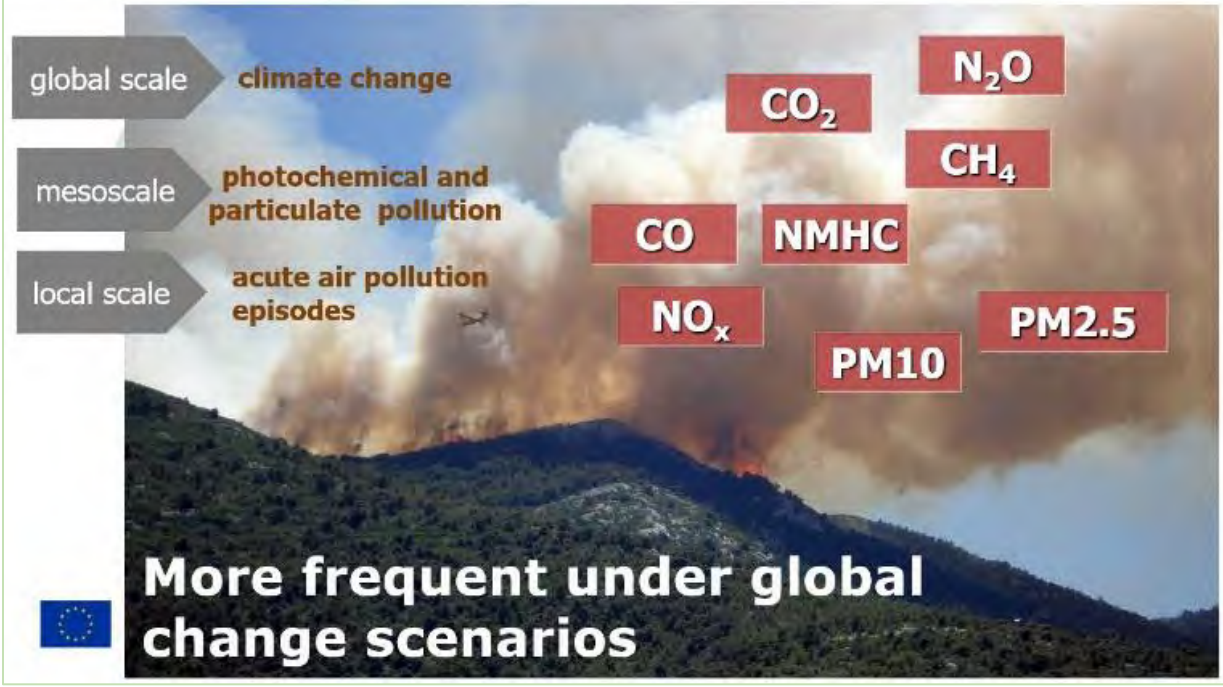




## What health effects?

... for the protection of human health

- Air quality limit values (e.g. European Directive)
- World Health Organization guidelines

- **Short term** (hourly or daily) and **long term** (annual)

## October 2017

**To estimate the impact of these extreme wildland fires on air quality (and health)**



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and innovation programme

## From emitted smoke to health




### Bottom up approach

To estimate atmospheric emissions using a bottom-up approach with high spatial and temporal resolution

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# Central Portugal October 2017

The use of emission factors

Fuel load - available fuel mass per area ($kg.m^{-2}$)

$$Emission = EF \times A \times W \times \beta$$

Mass of emitted pollutant per consumed fuel ($g.kg^{-1}$)

Burnt area ($m^2$)

Fuel consumption ($kg.m^{-2}$)

Burning efficiency (fraction of consumed fuel)

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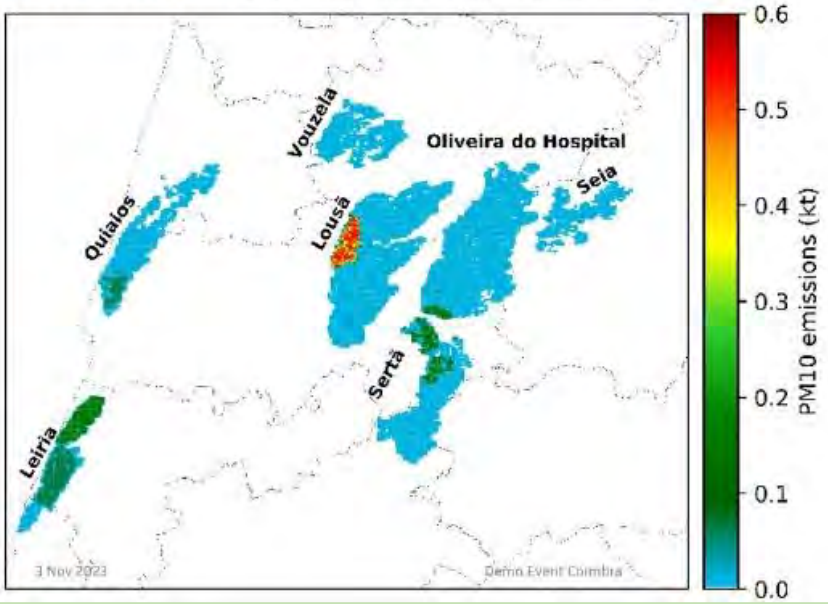
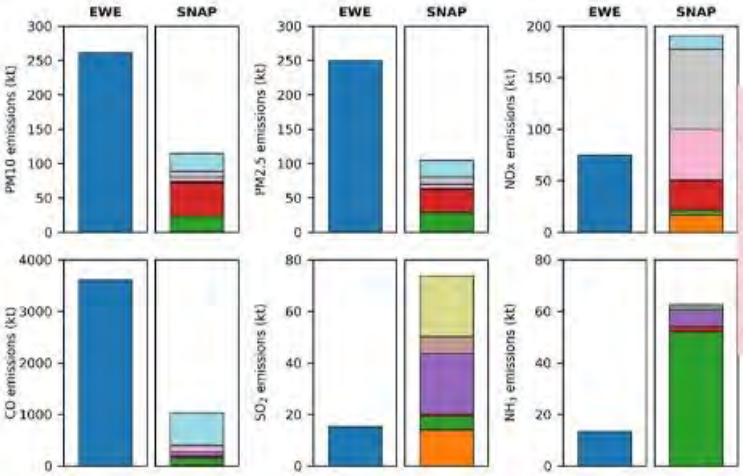
# Emissions

Spatial distribution of PM10 emissions (500 m x 500 m)



# Emissions wildfires events (EWE) vs antropogenic

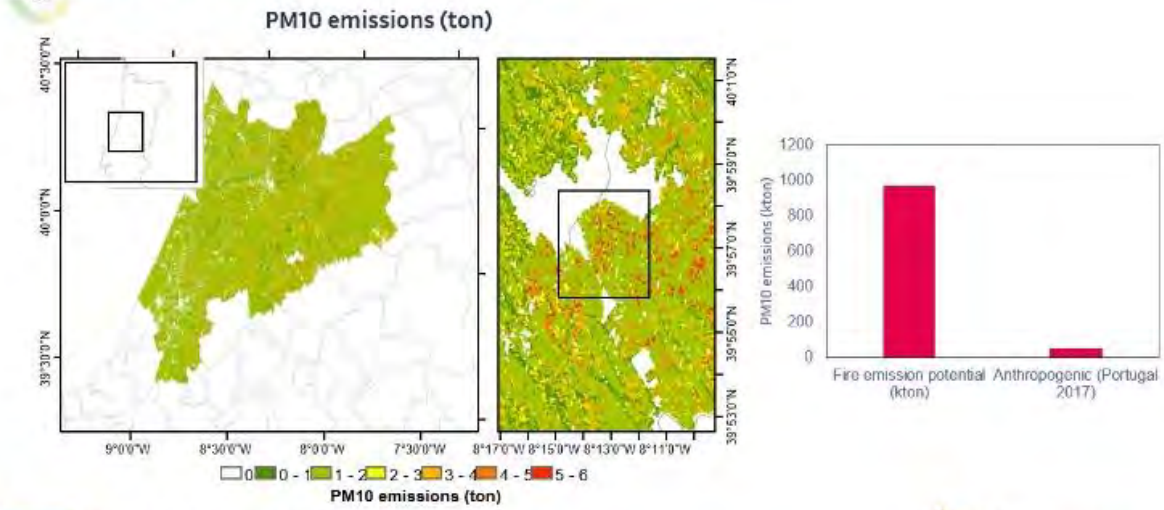



Wildland fires (~26 hours) emitted more than Portuguese anthropogenic activities (entire year) by a factor of:

- 2.7 PM10
- 3.6 PM2.5
- 4.7 CO



# Emission potential – Central Portugal

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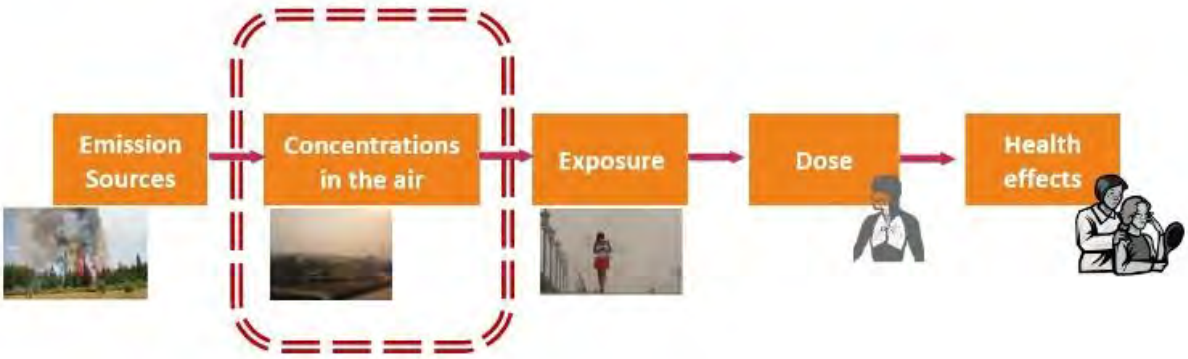
# From emitted smoke to health

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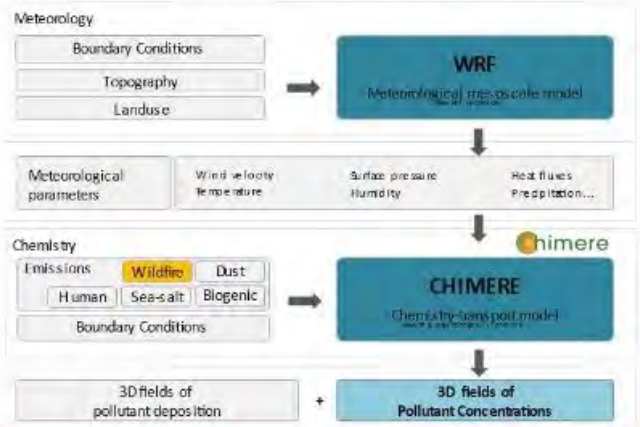
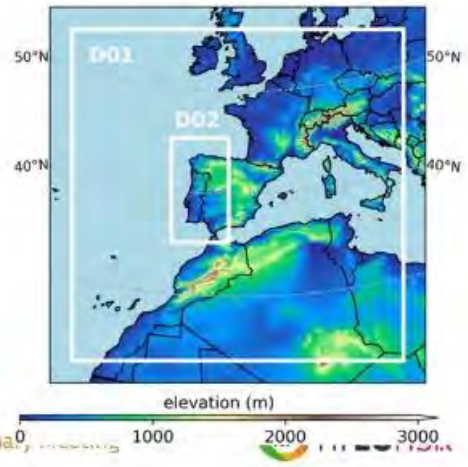
# Modelling system

## sistem WRF-APIFLAME-CHIMERE

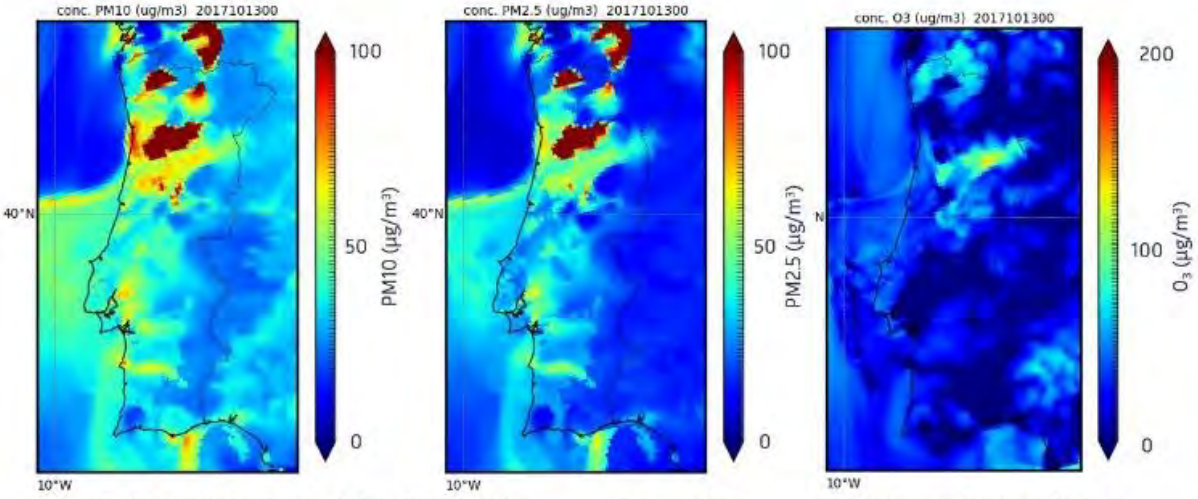



| Domain | Resolution | Start | End |
|---|---|---|---|
| D01 | 25 km | 1st Oct 2017 | 24th Oct 2017 |
| D02 | 5 km | 1st Oct 2017 | 24th Oct 2017 |

Included North Africa due to influence of dust from Sahara desert



# Air quality results

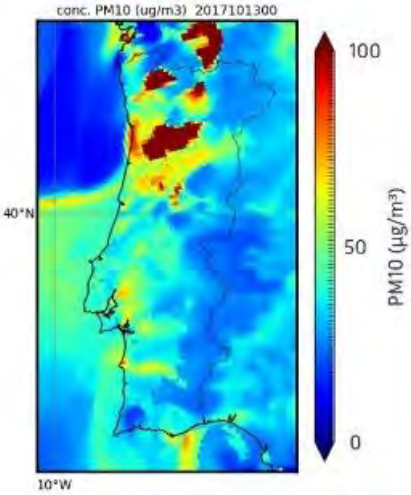



- On the 14 concentrations are already high due to smaller wildfires
- Air Quality of N Portugal strongly affected
- Saharan dust transported from South
- $O_3$ is a reaction product of wildfire emissions (NOx and VOC)

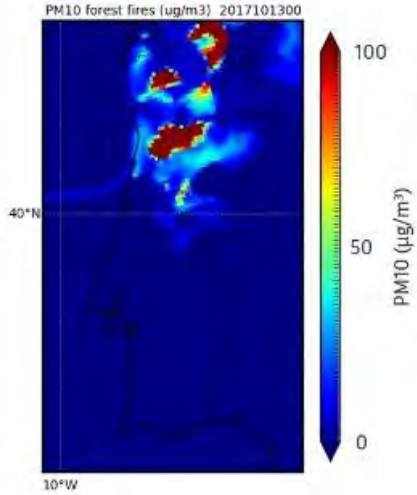


# Results

Full simulation



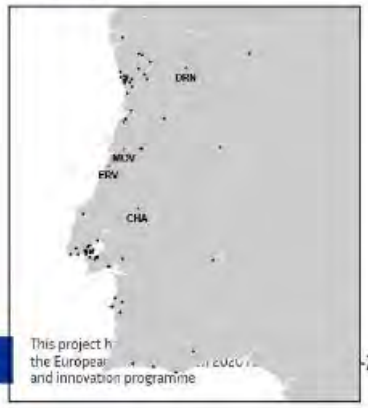

Contribution from wildfires




- Smoke from wildfires mainly affected the N
- Sand from the Sahara affects AQ in S Portugal considerably
- Most of the dust cloud passes off the coast

# Results PM10 (validation)

- Slight overestimation of PM10 concentrations
- DRN station stopped measuring, likely due to excessive levels of smoke

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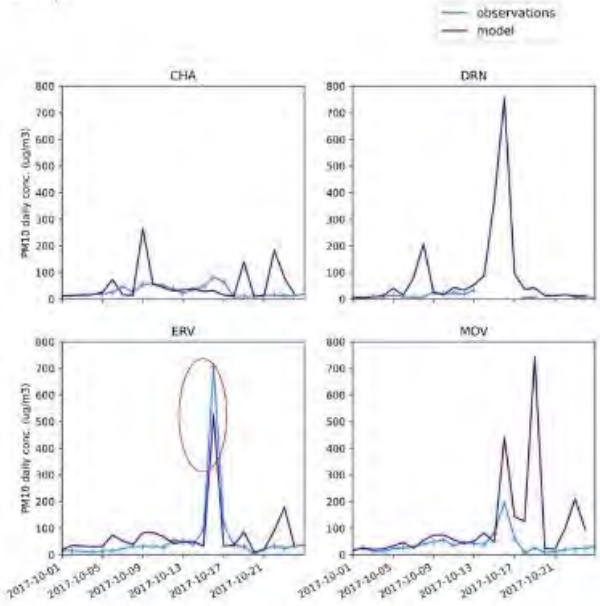
the Europea
and innovation programme

29/09




## To help protecting people...



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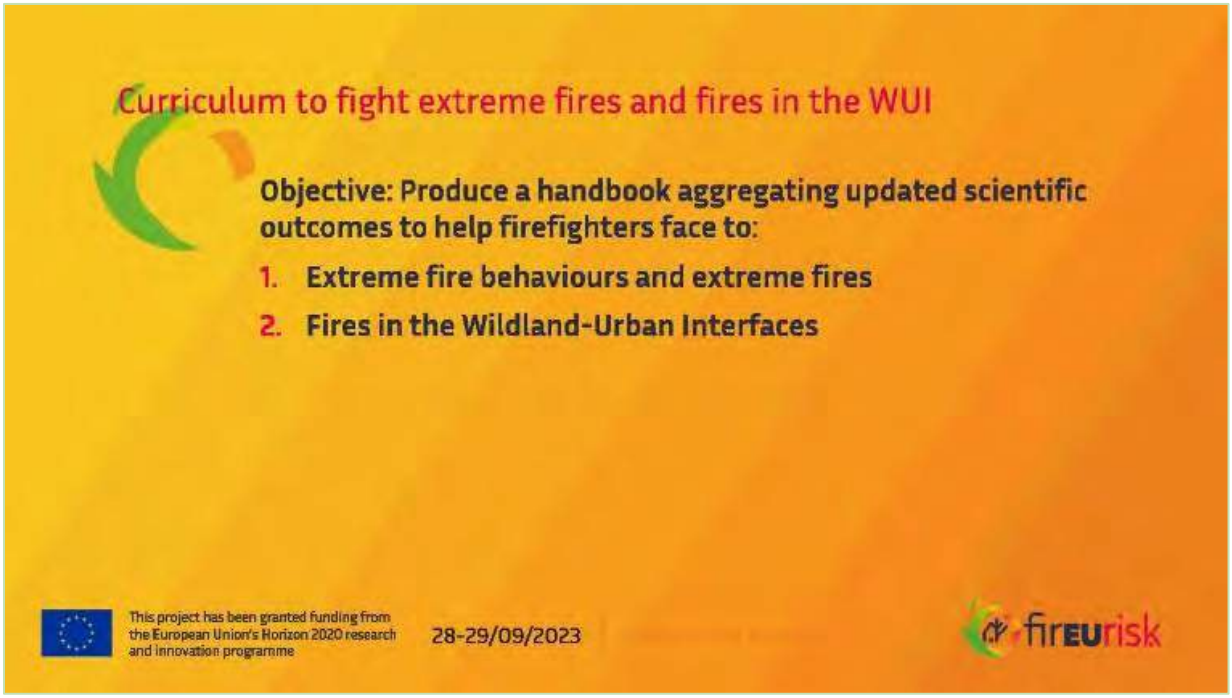
Muito obrigada!

## Curricula for extreme fires and WUI

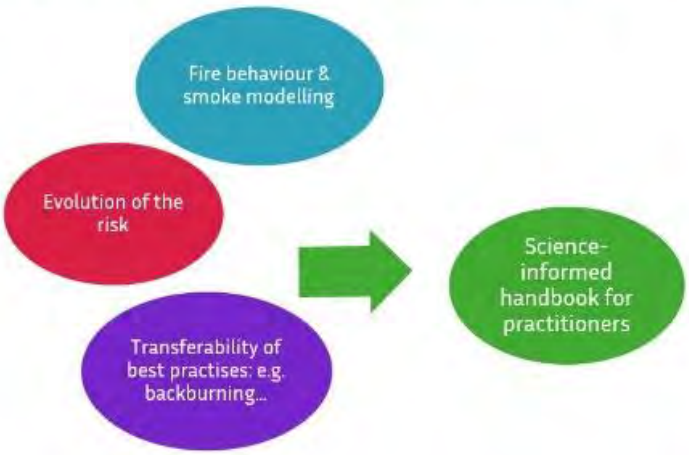


## Curriculum to fight extreme fires and fires in the WUI

3

**Working plan:**

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## Curriculum to fight extreme fires and fires in the WUI

4

**Working plan:**




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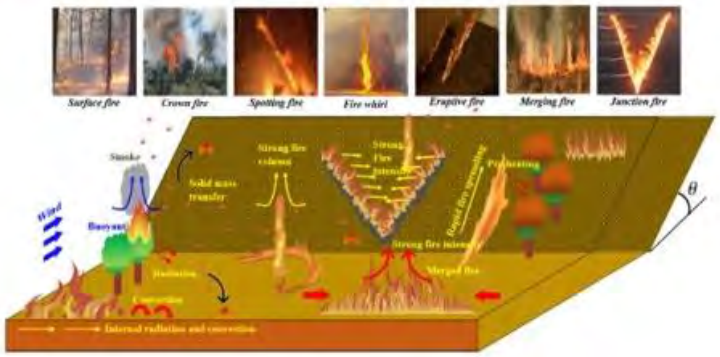
# Extreme Fire modelling

- 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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# Curriculum to fight extreme fires and fires in the WUI

**Working plan:**

Evolution of the risk → Science-informed handbook for practitioners

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## Evolution of the risk

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

**Working plan:**



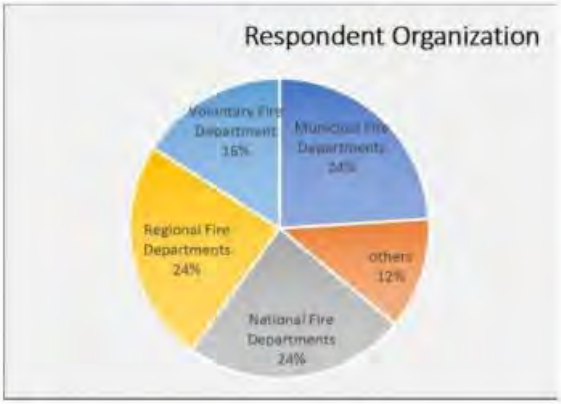
9

## Survey and interview of FF

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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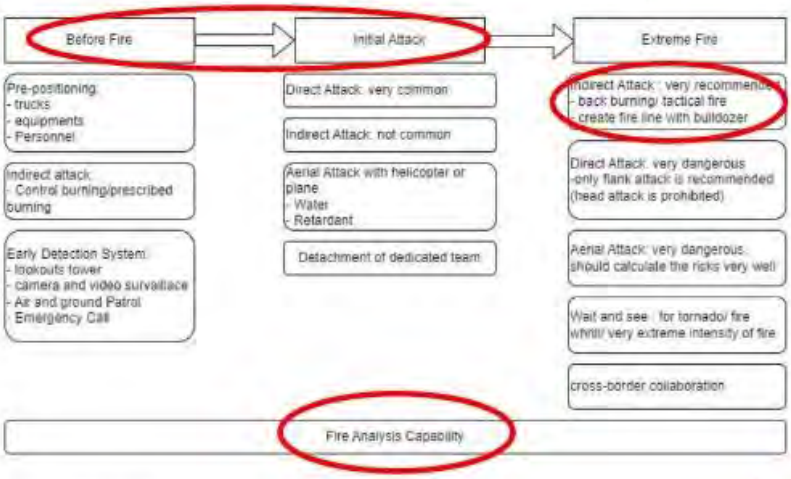
## Fire Suppression Strategy to fight Extreme Fire

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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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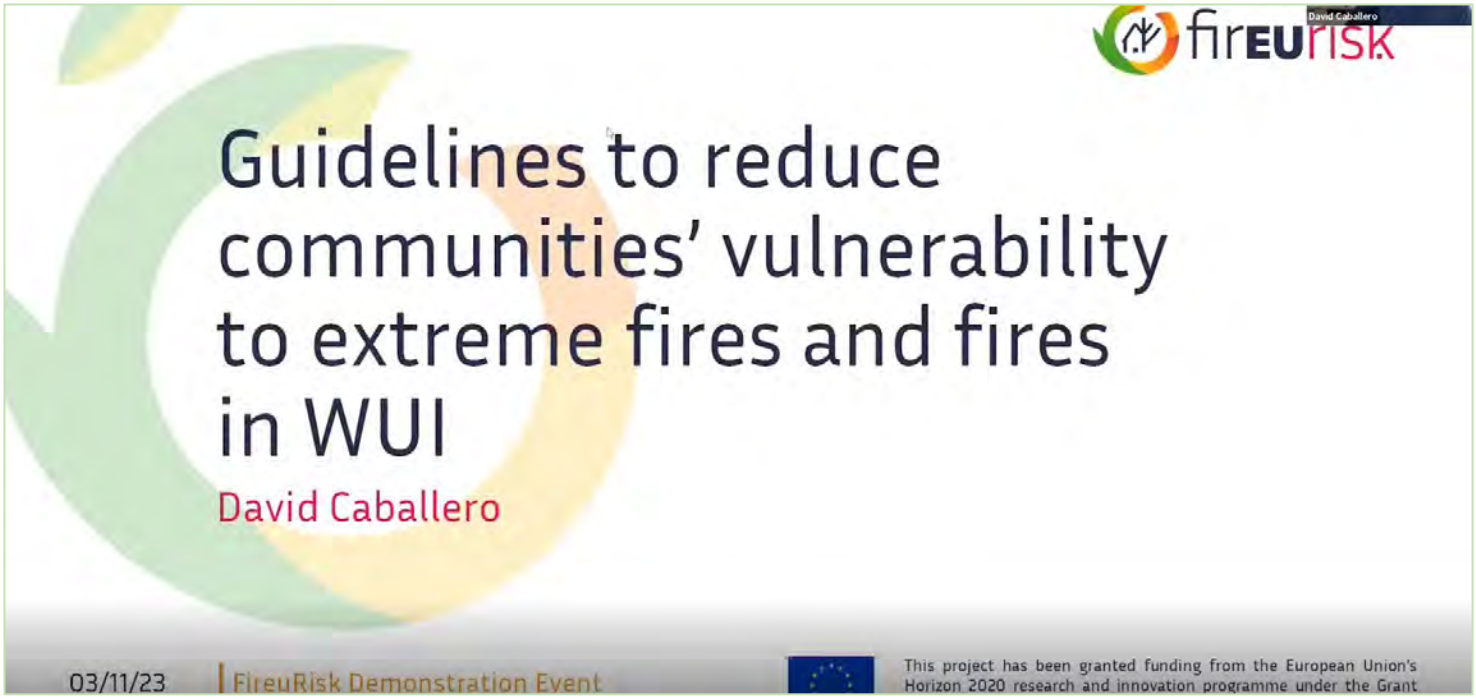
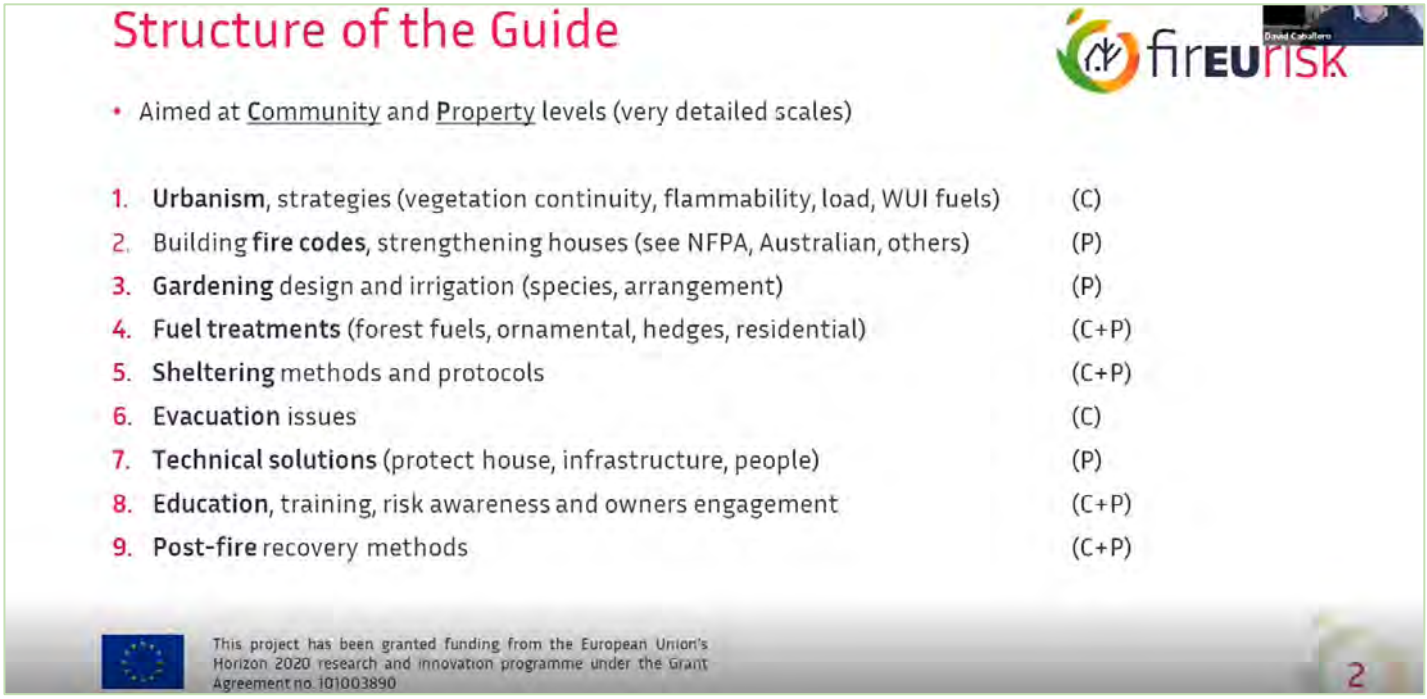
## Product 27 Guidelines to reduce communities' vulnerabil. to extreme fires and fires in WUI



# The challenge

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# Prevention strategies – Fuel treatments

**In the Exterior**

- Fuel management (fuel mitigation, prescribed fire, livestock)
- Soil protection, water reserve
- Live fuel moisture control, prescribed irrigation
- Improve access and penetrability to fire fighting resources
- Water Availability for fire fighting operations

**In the Border Plots**

- Absence of flammable fuels, or fuels within enclosures
- Absence of fine dead fuels
- Absence of flammable materials and objects (LRF)
- Ideally, presence of wall and/or separation panels
- Ensure plot accessibility from the rear side
- Ensure water availability for house defense and fire fighting operations
- Structures adaptation to the pass of fire (glazing, roofing, openings, etc.)
- Building setback to the slope edge (at least 2 times flame length)
- Whenever possible, buried LPG tanks

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# Prevention strategies – Fuel treatments




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# Tools for WUI urban design assessment

1. Estimation of **fuel load** in communities, LiDAR-based estimation
2. Measurement of **fuel continuity** in communities, WUIX index
3. Estimation of **house exposure** to vegetation, WUIX index (linked to point 2)
4. Application of **probabilistic-based fire spread** over WUI areas for risk assessment

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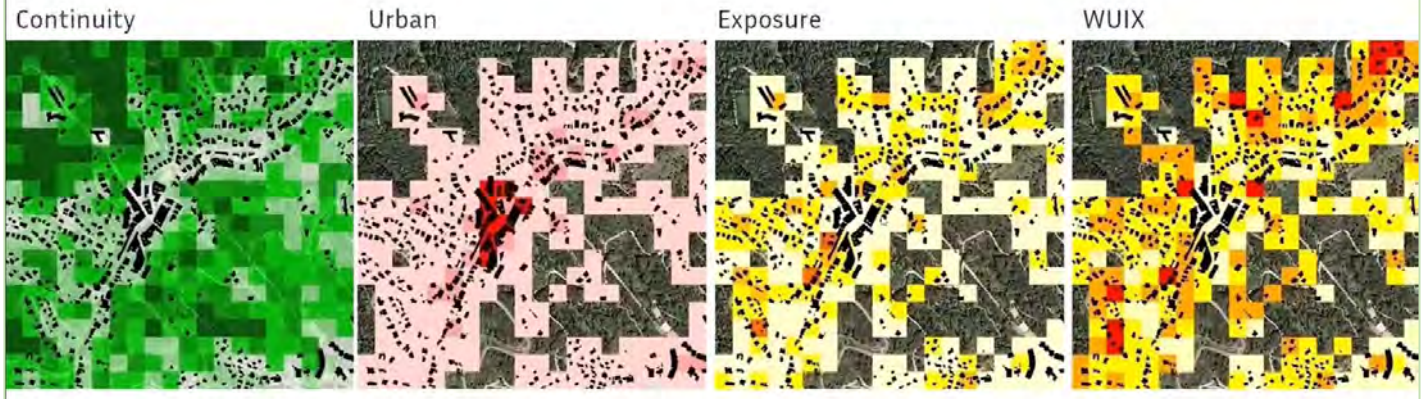
# The WUIX Index

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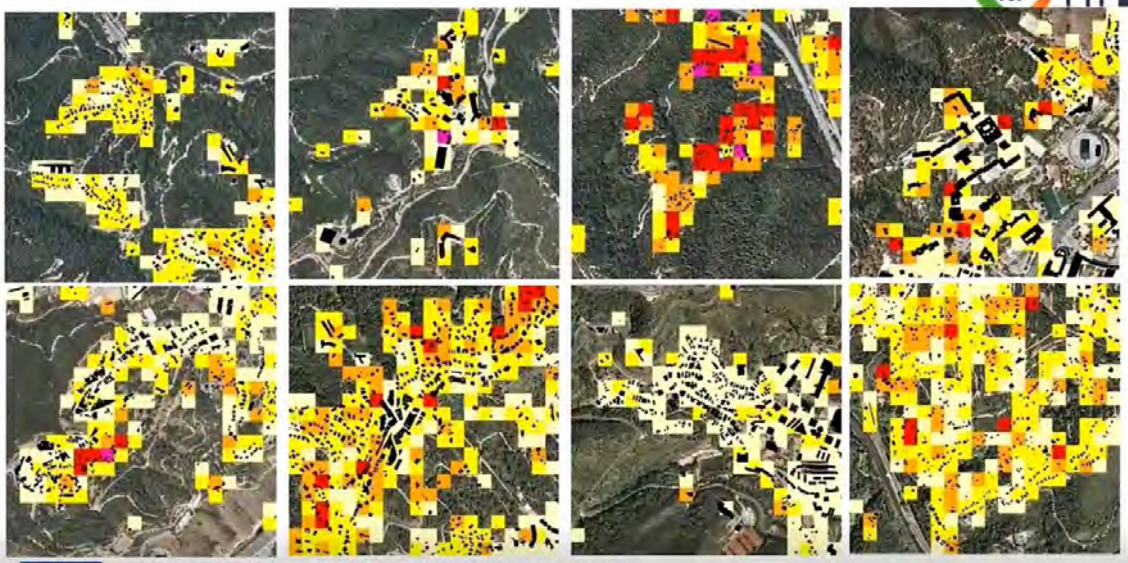
# The WUIX Index - Comparative



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# Probabilistic fire spread simulation




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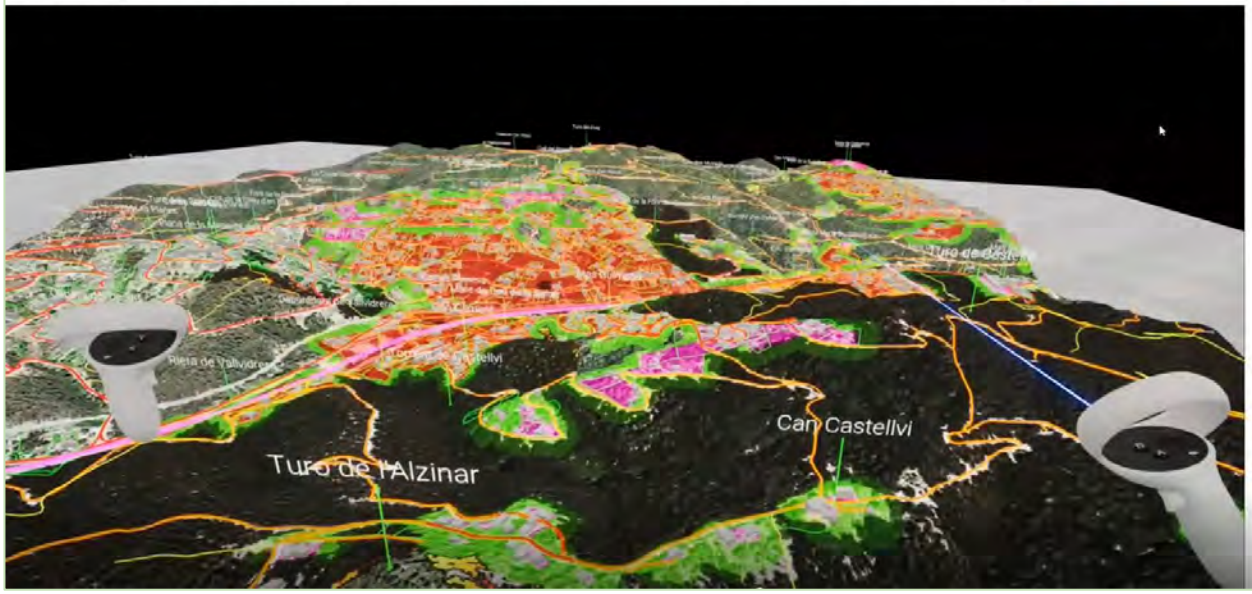
# Probabilistic fire spread simulation

Example of application of probabilistic fire spread simulation over preventive treatments in a WUI area near Barcelona – WUICOM project



# Fire code for building in the WUI

- Inspired in the **2009 Australian Standard (**Construction of buildings in bushfire-prone areas)

- Determining the **Wildfire Attack Level** (WAL)
- Determining the **Level of Defense and Protection** (LDP)
- Based upon **Levels of Exposure** (LEO) (*Use of WUIX Exposure)*

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# Assessment procedure

1. Determine **Fire Danger Index** (FDI): *FireuRisk indexes calculation procedures*
   - Depending upon regions in Europe
   - Depending upon fire behavior (historical weather records)
   - Depending upon ignitions (historical records)
2. Determine classified **vegetation type**: *Detailed fuel types in Pilot Sites*
3. Determine **distance** to vegetation: *WUIX exposure*
   - Measured in the horizontal plane
   - Effective slope, by classes
4. Determine **WAL** according tables: FDI + Exposure
5. Determine appropriate **construction requirements** for each WAL+LDP
   - General requirements for buildings
   - Requirements for other specific structures
     - Attached structures
     - Garage and cartports
     - Adjacent structures

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# Garden design and irrigation

- Control of the most **flammable elements**, throughout the plot
- Where is the **dead vegetal fine fuel**?
- What other non-vegetal items are flammable (role of **Light Residential Fuels** LRF)?
- Reduction of fuel load
- Reduction of fuel continuity (horizontal, vertical)
- Reduction of fuel flammability (selection of resistant species)

Objectives

1. **Reduce damages** of the approaching fire front and the fires inside the settlement
2. Create a **Defensible Space** (opportunity for defense operations) in around 30 m
3. **Reduce the spread** from one plot to the neighbors inside the settlement
4. Make **house resistant** to the pass of fire (radiation, flame contact)

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# Garden design and irrigation





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# Garden design and irrigation



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# Gardening methods

- Species selection, lower load, higher moisture, less flammability
- Separation of fuel elements (discontinuity) D=2H
- Separation of surface vegetation from tree canopies
- Separation of light residential fuels (LRF) from the house and vegetation
- Removal of all dead fine material
- Increase moisture of the living part (pre-irrigation)
- Temporary increase in the fine dead fuel moisture (instant watering)
- Ensure water availability for local defense
- Reduce exposure of house components (prescribed distances to fuels)

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# The role of Light Residential Fuels?



Lahaina, Maui, 08/08/2023



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# Technical solutions

1. Creating and maintaining **Defensible Space**
2. **Passive** fire protection (house hardening, retrofitting)

   In a passive system, stationary materials are designed to help prevent the spread of fire or smoke, keeping the fire to its original area and stopping it from spreading through the building.

   - Roofing, gutters, eaves
   - Glazing, shutters, blinds
   - Openings
   - Siding
   - Decks
   - Fire doors, walls, floors
   - Flame shields
   - Ignition-resistant building materials
   - Fire curtains
   - Treatments and Fire Protection Paint For Wood, Fire Resistant Insulation, intumescing paint, mortar coating, mineral fiber matting

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# Technical solutions

3. **Active** fire protection systems and methods
   An active fire protection system means that action of some kind is taking place. This action can be manual, meaning that a person or persons may engage in it, or it may be automatic, deploying once fire, smoke or heat is detected.
   - Sensing, domotics, smoke detectors
   - Exterior sprinkler systems, fire extinguishers, other suppression systems
   - Ventilation systems
   - Hypoxic environments
   - Water cannon (rainguns)
   - Automated fire doors
   - Fire suppression systems

4. Analysis of **condominium** (towers and block of flats)

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Thank you!

david@meteogrid.com

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## Product 47 Citizens/scientist network and Engagement Plan








"I want YOU to act as if your house is on fire...
..because it is.

I WANT YOU TO PANIC."

Greta Thunberg

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## WHAT IF WE EMPOWERED COMMUNITIES SO NOT TO PANIC IN CASE OF EMERGENCY?

Applying Participatory Action Research principles to enable collaborative actions between communities, decision-makers and practitioners to increase ownership of preparedness and prevention measures

### CO-CREATION

involves continuous and structured engagement of end users throughout a project's lifecycle.

**CO-DESIGN** – Engagement activities aimed at the identification and analysis of problems and related solutions.

**CO-PRODUCTION** – Engagement activities aimed at the implementation & testing of the proposed solutions.

# INVOLVING COMMUNITIES: WHEN?




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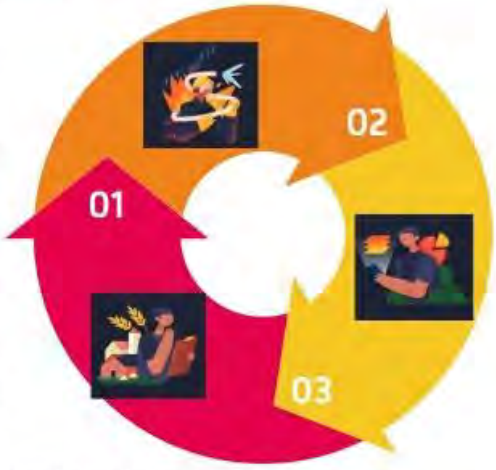
# INVOLVING COMMUNITIES: HOW?

**2. REDUCTION**

COOPERATING WITH LOCAL COMMUNITIES FOR REDUCING HUMAN CAUSED IGNITIONS, INCLUDING LAND MANAGEMENT STRATEGIES..




**1. ASSESSMENT**

INTEGRATING LOCAL KNOWLEDGE IN EVALUATION OF DANGER, EXPOSURE AND VULNERABILITY..

**3. ADAPTATION**

INTEGRATE CITIZENS' AND COMUNITIES INPUTS IN DESIGNING PREVENTION AND PREPARADNESS STRATEGIES.

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# FIREURISK PARTICPATORY MODEL

## A2.4.3 – CITIZENS INVOLVEMENT IN WILDFIRE RISK REDUCTION

03/11/23 | DEMO EVENT PT

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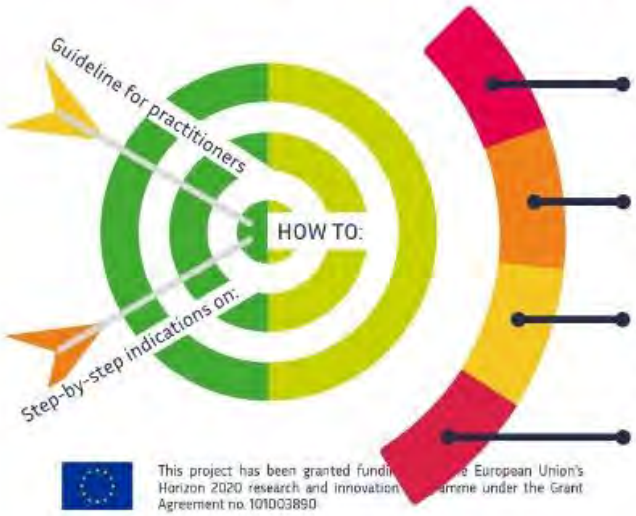
# FIREURISK PARTICIPATORY MODEL

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**TOOLBOX**

- Supports the co-production of context-based and community-driven strategies for reducing fire risk and increasing societal resilience through preparedness

**BUILDS ON:**

- Council of Europe
  - Civil participation Toolkit for decision Making (CoE/ISIG, 20)
  - ReBuS – Resilience Building Strategies Toolkit (CoE/ISIG, 21)
- Ostrom – IDF (1994)

# PARTICIPATORY APPROACHES TO FIRE RISK REDUCTION AND RESILIENCE STRATEGIES: HOW?

fireurisk



**SELECTING ACTORS**

Structured approach towards the mapping and analysis of relevant stakeholders.

**SETTING-UP ENGAGEMENT STRATEGIES**

Identification of targeted engagement actions for identified stakeholders.

**ESTABLISHING LOCAL PARTNERSHIPS**

Citizen-scientists networks- Informal partnerships of stakeholders @ local level

**STRENGHTENING CAPACITIES**

**Learning by doing approach**: Co-production of assessment of fire-risk and local needs through project proposed tools and methodologies.

# HOW DO WE APPLY IT?

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**1. INTERACTION WITH COMMUNITIES**

1. Preliminary contextualisation of the model
2. Preliminary analysis: context & stakeholders

**2. LAUNCH SURVEY**

1. Perception & awareness

**3. NEEDS ASSESSMENT WS**

1. Context analysis
2. Stakeholder analysis.

**4. ACTION PLANS**

1. Developed through co-production WS
2. Validated with citizens

**5. IMPLEMENTATION**

1. Co-production workshops
2. Validation activities
3. Implementing Awareness raising campaign

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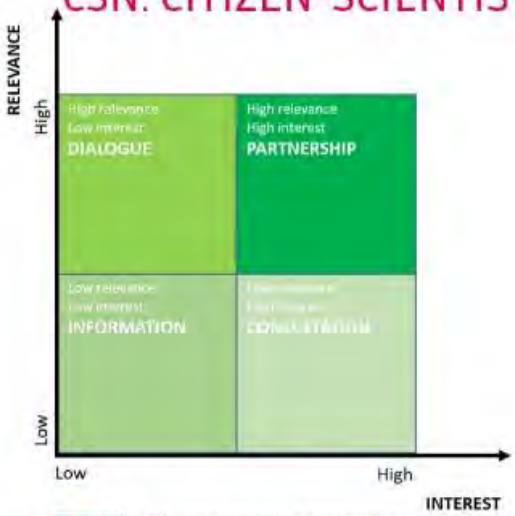
# CSN: CITIZEN-SCIENTISTS NETWORKS

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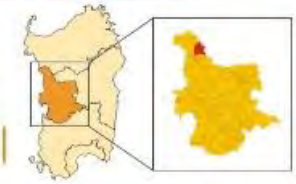
- **WHAT ARE CSN?**
  - Informal partnerships of stakeholders @ local level.
  - Task-force for fire risk reduction.
- **WHAT DO THEY DO?**
  - Support research activities with their context knowledge (workshops, surveys).
  - Work together with scientists and practitioners to map obstacles and identify context-aware solutions for fire risk reduction.
  - Mainstream participation and representation in the decision-making
  - Ensure that the needs of all groups in the community are considered in resilience building.





# FIREURISK PARTICPATORY MODEL

## TESTING IN SARDINIA (ITALY)



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## PRELIMINARY RESULTS: CO-PRODUCING STRATEGIES

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**REGIONAL STRATEGIES**

- Full **legal recognition** of prescribed burnings
- **Rural development plans**
- Shifting resources **from emergency to prevention**.

**REGIONAL ACTIONS**

- Economic valorisation of **local products and economy**

**LOCAL STRATEGIES**

- Analysis of **community resources**
- Development of a **communication strategy**
- Implementation of **cultural and dissemination activities**

**LOCAL ACTIONS**

- Design and implementation of a **Inter-municipal Civil Protection Plan**

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# FIREURISK PARTICPATORY MODEL

## TESTING IN PORTUGAL

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# VISION

**MORE RESILEINT COMMUNITIES TO WILDFIRES!**

# MISSION

1. ADAPT FIREURISK PARTICPATORY MODEL TO PORTUGAL
2. ACTIVATE CITIZEN-SCIENTIST NETWORKS
3. CO-PRODUCE STRATEGIES WITH COMMUNITIES

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**CENTRAL PORTUGAL SETTLEMENTS:**

- AVELEIRA
- TORROZELAS

CASE STUDY 2

CASE STUDY 1

**'VIRTUAL' SETTLEMENT:**

- BRAVO MUNDO NETWORK

# ROADMAP FOR PORTUGAL PILOT SITE

PHASES

**DEC. 2023** — **ANALYSE PROBLEMS**
- Citizens' Survey
- Workshops for Needs & Stakeholders analysis

**MAR. 2024** — **IDENTIFY SOLUTIONS**
- Establish CSNs
- Co-produce Action Plans
- Develop Awareness raising & Training materials

**APR. 2024** — **SET & REACH GOALS**
- Validate by Citizens Assemblies.
- Implement activities
- Monitor & evaluate

| | |
|---|---|
| OBJECTIVE | • DEVELOP A 2-YEARS ENGAGEMENT STRATEGY FOR WILDFIRE RISK REDUCTION MEASURES. |
| ACTIVTIES | • AWARENESS RAISING CAMPAIGNS<br>• CAPACITY BUILDING & TRAINING MATERIALS |
| APPROACH | • CO-PRODUCING STRATEGIES WITH COMMUNITIES AND STAKEHOLDERS |

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# PRELIMINARY RESULTS

## CASE STUDY: AVELEIRA & TORROZELAS

- Performed activities:
  - 2 preliminary workshops – preliminary needs assessment and stakeholder analysis.
- Goals:
  - Strengthen self-protection capacity of residents
  - Cooperation with neighbouring settlements
- Next steps:
  - Needs assessment & Stakeholders workshop
    TOMORROW

## CASE STUDY 2: BRAVO MUNDO NETWORK

- Performed activities:
  - 2 preliminary workshops – preliminary needs assessment and stakeholder analysis.
- Identified focus:
  - Strengthen self-protection capacity of residents
  - Strengthen cooperation with institutional actors.
- Next steps:
  - Organise a Participatory review of 'action plan' developed by the network with institutional actors.
    DECEMBER 23

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OBRIGADO!

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## Product 8. Future climate information

# Future climate information

Jaime Ribalaygua Batalla
Meteogrid (Spain)

03/11/2023 | Demonstration Event (PS3: Portugal)

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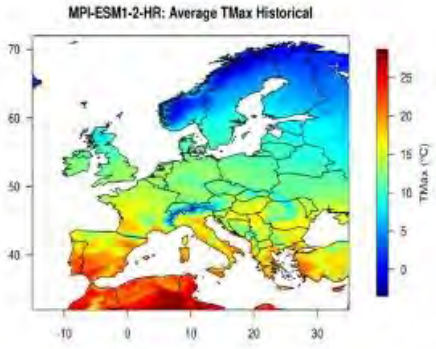
## Work phases

1. **Selection of main variables** required: maximum and minimum temperature, precipitation, maximum and minimum relative humidity, wind, and solar radiation.
2. **Production of scenarios for the whole Europe**, with daily resolution and 0.07° x 0.07° (≈ 9 km) spatial resolution (that of the ERA5-Land Reanalysis)
3. **Selection of 3 projections** that, having successfully passed the validation analyses, represent the uncertainty of the projection ensemble (one representing low, one medium and one high changes in DC), averaged over Europe, and for each PS and DA.
4. **Production of scenarios for the PS and DA**, for the 3 selected models, with daily temporal resolution and 1 km x 1 km spatial resolution.

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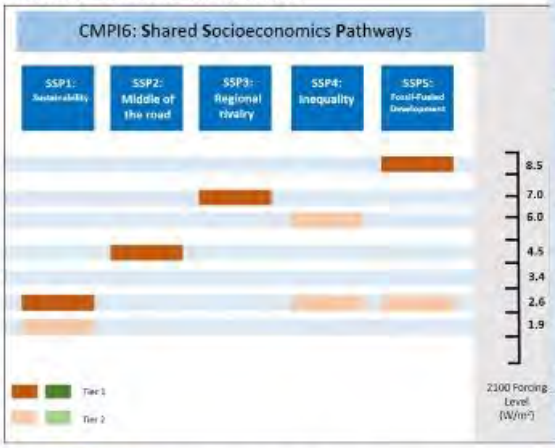
## 3 Climate models:

**Periods = 1974-2014; 2015-2100**

### CMIP6 Climate Scenarios




| CMPI6 MODELS | Resolution | Responsible Centre | References |
|---|---|---|---|
| BCC-CSM2-MR | 1,125º x 1,121º | Beijing Climate Center (BCC), China Meteorological Administration, China. | Wu, T. et al. (2019) |
| CanESM5 | 2,812º x 2,790º | Canadian Centre for Climate Modeling and Analysis (CC-CMA), Canadá. | Swart, N.C. et al. (2019) |
| CNRM-ESM2-1 | 1,406º x 1,401º | CNRM (Centre National de Recherches Meteorologiques), Meteo-France, Francia. | Seferian, R. (2019) |
| EC-EARTH3 | 0,703º x 0,702º | EC-EARTH Consortium | EC-Earth Consortium. (2019) |
| GFDL-ESM4 | 1,250º x 1,000º | National Oceanic and Atmospheric Administration (NOAA), E.E.U.U. | Krasting, J.P. et al. (2018) |
| MPI-ESM1-2-HR | 0,938º x 0,935º | Max-Planck Institute for Meteorology (MPI-M), Germany. | Von Storch, J. et al. (2017) |
| MRI-ESM2-0 | 1,125º x 1,121º | Meteorological Research Institute (MRI), Japan. | Yukimoto, S. et al. (2019) |
| UKESM1-0-LL | 1,875º x 1,250º | Uk Met Office, Hadley Centre, United Kingdom | Good, P. et al. (2019) |
| NorESM2-MM | 1,250º x 0,942º | Norwegian Climate Centre (NCC), Norway. | Bentsen, M. et al. (2019) |
| ACCESS-ESM1-5 | 1,875º x 1,250º | Australian Community Climate and Earth System Simulator (ACCESS), Australia | Ziehn, T. et al. (2019) |

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## 4 0.07º scenarios: ERA5-Land

### ERA5-Land reanalysis




**ERA5-Land**
- **Used period: 1979-2020**
- **Used temporal resolution: Daily**

**FirEUrisk grid = ERA5-Land grid**
- **Spatial resolution ≈ 0.07° (≈ 9 km)**
- **Borders = 32°N, 72°N; 15°W, 35°E**

**Number of grid cells**
- **Total: 404,559**
- **Inland cells: 196,367**

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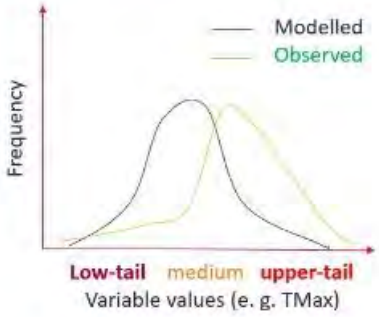
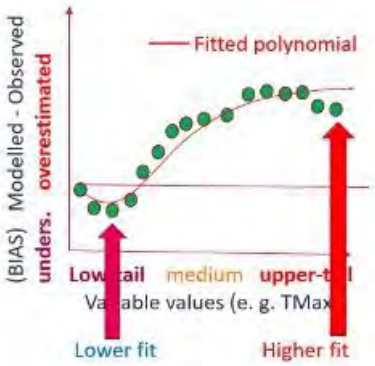
## 5 Downscaling methodology

**Bias correction based on parametric quantile-quantile mapping**

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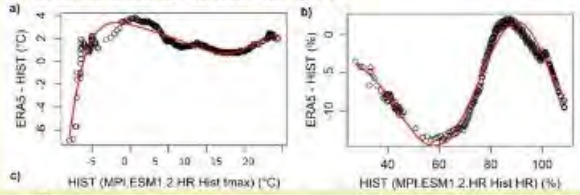
## 6 Downscaling methodology

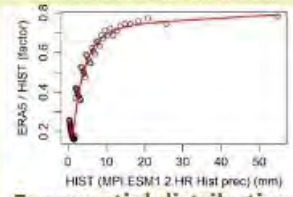
**Fast parametric quantile mapping (for each grid point and variable)**

**Smooth distribution variable**




$f$ := mapping(sort(ERA5), sort(ERA5) - sort(HIST))

MOD_smooth_var = MOD_smooth_var + $f$(MOD_smooth_var)




LEGEND:

- Correction obtained from qqmap
- Transfer function

$g$ := mapping(sort(ERA5), sort(ERA5)/sort(HIST)) for ERA5>0 and HIST>0

MOD_exponential_var = MOD_exponential_var × $g$(MOD_smooth_var)

**Exponential distribution variable**

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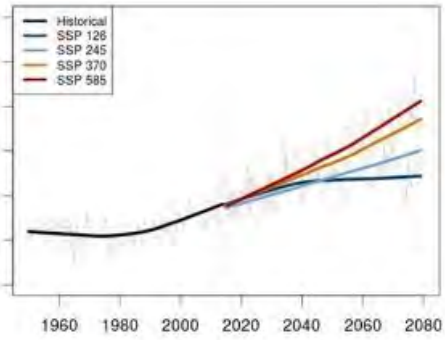
## 7 Selection of 3 projections: Validation

- It is **not possible** for impact modelers to run their models for 40 (10 models x 4 SSP) projections
- We have to **select a few projections**, ensuring that **uncertainty** is considered
- First of all, a **validation analysis** is performed for the 10 models, rejecting those that do not pass this validation satisfactorily

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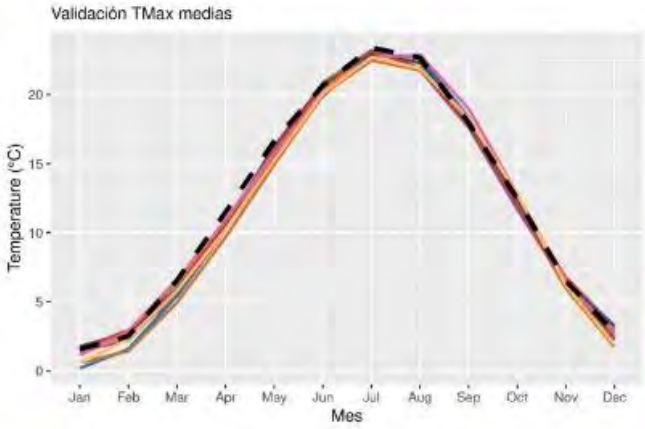
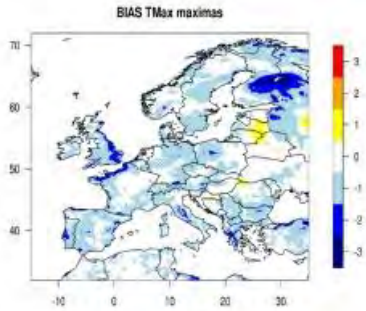
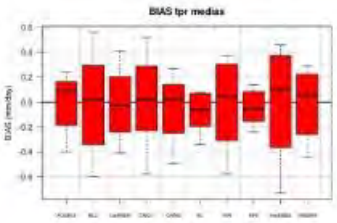
## 8 Selection of 3 projections: Validation

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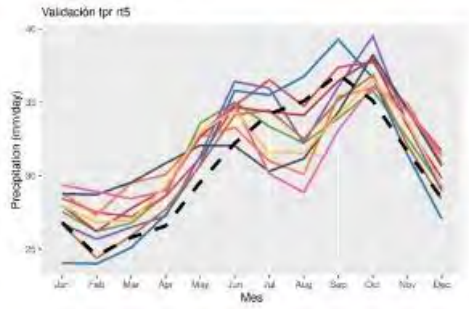
03/11/2023 | Demonstration Event PS3: Portugal

## 9 Selection of 3 projections: Validation

**Not only mean values** were analysed, but **also extremes** (example: maximum daily precipitation associated to a 5 years return period, for each month within 1985-2014)

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## 10 Validation results and selection of 3 projections

- **Rejected models:**
  - 3 models were rejected because some important variables were not available
  - The other 7 models were good enough
- **Final selection:** both for the average over the **whole of Europe, and for each of the PS and DA:**
  - The 7 models that were successfully validated were **ranked according to the changes in the Drought Code (DC)** of the FWI
  - **3 models are selected**, one for low, one for medium and one for high changes in DC.



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03/11/2023 Demonstration Event PS3: Portugal

## 11 Selection of 3 projections

**For each PS and DA**, and for the average for the **whole of Europe**, the 28 projections (7 models x 4 SSP each one) are sorted attending the changes in DC.

| Model | Scenario | DC Difference | Centile |
|---|---|---|---|
| CanESM5 | ssp245 | -5.84 | 0 |
| MRI-ESM2-0 | ssp126 | -2.78 | 3 |
| MPI-ESM1-2-HR | ssp126 | -2.73 | 6 |
| ACCESS-CM2 | ssp126 | 3.79 | 10 |
| EC-EARTH3 | ssp126 | 6.28 | 13 |
| CMCC-ESM2 | ssp245 | 11.02 | 17 |
| CMCC-ESM2 | ssp370 | 13.41 | 21 |
| CMCC-ESM2 | ssp126 | 19.04 | 25 |
| CanESM5 | ssp126 | 22.69 | 29 |
| MPI-ESM1-2-HR | ssp370 | 48.03 | 34 |
| CNRM-ESM2-1 | ssp126 | 51.29 | 38 |
| MPI-ESM1-2-HR | ssp245 | 66.11 | 42 |
| EC-EARTH3 | ssp370 | 71.21 | 46 |
| ACCESS-CM2 | ssp245 | 77.57 | 50 |
| EC-EARTH3 | ssp245 | 82.4 | 53 |
| CNRM-ESM2-1 | ssp370 | 94.65 | 57 |
| MRI-ESM2-0 | ssp370 | 99.07 | 61 |
| EC-EARTH3 | ssp585 | 99.23 | 64 |
| MRI-ESM2-0 | ssp245 | 99.69 | 68 |
| CNRM-ESM2-1 | ssp245 | 101.07 | 71 |
| CMCC-ESM2 | ssp585 | 106.16 | 75 |
| ACCESS-CM2 | ssp370 | 117.32 | 79 |
| CanESM5 | ssp370 | 119.11 | 83 |
| MPI-ESM1-2-HR | ssp585 | 126.76 | 87 |
| ACCESS-CM2 | ssp585 | 135.16 | 90 |
| MRI-ESM2-0 | ssp585 | 138.78 | 93 |
| CNRM-ESM2-1 | ssp585 | 156.79 | 97 |
| CanESM5 | ssp585 | 185.13 | 100 |

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



## 12 Selected projections

### For Europe

| Model | Scenario | DC Difference |
|---|---|---|
| CanESM5 | ssp245 | 4.36 |
| CMCC-ESM2 | ssp370 | 46.68 |
| CanESM5 | ssp585 | 75.01 |

### For each PS and DA

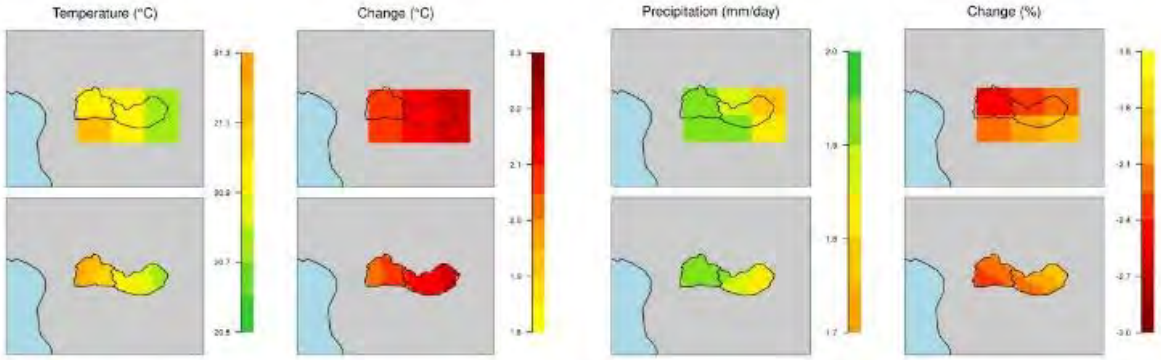
| | | | |
|---|---|---|---|
| DA-19-ES | CanESM5_ssp126 | MRI-ESM2-0_ssp370 | CanESM5_ssp370 |
| DA-20-HR | CNRM-ESM2-1_ssp126 | CNRM-ESM2-1_ssp245 | MPI-ESM1-2-HR_ssp585 |
| DA-21-PT | MRI-ESM2-0_ssp126 | ACCESS-CM2_ssp370 | EC-EARTH3_ssp585 |
| DA-22-PT | CanESM5_ssp126 | ACCESS-CM2_ssp370 | MPI-ESM1-2-HR_ssp585 |
| DA-23-EL | MRI-ESM2-0_ssp126 | CNRM-ESM2-1_ssp126 | CNRM-ESM2-1_ssp370 |
| DA-24-EL | MRI-ESM2-0_ssp126 | MPI-ESM1-2-HR_ssp245 | ACCESS-CM2_ssp585 |
| DA-25-CZ | CanESM5_ssp245 | MRI-ESM2-0_ssp585 | ACCESS-CM2_ssp370 |
| DA-26-RO | CNRM-ESM2-1_ssp126 | CMCC-ESM2_ssp245 | EC-EARTH3_ssp585 |
| PS-01-SE | EC-EARTH3_ssp126 | EC-EARTH3_ssp585 | ACCESS-CM2_ssp370 |
| PS-02-DE.CZ.PL | MRI-ESM2-0_ssp245 | MRI-ESM2-0_ssp585 | CMCC-ESM2_ssp585 |
| PS-03-PT | MRI-ESM2-0_ssp126 | ACCESS-CM2_ssp370 | CMCC-ESM2_ssp370 |
| PS-04-ES | CanESM5_ssp245 | MRI-ESM2-0_ssp245 | MPI-ESM1-2-HR_ssp585 |
| PS-05-EL | ACCESS-CM2_ssp126 | CNRM-ESM2-1_ssp126 | MPI-ESM1-2-HR_ssp585 |

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

03/11/2023 Demonstration Event PS3: Portugal

## 13 1 km scenarios for each PS and DA

**Example for DA-01-IT (Sardinia, Italy)**

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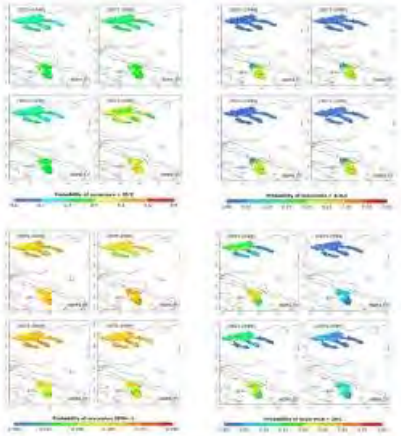
## 14 CMIP5 contrast experiment in MED-Greece (NCSRD)

**RCP4.5 and RCP8.5 CMIP5** climate projections of EC-Earth were **dynamically downscaled** by using the Weather Research and Forecasting Model (**WRF**) at a resolution of **5 km x 5km**.

**Extreme value analysis**: estimation of climate values for maximum temperature, wind speed and 6-months Standardised Precipitation Index -SPI- of September, for **various return periods** (20, 50, 100 years) and the probability of exceeding a value which **favour fire events**, based on extreme value theory for the selected pilot and demonstration areas in Greece



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


fireurisk
Thank you for your attention!
More details in Deliverable 3.1: Climate projections
This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

## Product 75. Continental land-use change scenarios and stylised fuel management scenarios

# How will our present land management affect our future fire risk?

Using models to explore Europe's future fuelscapes



**Presenting:**
**Alex Neidermeier**
Vrije Universiteit, Amsterdam
a.Neidermeier@vu.nl

Nov. 3rd, 2023
Demonstration Event, Portugal



## How are fuelscapes changing in Europe?




**Climate change**

***Land abandonment***

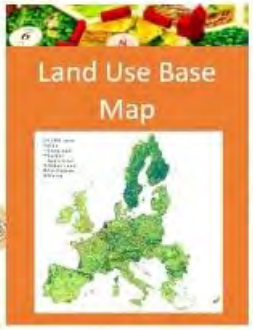
**Changes in the WUI**

*From Moreira et al. 2011*

| Drivers | Landscape patterns | Fire hazard |
|---|---|---|
| Decrease of farming activities | Forests ↑<br>Shrublands ↑<br>Agricultural areas ↓ | ↑ |
| Decrease of pastoral activities | Forests ↑<br>Shrublands ↑<br>Grasslands and pastures ↓ | ↑ |
| Population ageing and decline/ Emigration | Forests ↑<br>Shrublands ↑<br>Agricultural areas ↓ | ↑ |
| Afforestation/reforestation | Forests ↑ | ↑ |
| Decreased exploitation of timber and wood resources | Forests ↑<br>Shrublands ↑ | ↑ |

# CLUMondo: A spatially explicit land use model












a.neidermeier@vu.nl

# Imagining the future: Shared Socioeconomic Pathways

**SSP1: Sustainability**
***Taking the Green Road***

SSP2: Middle of the Road

**SSP3: Regional Rivalry**
***A Rocky Road***

SSP 4: Inequality
*A Road Divided*

[illegible]

**Associated climate pathway: Representative Concentration Pathway (RCP) 2.6**, which assumes a high effort to reduce emissions and increase renewable energy and emissions capture

**Associated climate pathway: RCP7.0,** which indicates mixed renewable and fossil fuel energy generation, limited public transportation options, and an overall low effort to curb emissions.




a.neidermeier@vu.nl

# CLUMondo: Land use demands




| | *SSP1-Sustainable* | | | | *SSP3-Regional Rivalry* | | | |
|---|---|---|---|---|---|---|---|---|
| **Change by 2050** | **east** | **north** | **south** | **west** | **east** | **west** | **south** | **north** |
| Population | -8% | 32% | 6% | 14% | -14% | 4% | -13% | -7% |
| Annual crops | 10% | 12% | -25% | 5% | -1% | -13% | -31% | -2% |
| Permanent crops | 23% | 9% | 30% | 27% | 50% | 41% | 56% | 53% |
| Livestock | 9% | 30% | -15% | -9% | -9% | -13% | -19% | -6% |
| Forest products | 25% | 15% | 17% | 23% | 16% | 10% | 5% | 9% |

## Rules and settings

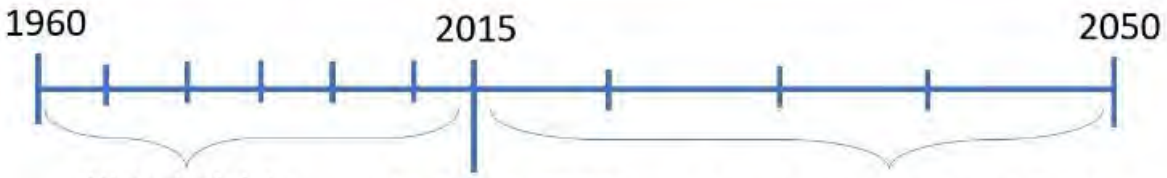


- Area restrictions
- Conversion restrictions
- Competitive advantage
- Local suitability
- Neighborhood influence
- Conversion resistance

| Present land use ↓ \ Future land use → | Forest | Agriculture | Grassland |
|---|---|---|---|
| Forest | + | + | + |
| Agriculture | - | + | + |
| Grassland | - | + | + |

+ Can be converted
- Cannot be converted

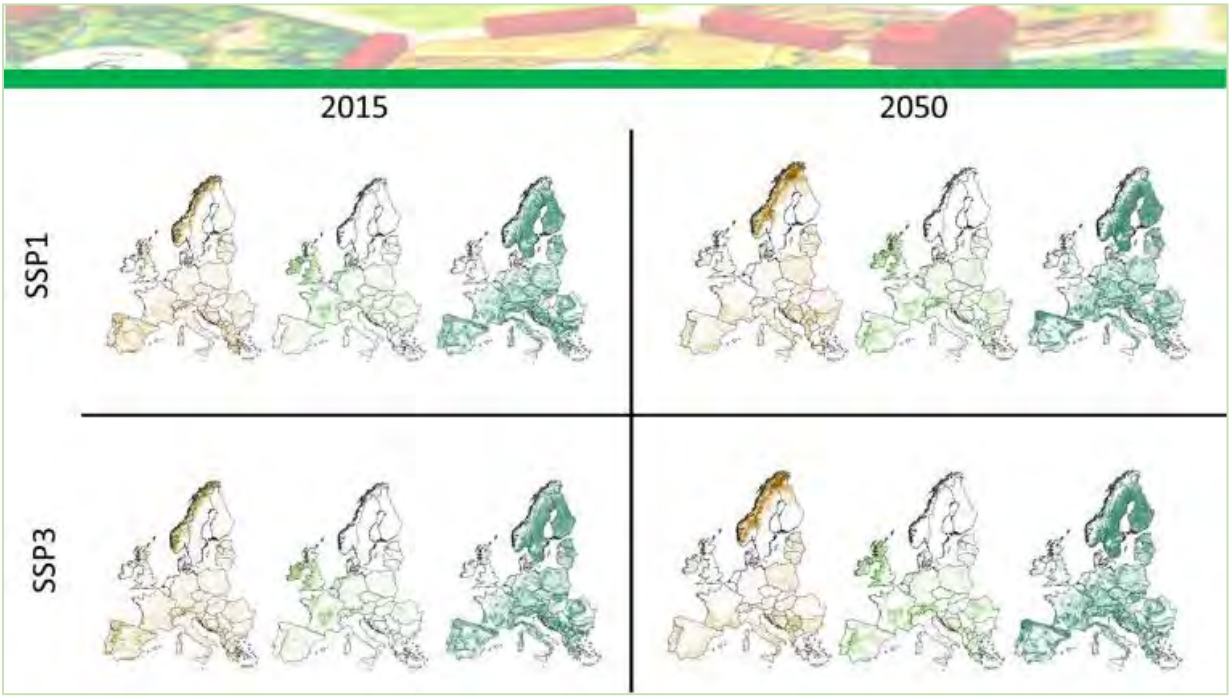
# Final product




Historical data from HILDA+
- *Aggregated to 9km with revised legend*

Land systems base map
- *from Dou et al. 2021*
- *21 classes initially*

Future scenarios modelled in CLUMondo
- *Originally 1 km resolution*
- *Aggregated to 9km resolution and revised legend*
- *Years: 2020, 2030, 2040, 2050*
- *SSPs 1 & 3*
- *Demands from GLOBIOM*

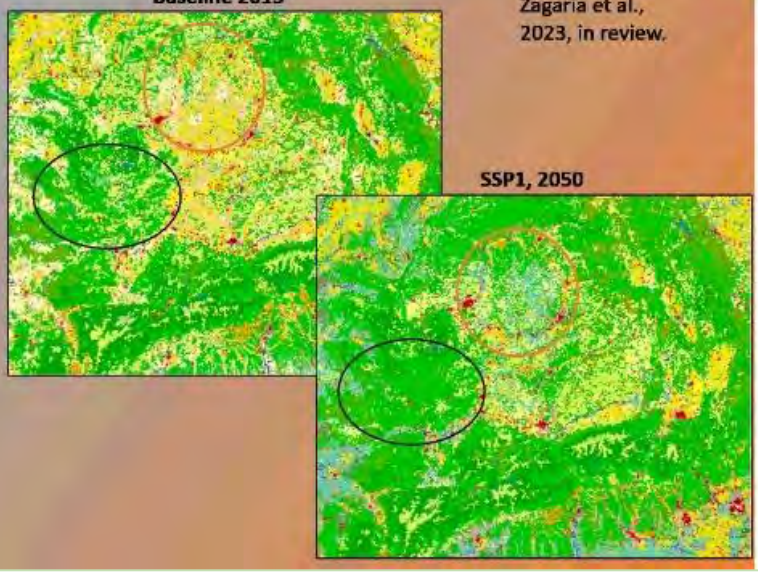


# CLUMondo: sample results

**Sample results in the Carpathian Mountains, Romania**

Low-intensity cropland → forest and cropland mosaics

Medium-intensity forest expansion




Zagaria et al., 2023, in review.

- Water
- Village
- Peri-urban
- Urban
- Extensive permanent crops
- Intensive permanent crops
- Low intensity forest
- Medium intensity forest
- Forest and grassland mosaics
- Low intensity agricultural mosaics
- Medium intensity agricultural mosaics
- High intensity agricultural mosaics
- Shrublands
- Bare land and rocks
- High intensity forest
- Low intensity grassland
- Medium intensity grassland
- High intensity grassland
- Low intensity cropland
- Medium intensity cropland
- High intensity cropland
- Forest and cropland mosaics

## What does this tell us about managing future fire risk?



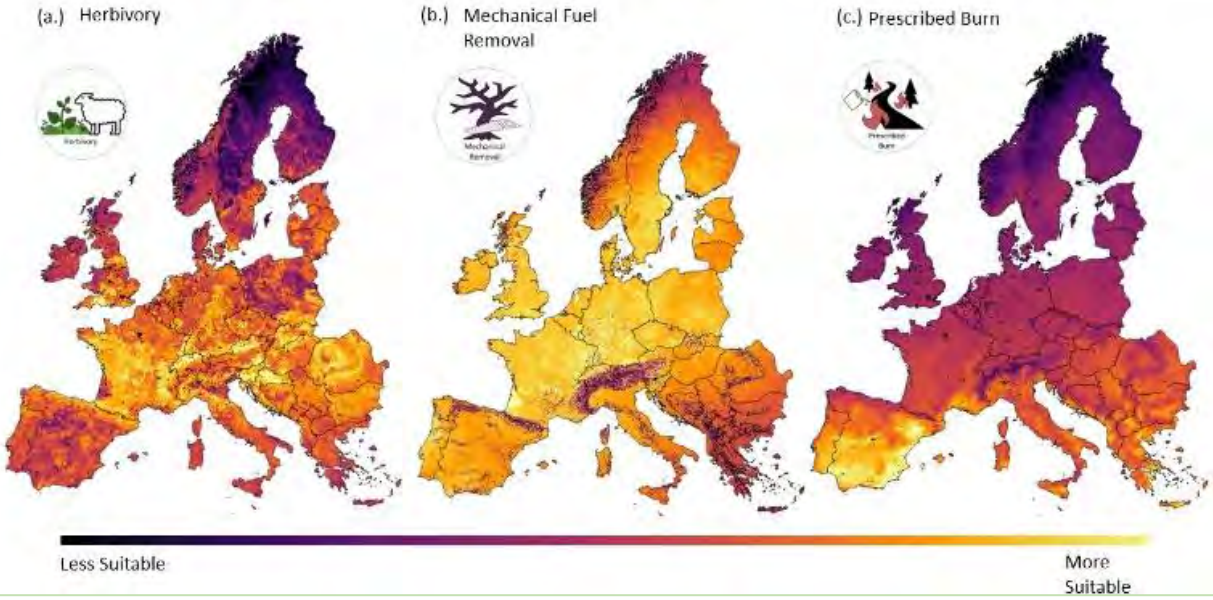
# Simulating future vegetation

**D**ynamic
**G**lobal
**V**egetation
**M**odels

LPJmL, PIK




## Estimated range of suitable areas for the adoption of each LMS

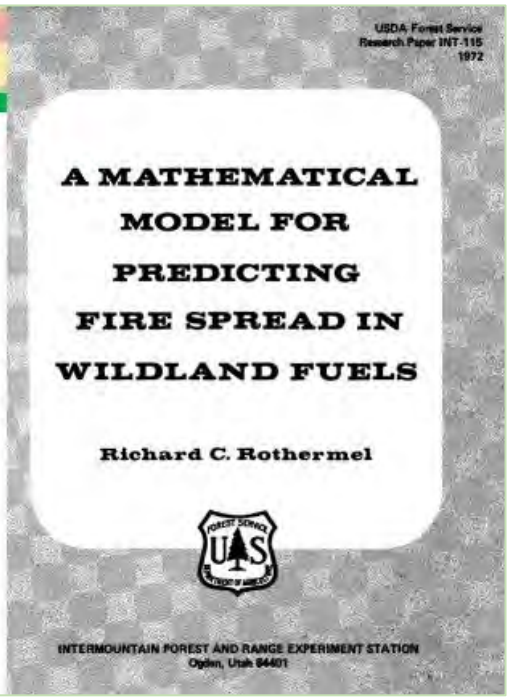


# Simulating future vegetation

LPJmL + SPITFIRE for fire propagation

How will the amount of burned area change?




Thank you!

**Presenting:**
**Alex Neidermeier**
Vrije Universiteit
Amsterdam
a.Neidermeier@vu.nl

VU VRIJE UNIVERSITEIT AMSTERDAM

fireurisk

## Product 36 Future fire regime data base



# Future fire regime database

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

Dr. Kirsten Thonicke, on behalf of WP3

03/11/2023 Event | Demonstration Event Portugal

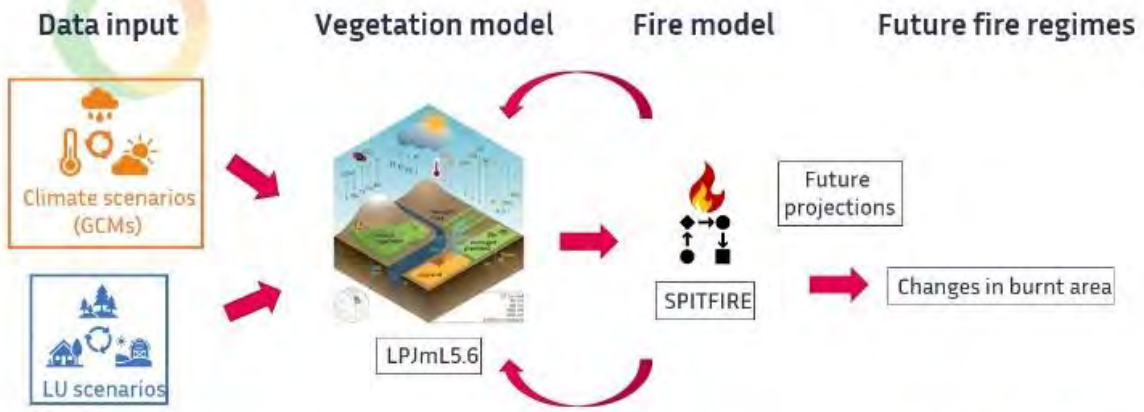
This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

## Overview

1. Methods used to simulate changes in future vegetation and fire under climate change
2. Possible changes in vegetation and fire in central Portugal
   - Fire weather
   - Burned area
   - Vegetation changes
3. Changes at 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

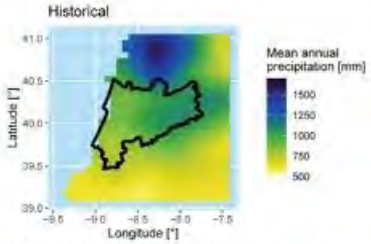
# What was our task?

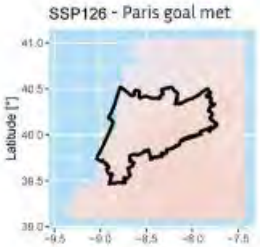


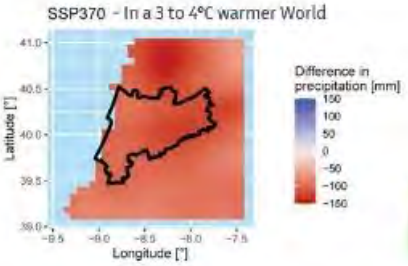

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme



# 1. Future climate conditions - Precipitation



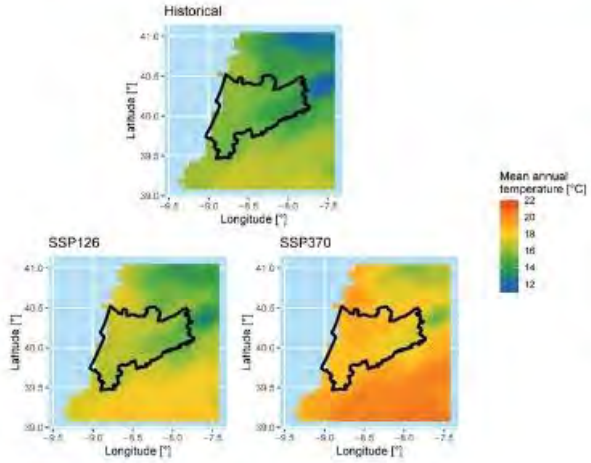




- Historical (1985 – 2014) reconstructed precipitation (ERA-5 Land)
- Bias-corrected against observed climate data
- averaged over 5 climate models
- Decrease in precipitation under climate change (2070-2099)

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

# 1. Future climate conditions – Air temperature

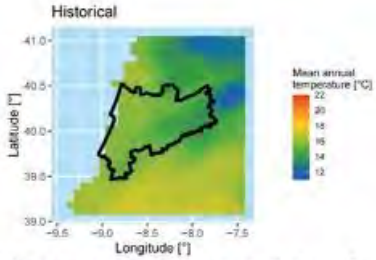



- Air surface temperature already deviates in 2001-2030
  - SSP126 ("Paris goal met") and
  - SSP370 ("In a 3 to 4°C warmer world")
- From historical climate (1985-2014)

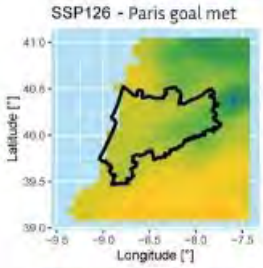
This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

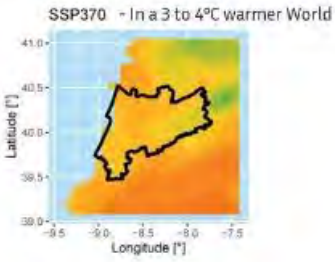


# 1. Future climate conditions – Air temperature




- Historical (1985 – 2014) reconstructed air surface temperature (ERA-5 Land)
- Bias-corrected against observed climate data
- averaged over 5 climate models
- Warming much stronger in lowland and under intense climate change (2070-2099)



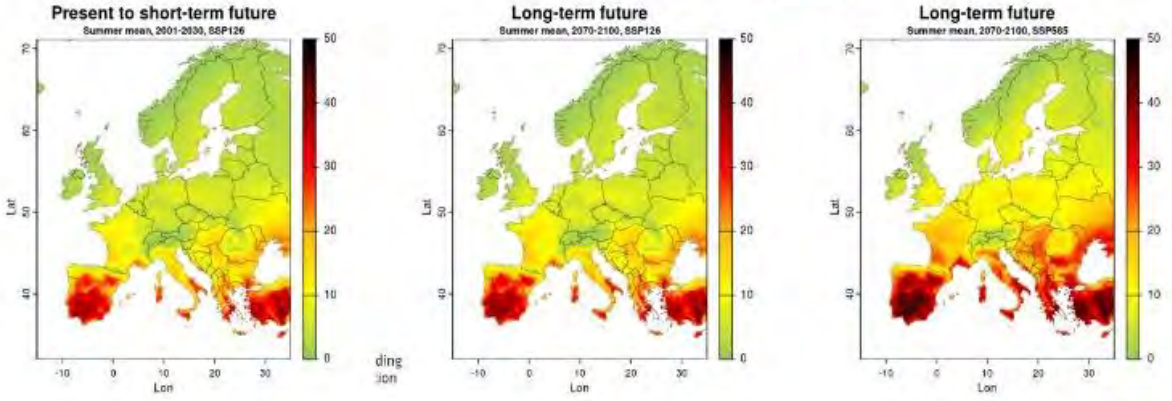




This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no. 101003890

# 1. Future fire weather

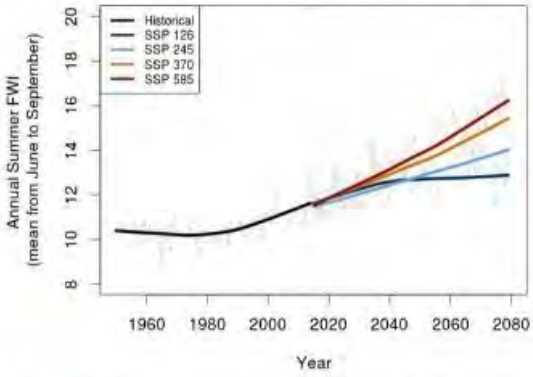
- Simulated FWI using future climate scenarios

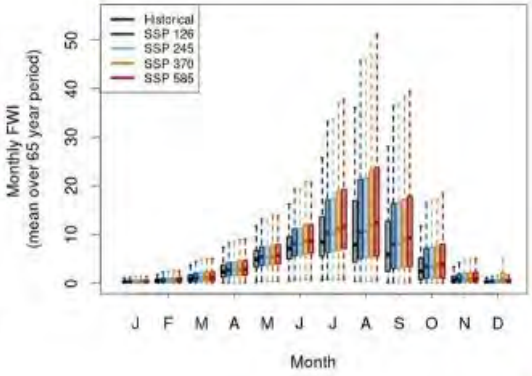
| Danger classes | |
|---|---|
| FWI < 5.2 | very low |
| 5.2 ≤ FWI < 11.2 | low |
| 11.2 ≤ FWI < 21.3 | moderate |
| 21.3 ≤ FWI < 38 | high |
| 38.0 ≤ FWI < 50 | very high |
| 50 ≤ FWI | extreme |




# 1. Future fire weather

- Long-term trends in Europe and Changes in seasonality



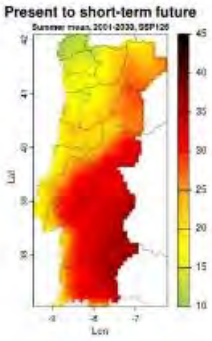

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no 101003890

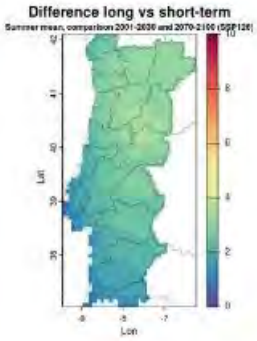
# 1. Future fire weather

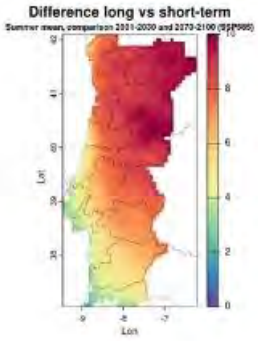
Ongoing climate change

Difference to 2070-2099
"Paris goal met"

Difference to 2070-2099
"In a 3 to 4°C warmer world"



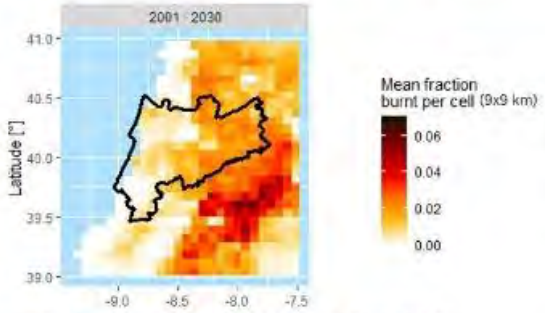



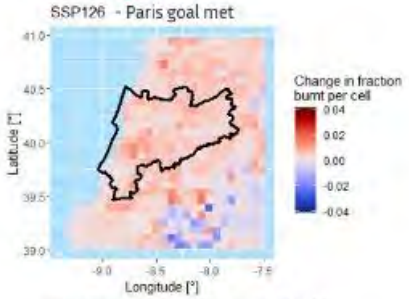



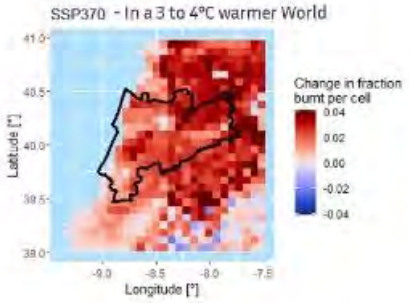

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no 101003890



# 2. Changes in area burnt – Central Portugal



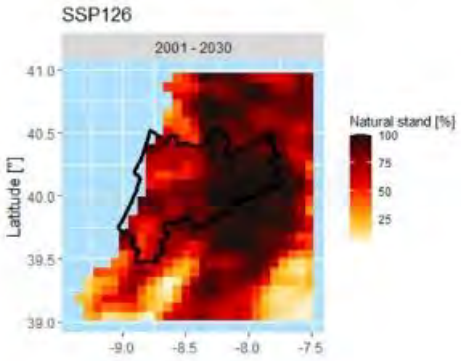




- Simulated by fire-enabled DGVM LPJmL-SPITFIRE: vegetation and fire are simulated process-based and interact
- Model forced with scenarios for land-use and climate change, vegetation changes in response to that and affects fire simulation
- Fractions burned per 9x9 km grid cell
- Small increases in SSP126, large increases if *global* warming is not kept well under 2°C

# 3. Effects of land-use change

**Proportion of natural vegetation within 9x9 km grid cell**




**Two different storylines of how land might be used**

**Changes in natural stand: in green less land-use = more potential area burned**



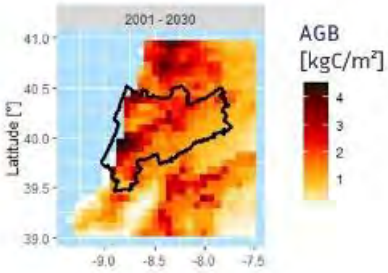
SSP126 – "Paris goal met"

Change in Natural stand [%]
40
20
0
-20
-40

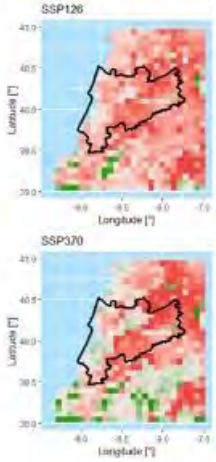
SSP370 – "in a 3 to 4 °C warmer World"

# 3. Effects of vegetation change within natural fraction

**Aboveground biomass (AGB)**




**Loss in AGB from climate effects, Increase in AGB likely due to land abandonment**



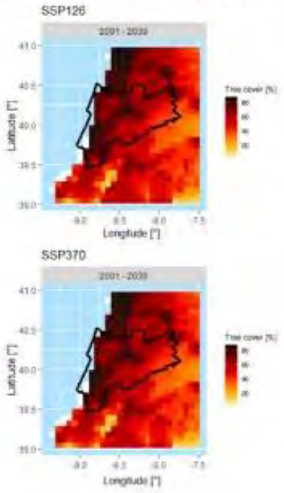

SSP126 – "Paris goal met"

Change in vegetation carbon [%]
50
25
0
-25
-50

SSP370 – "in a 3 to 4 °C warmer World"

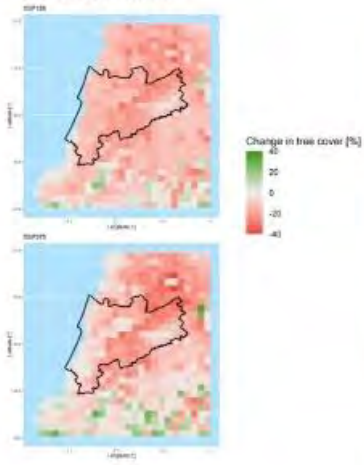
# 2. Changes in tree and grass cover

**Tree cover within natural fraction of 9x9 km grid cell**



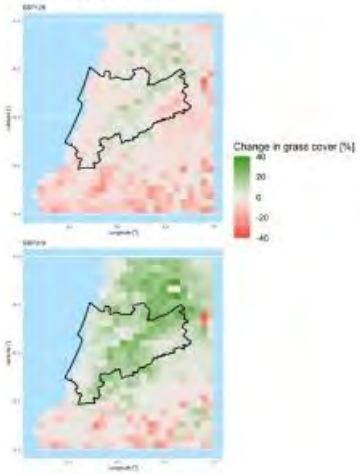

**Changes in tree cover**

2070-2099




**Changes in grass cover**

2070-2099




# 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

# Projections into the future: input data

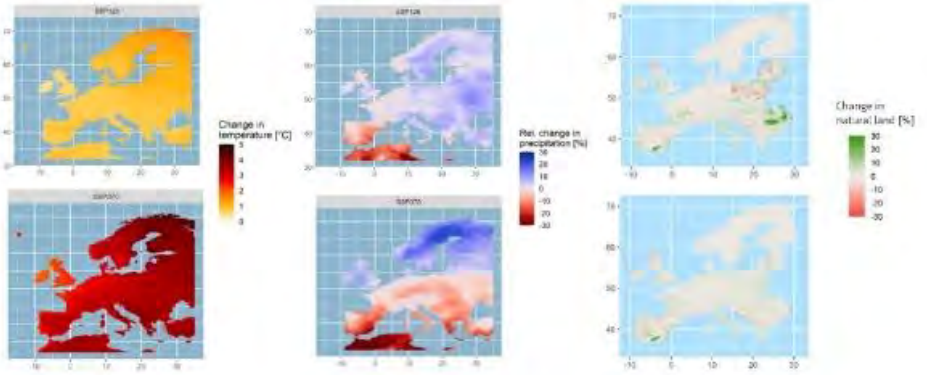
Temperature | Precipitation | Land-use change

SSP126

- sustainable
- low warming

SSP370

- not so sustainable
- medium warming



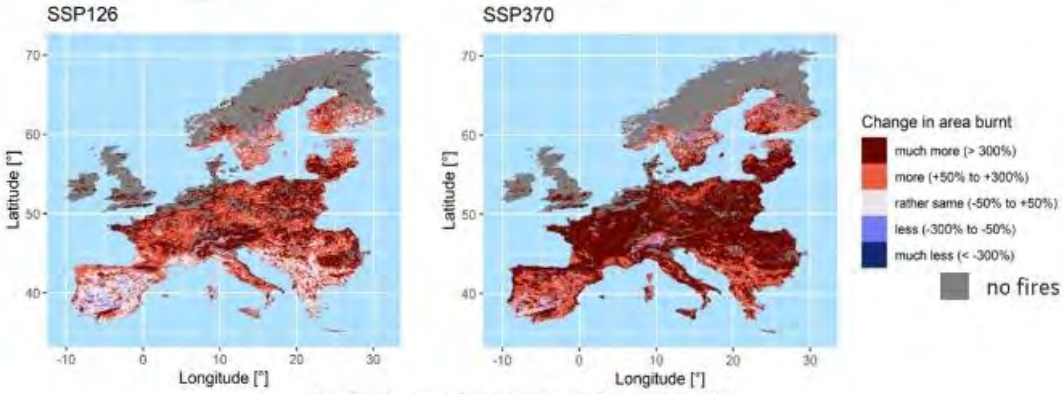

This project has been granted funding from the European Union's Horizon 2020 research and innovation programme



Changes in burnt area

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

SSP126 SSP370




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

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

# 5. Conclusion

- Future fire situation will depend on success global climate policy
- Pathways "Paris goal met" OR "in a 3 to 4°C warmer world" decide about intensity of changes in vegetation and the future fire situation
  - Future fire weather will increase, the fire season expand and become more extreme
  - Future area burned is a result of multiple changes happening at the same time
    - Land-use change: current land area used for agriculture and pasture needed for future sustainable pathway → little influence on area burnt
    - More abandonment under intense climate change → contributes to increase in area burnt
    - Climate change affects vegetation growth, and thus fire → changes in grass cover and biomass affect area burnt differently within the region
- Future potential burned area in Central Portugal as well as Europe will increase – it depends strongly on the global climate policy
- Next step: investigate chances and limitations of fire adaptation through land management (fuel removal)

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

# Annex B: Mentimeter questionnaire

## Session 0: Presentation and introduction

Presenter screen




Audience screen



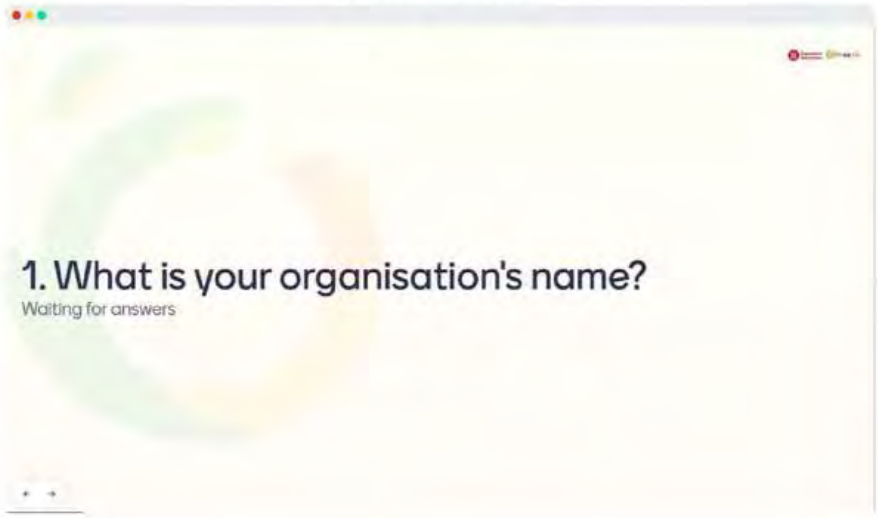

Presenter screen




Audience screen



Presenter screen




Audience screen




Presenter screen

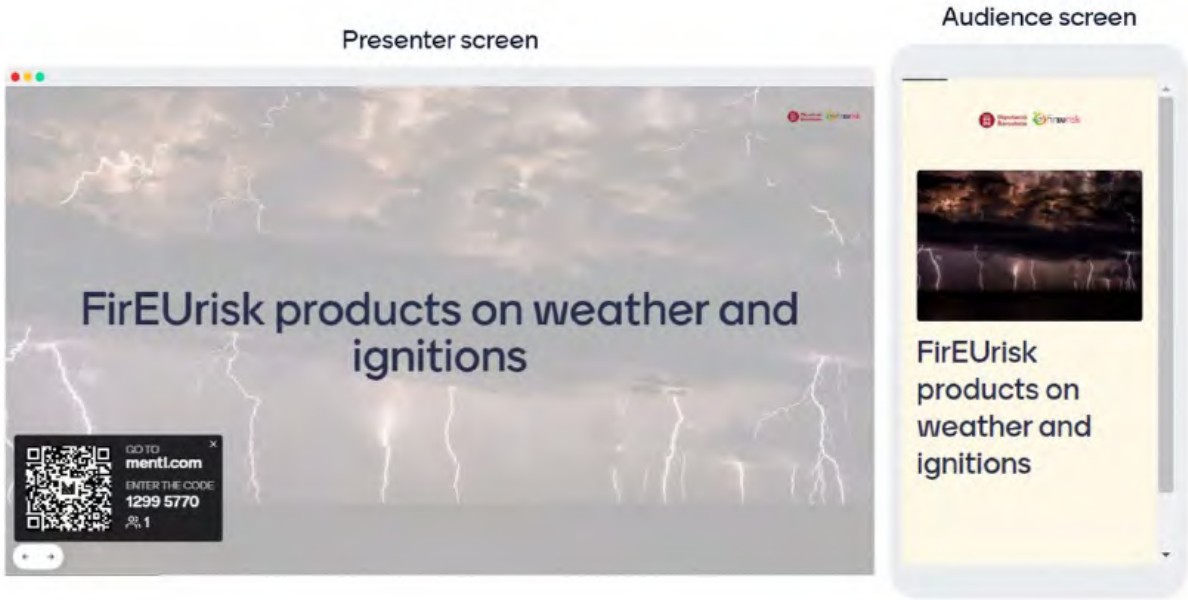



Audience screen






## Session 1: FirEUrisk products on fire risk assessment



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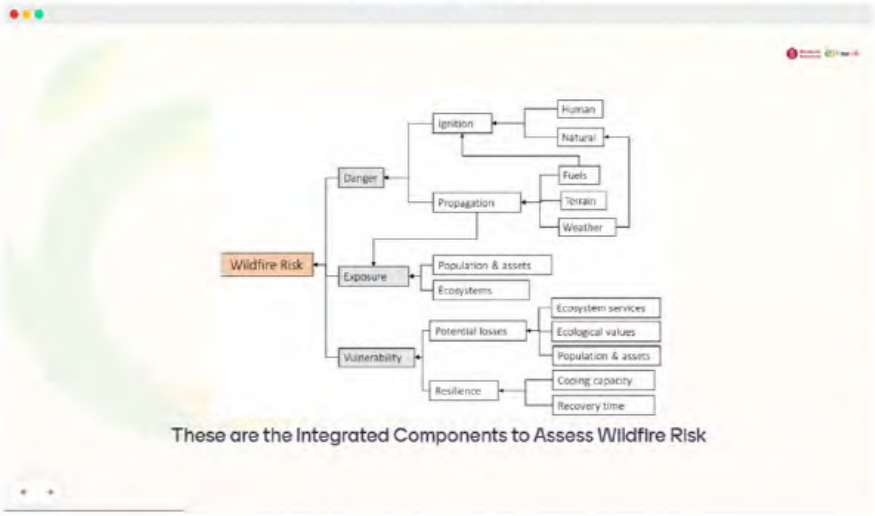


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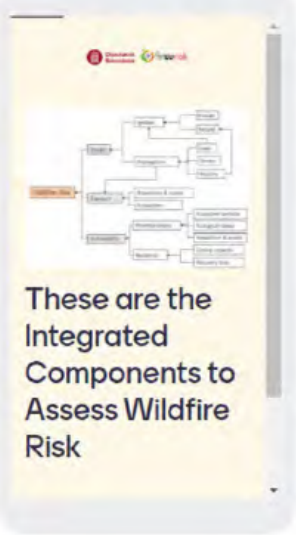


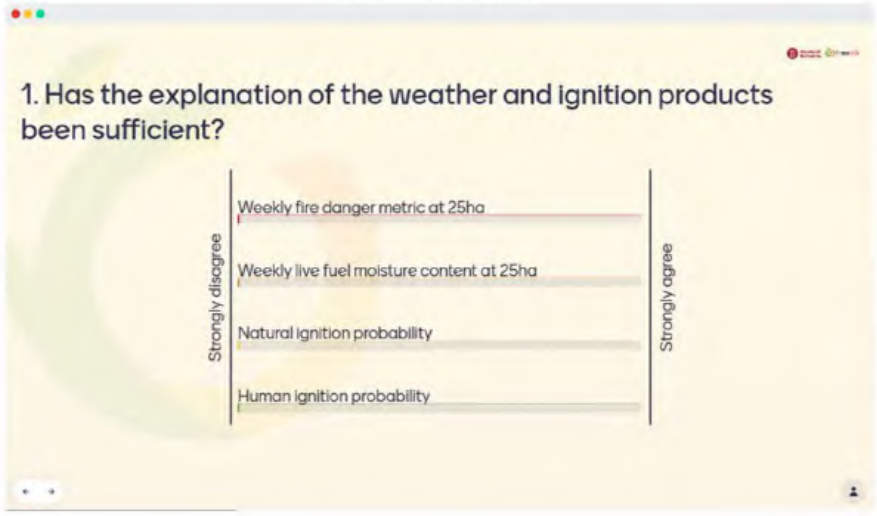

Presenter screen




Audience screen



Presenter screen

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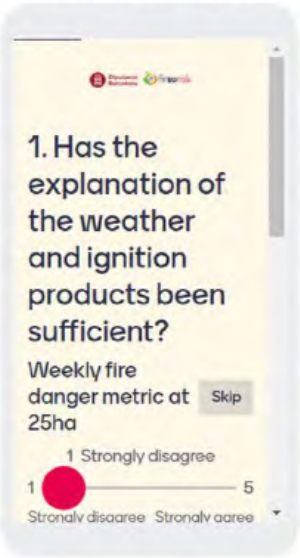
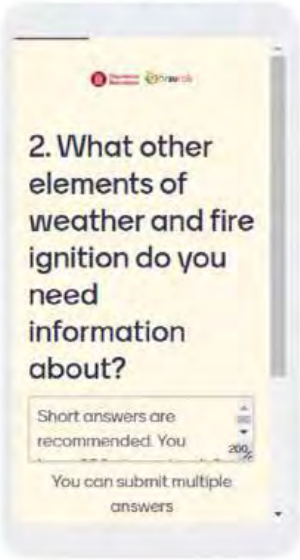



Presenter screen




Audience screen



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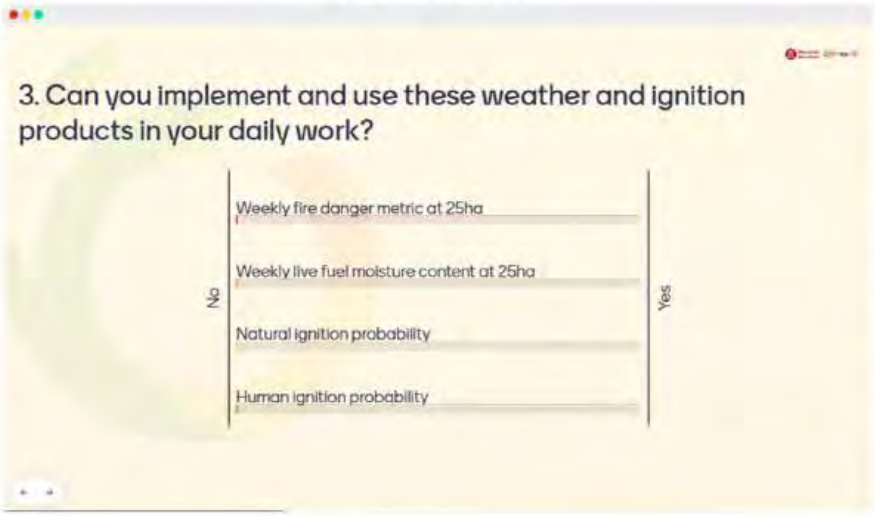


Audience screen




Presenter screen




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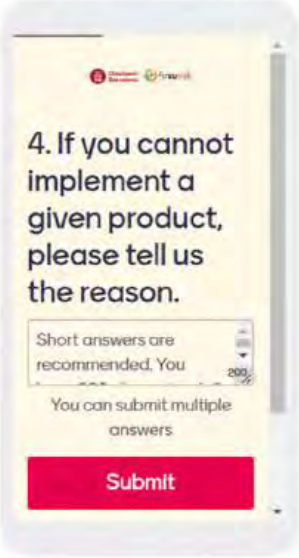

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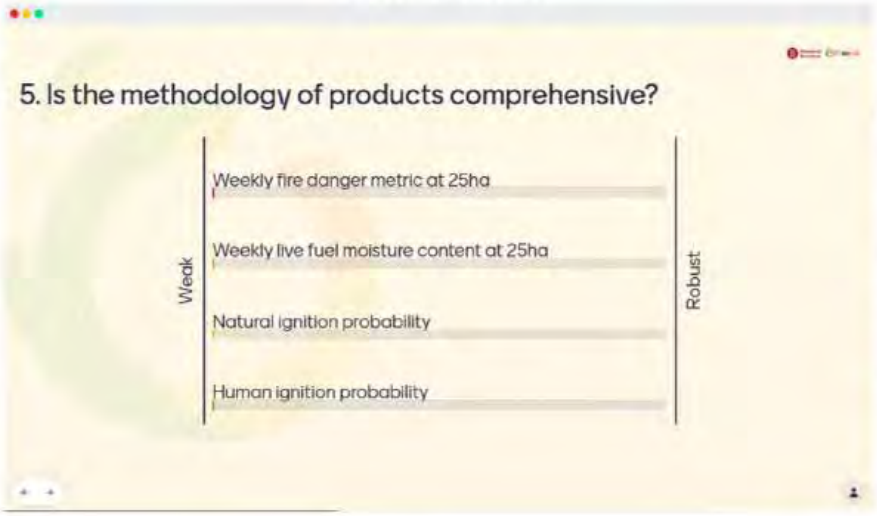


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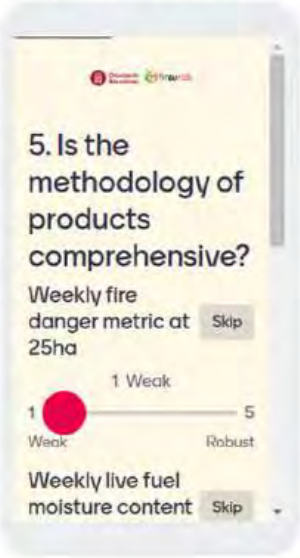


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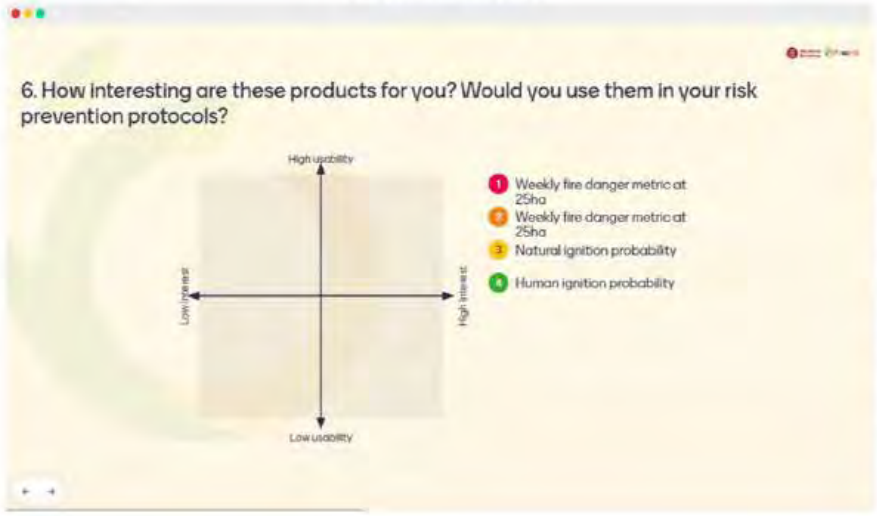



Audience screen

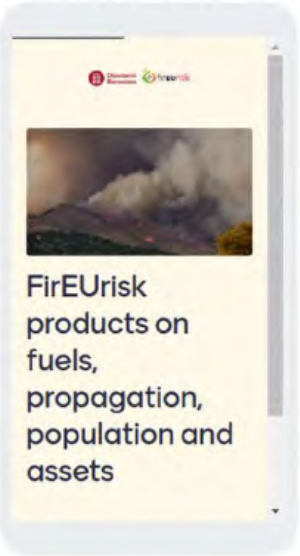


## Session 2: FirEURisk products on fire risk reduction

Presenter screen




Audience screen



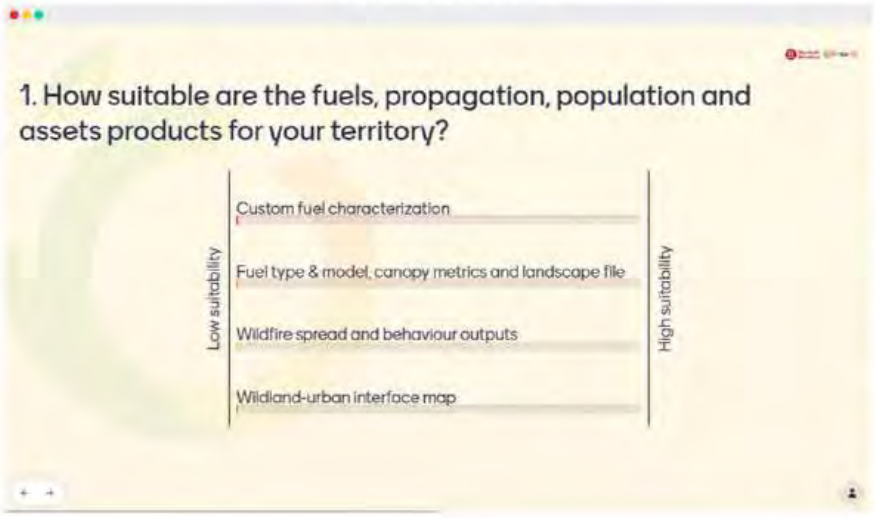

Presenter screen




Audience screen



Presenter screen

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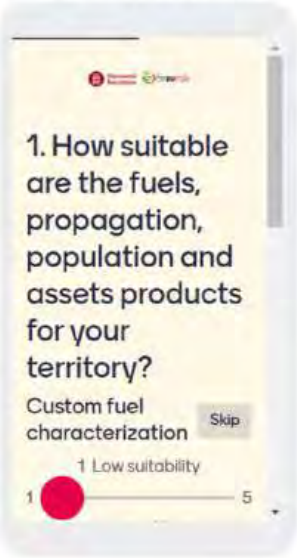


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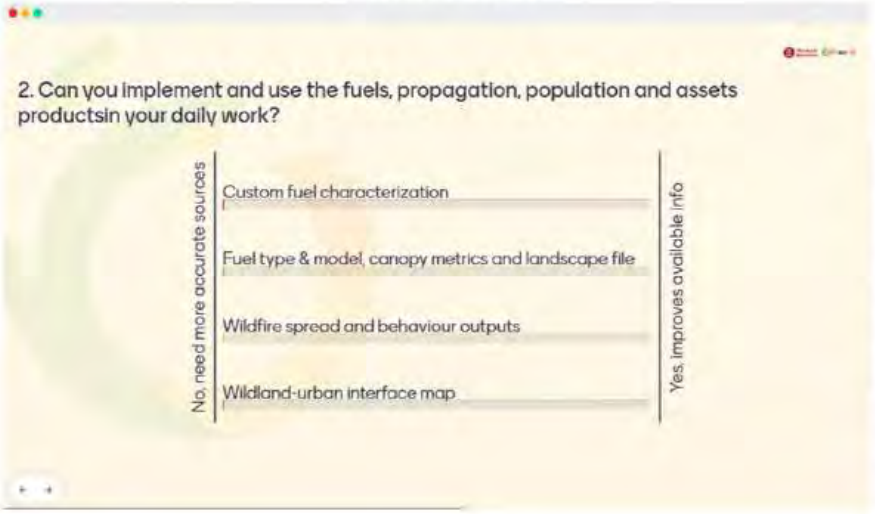


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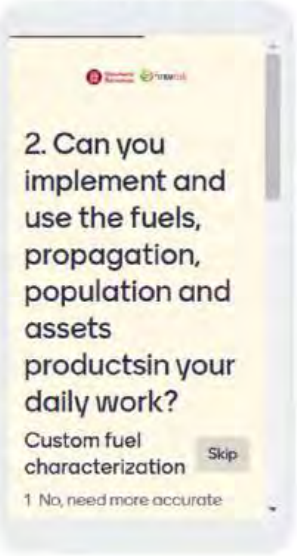

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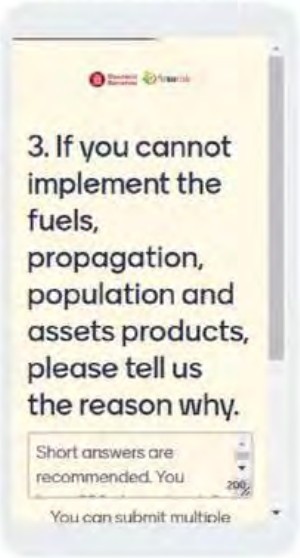
Audience screen

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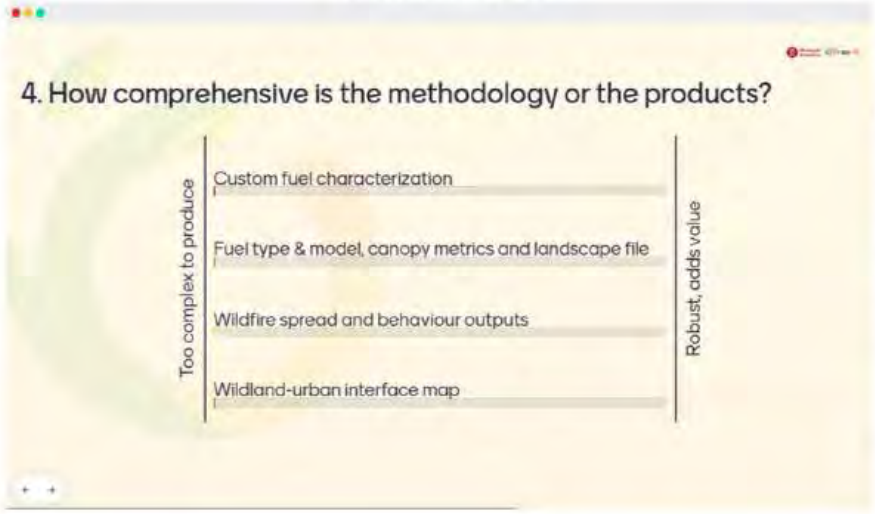


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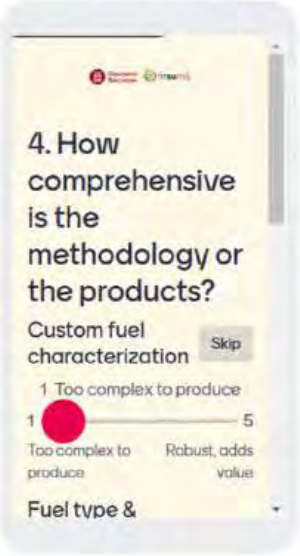
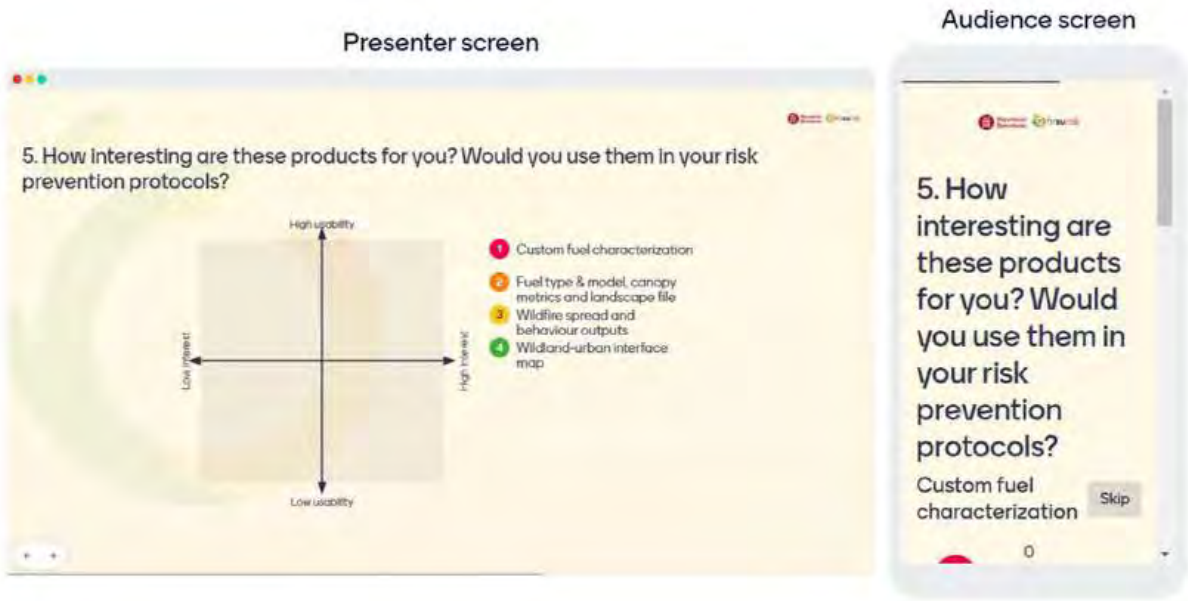
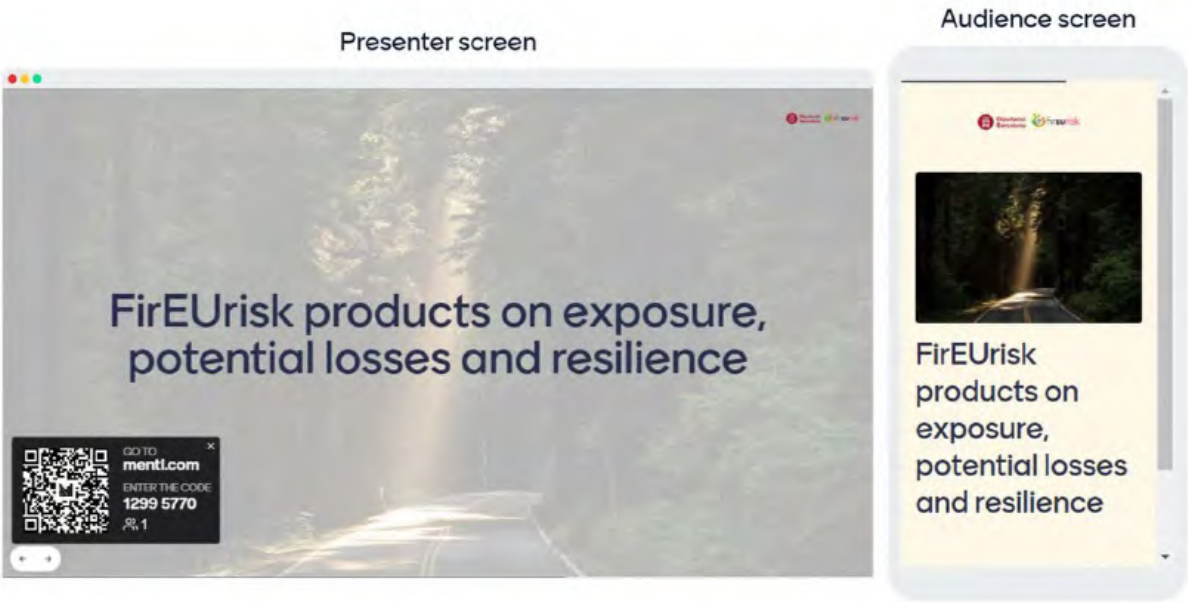





## Session 3: FirEUrisk products on fire risk adaptation



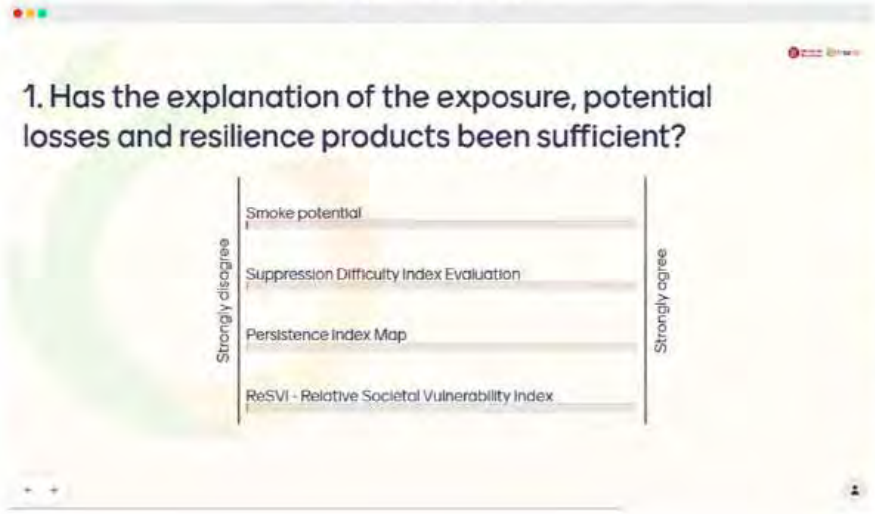
Presenter screen




Audience screen




Presenter screen

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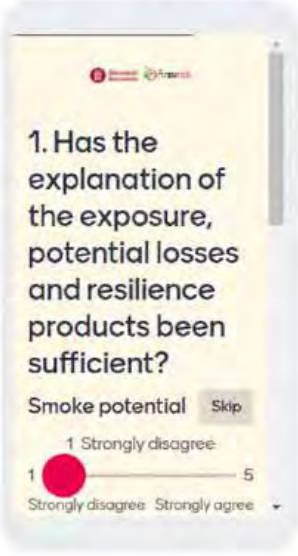

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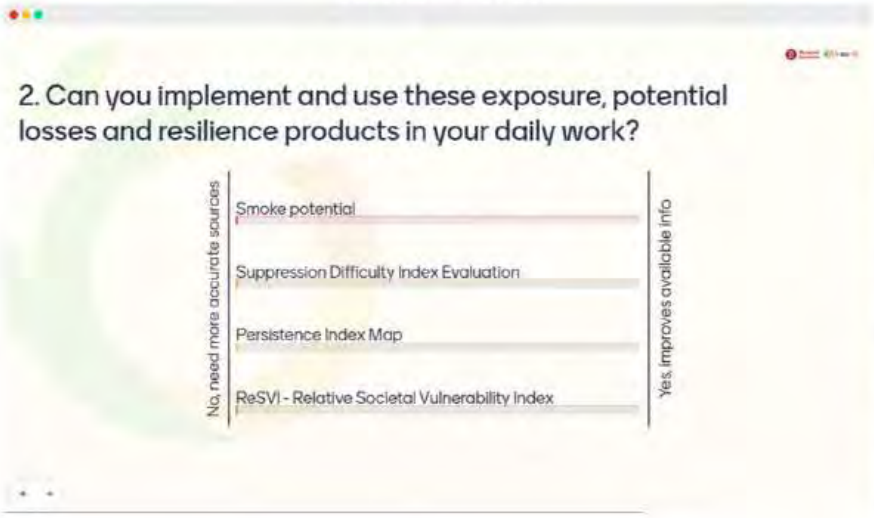


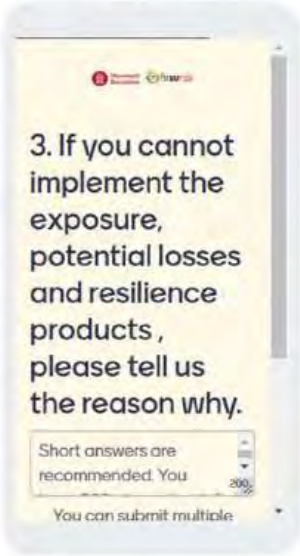

Audience screen




Presenter screen




Audience screen



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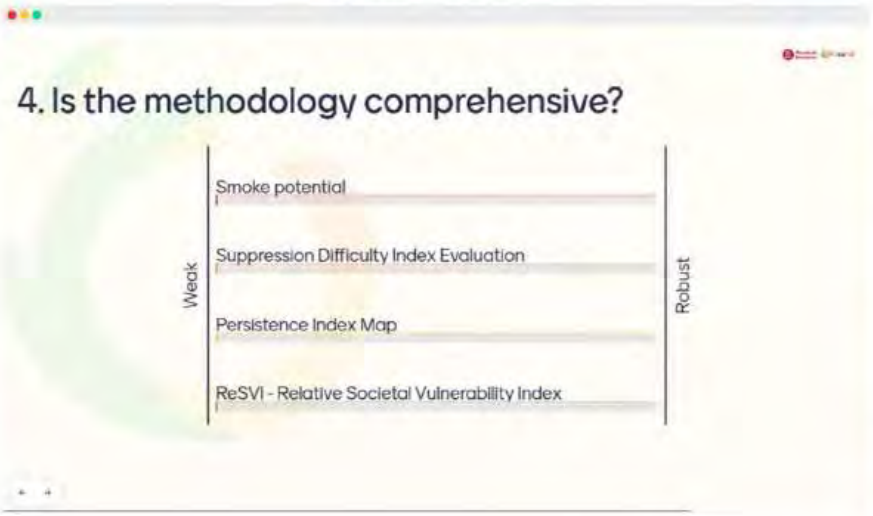


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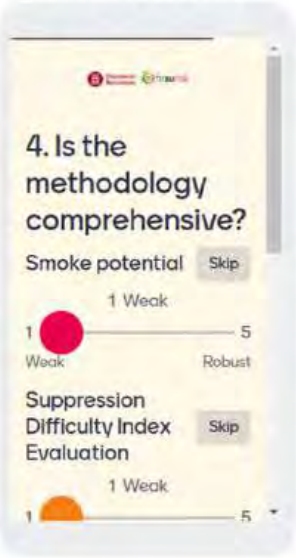


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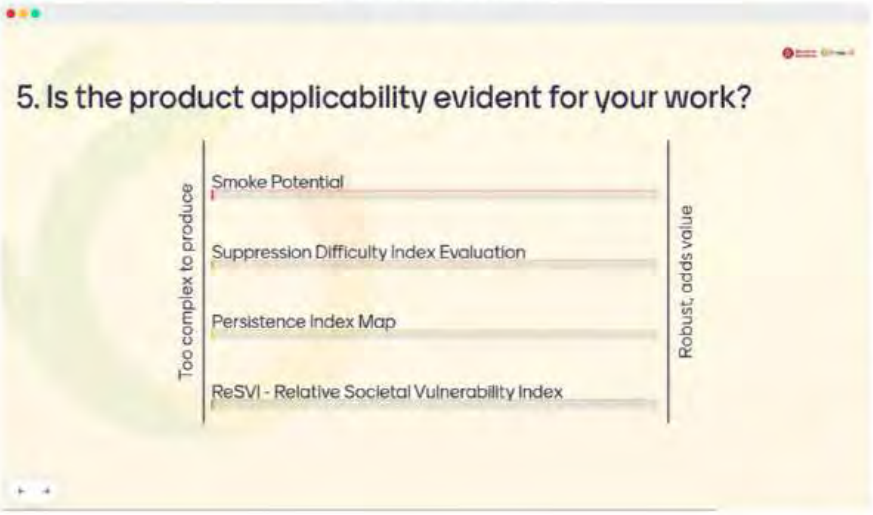


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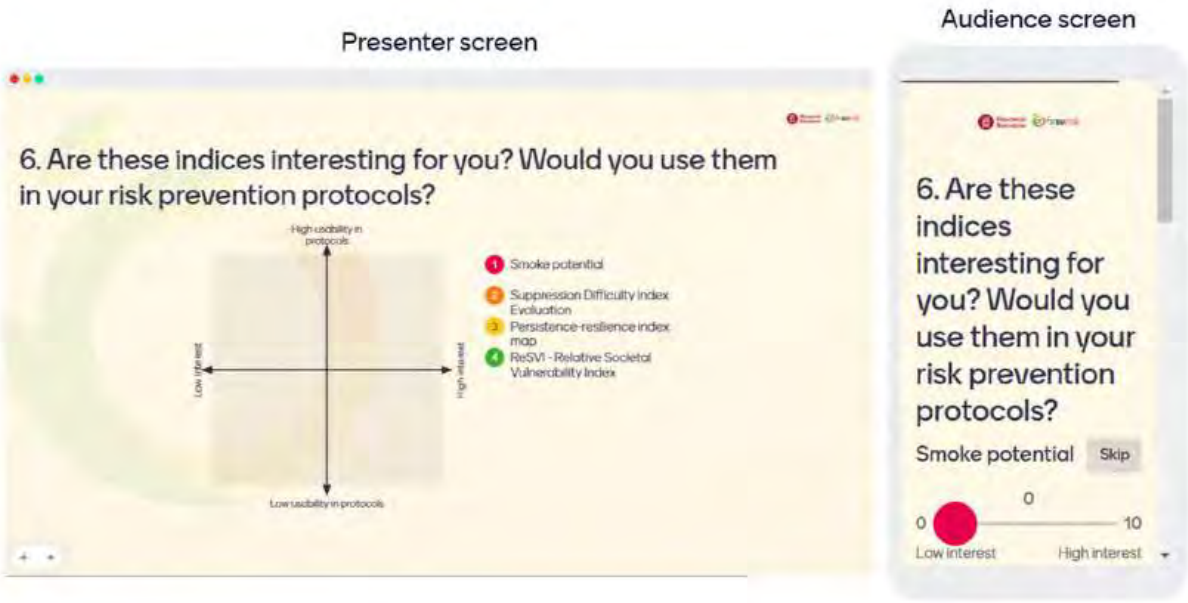
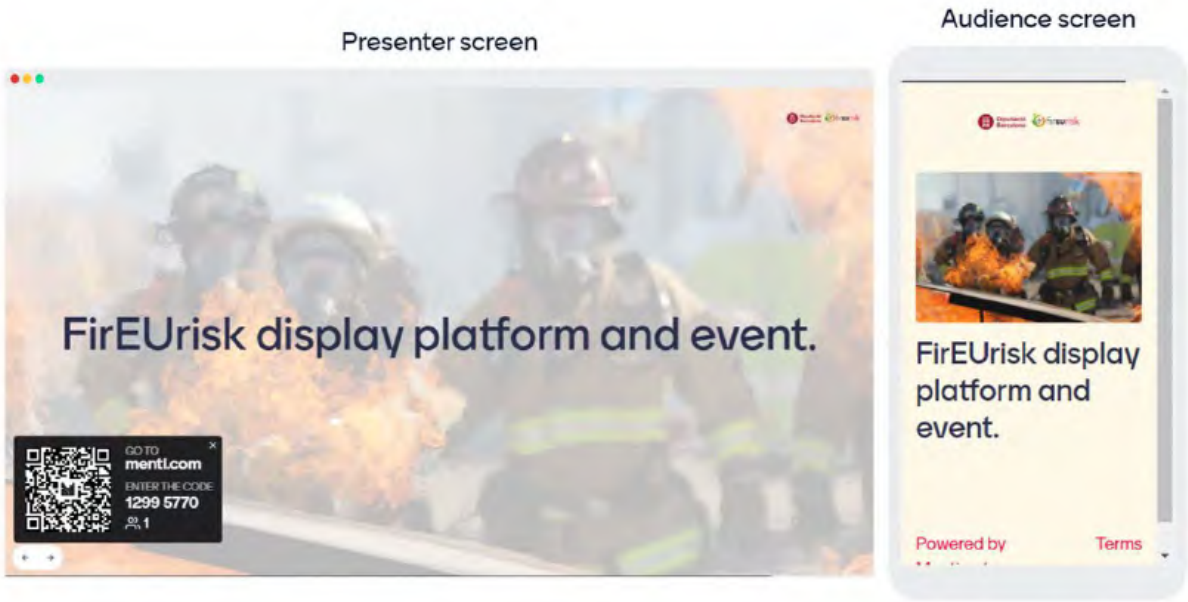
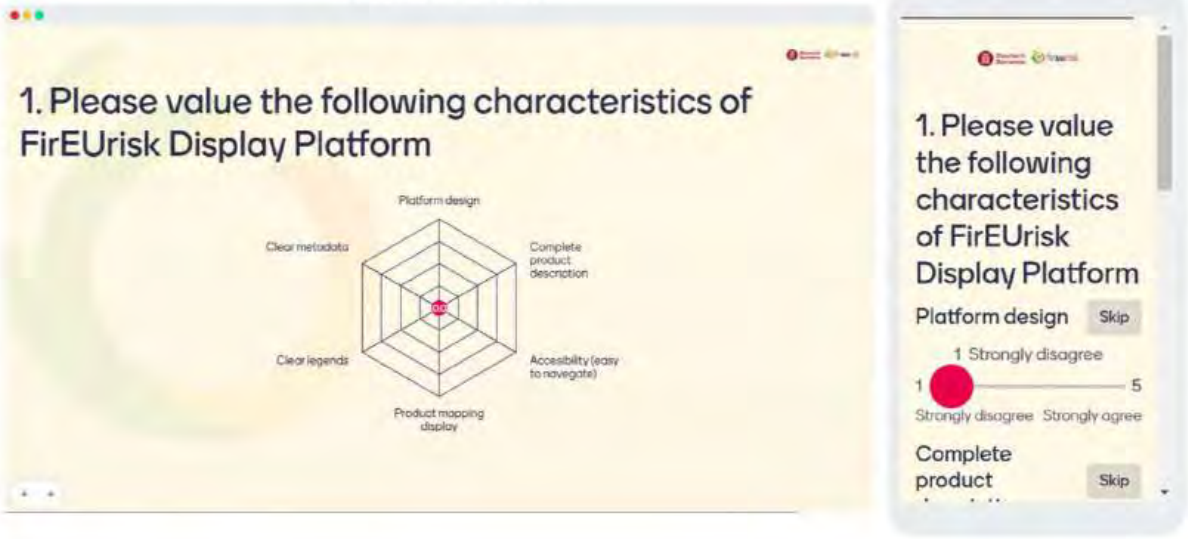



## Session 4: FirEUrisk display platform



Presenter screen

Audience screen




Presenter screen

Audience screen



Presenter screen




Audience screen




Presenter screen




Audience screen



# Annex C: Direct display of the Mentimeter questionnaire responses

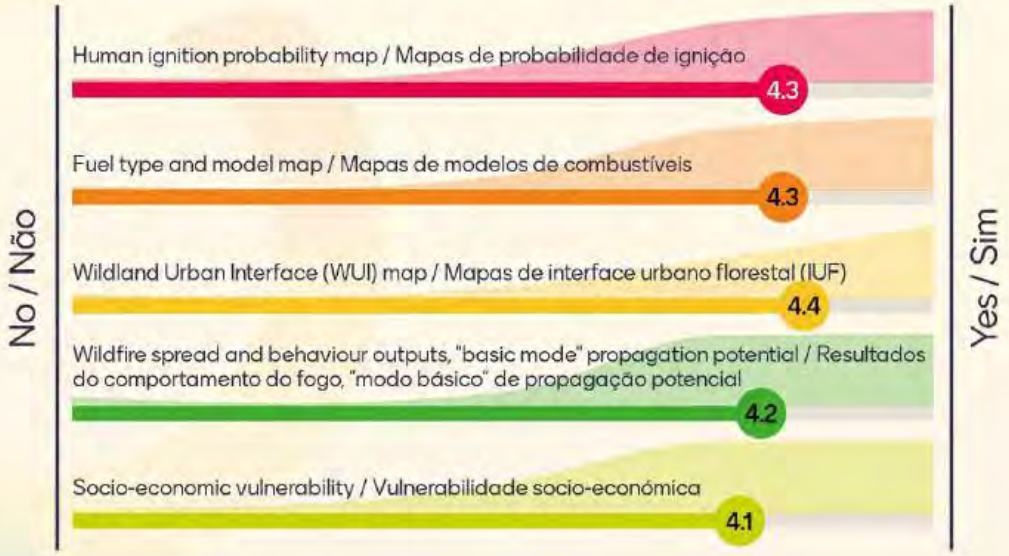
## Session 0: Presentation and introduction



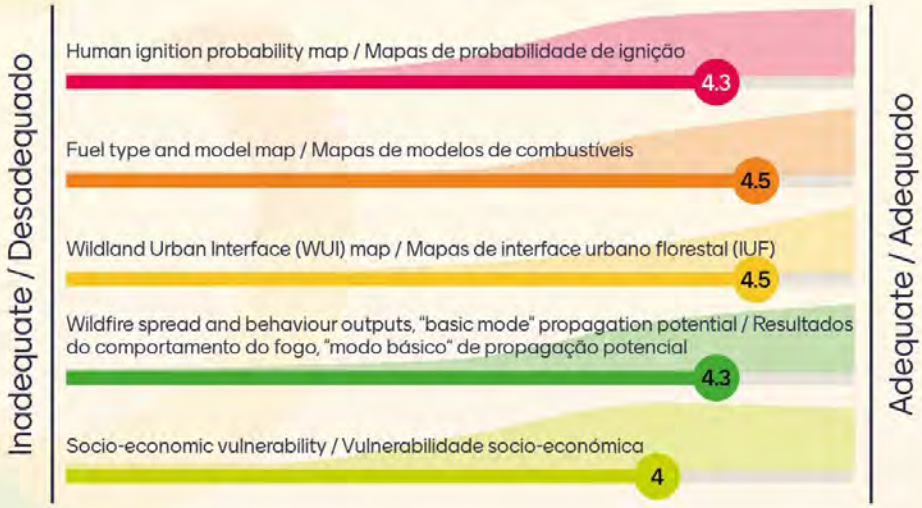



## Session 1: FirEUrisk products on fire risk assessment

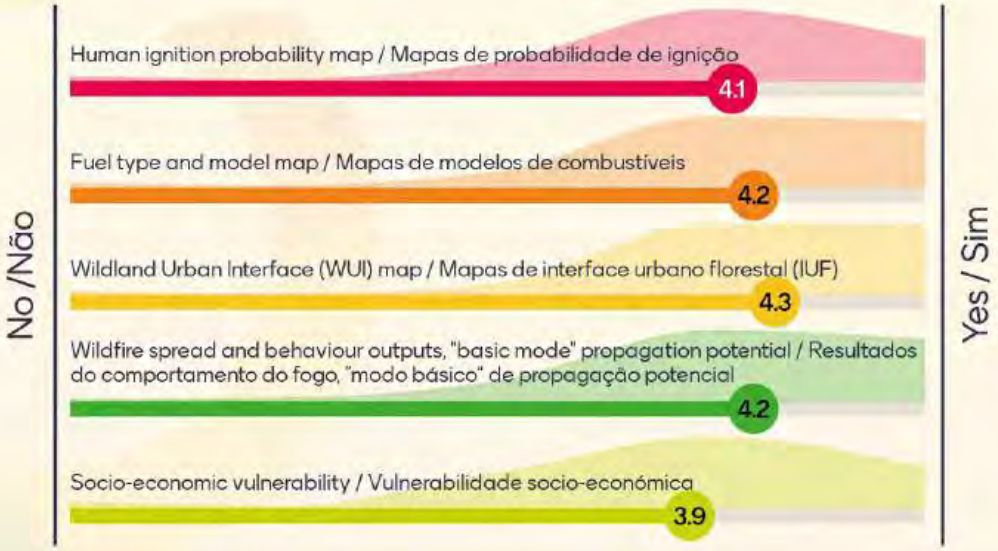
### 1. Was the explanation of the fire risk assessment products sufficient? | A explicação sobre os produtos de avaliação de risco foi suficiente?



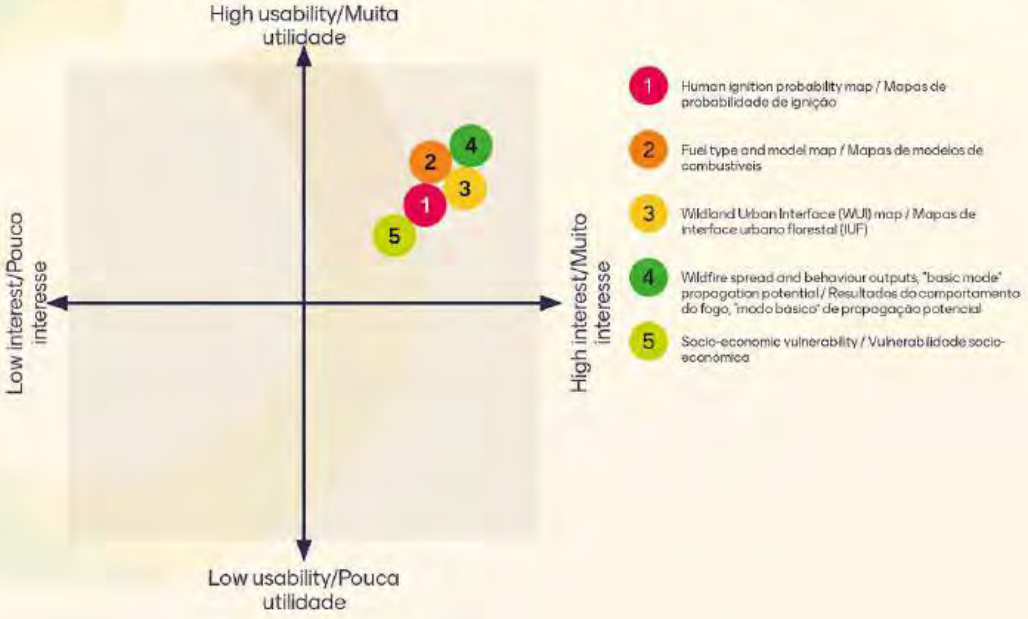

### 2.How suitable are these risk assessment products for your territory? | Quão adequados para o seu território são estes produtos de avaliação de risco?



## 4. Is the approach to fire risk assessment products comprehensive? A abordagem seguida para os produtos de avaliação de risco é completa?

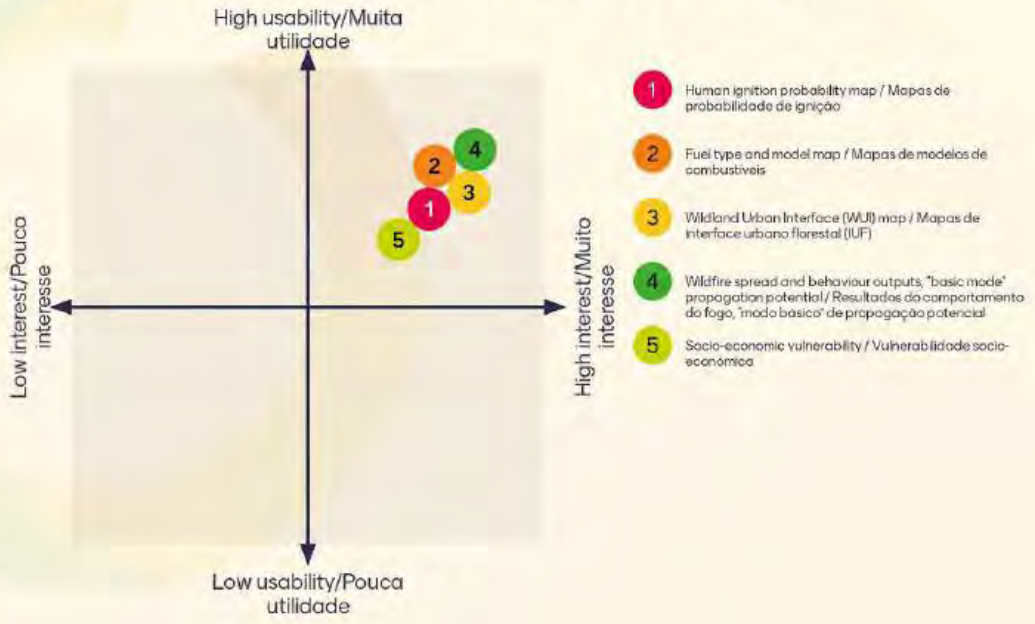



## 5. How interesting are these products? Would you use them in your activities? |Quão interessantes são estes produtos? Utilizá-los-ia na sua atividade?

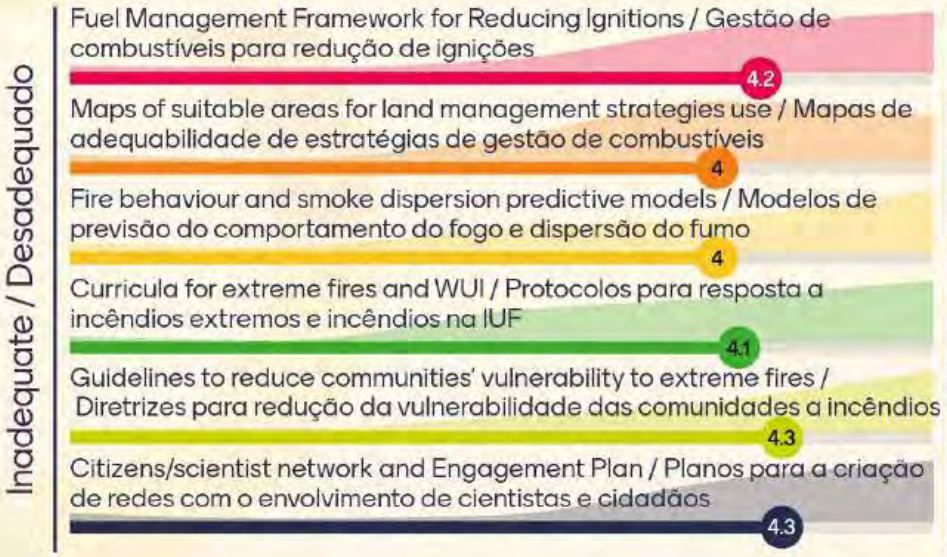


## Session 2: FirEUrisk products on fire risk reduction

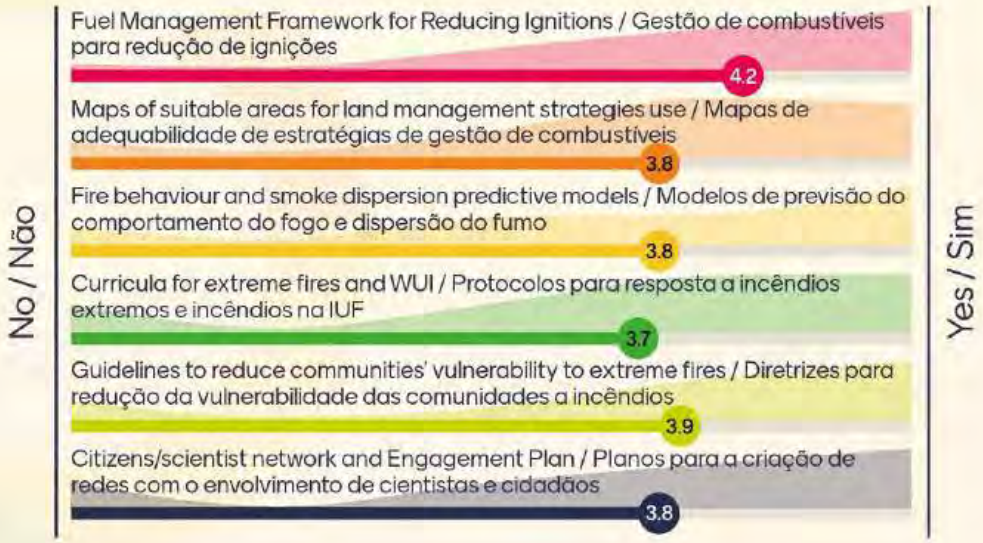
### 5. How interesting are these products? Would you use them in your activities? |Quão interessantes são estes produtos? Utilizá-los-ia na sua atividade?



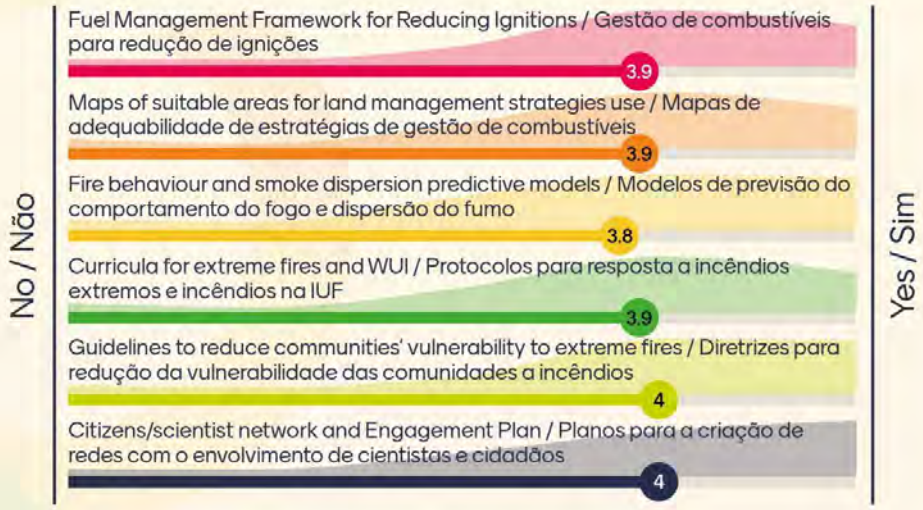

### 2. How suitable are this risk reduction products for your territory? |Quão adequados para o seu território são estes produtos de redução de risco?



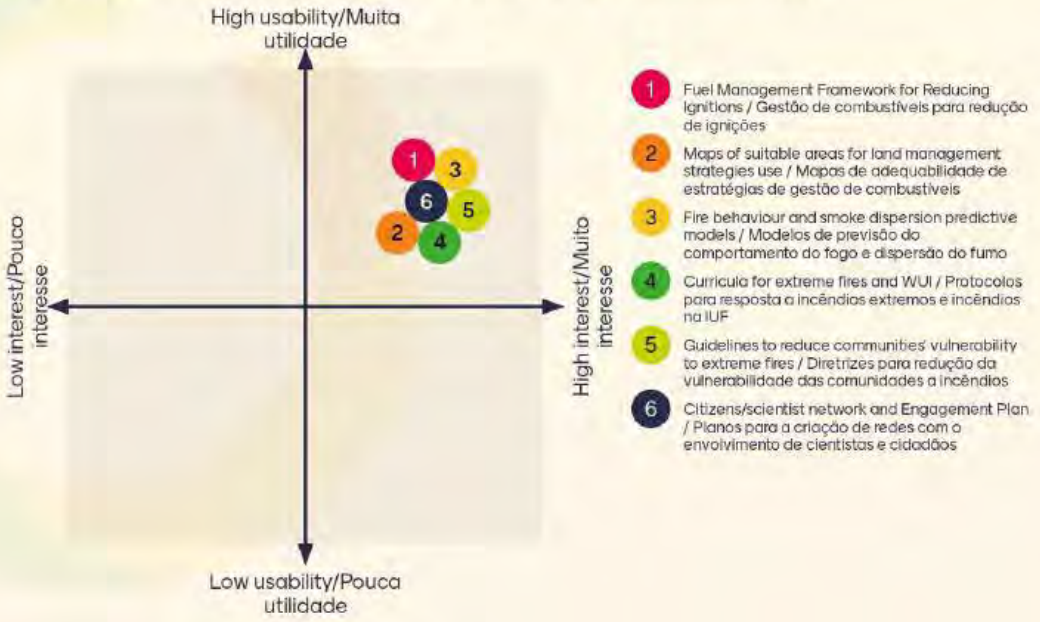
## 3. What other information for fire risk reduction would you need? | Que mais informação sobre redução de risco necessitaria?




## 4. Is the approach to fire risk reduction products comprehensive? | A abordagem seguida para os produtos de redução de risco é completa?

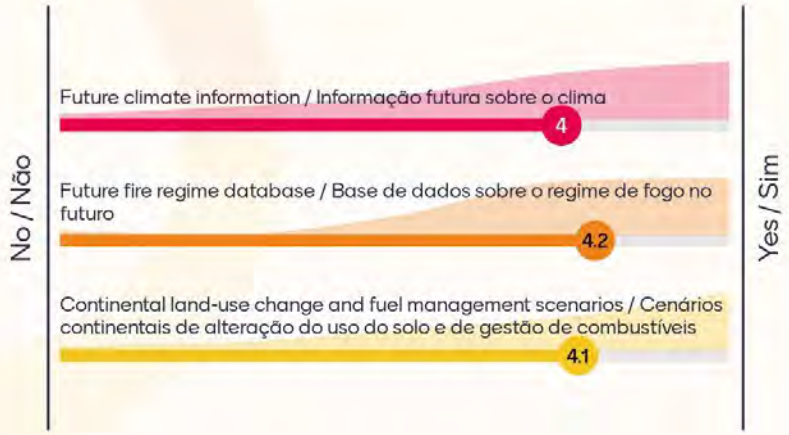


## 5. How interesting are these products? Would you use them in your activities? |Quão interessantes são estes produtos? Utilizá-los-ia na sua atividade?

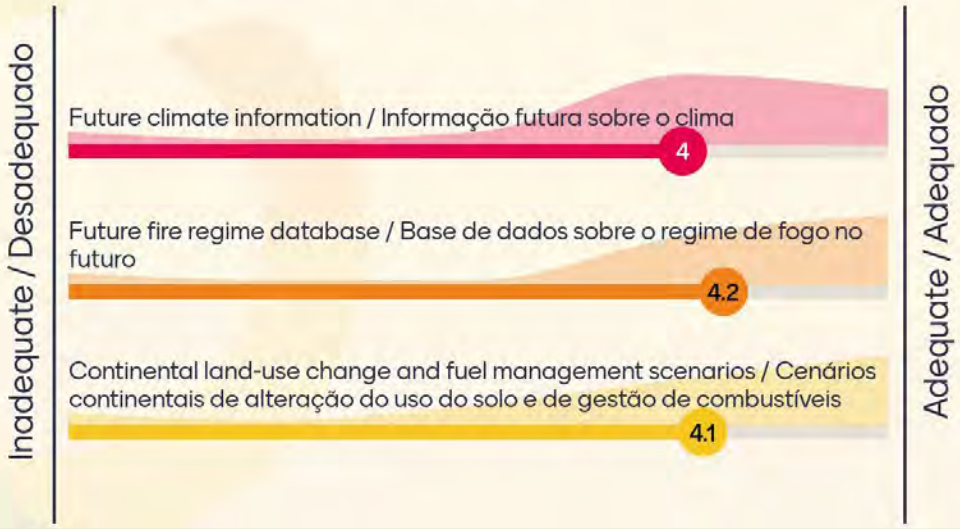


## Session 3: FirEUrisk products on fire risk adaptation

### 1. Was the explanation of the fire risk adaptation products sufficient? | A explicação sobre os produtos de adaptação ao risco foi suficiente?



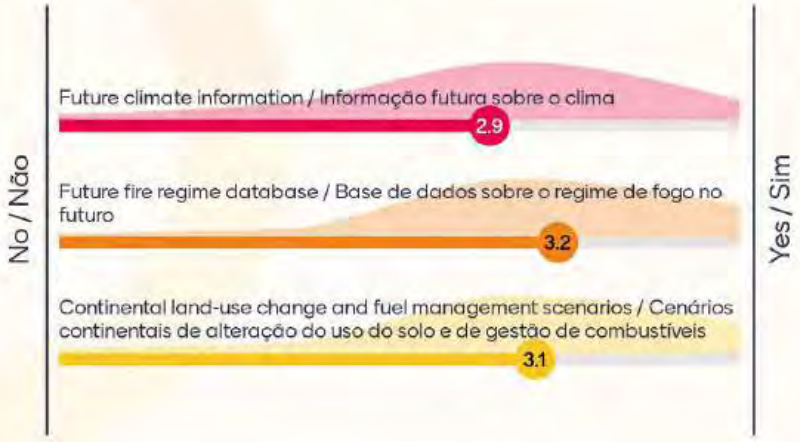

### 2. How suitable are this risk adaptation products for your territory? | Quão adequados para o seu território são estes produtos de adaptação ao risco?



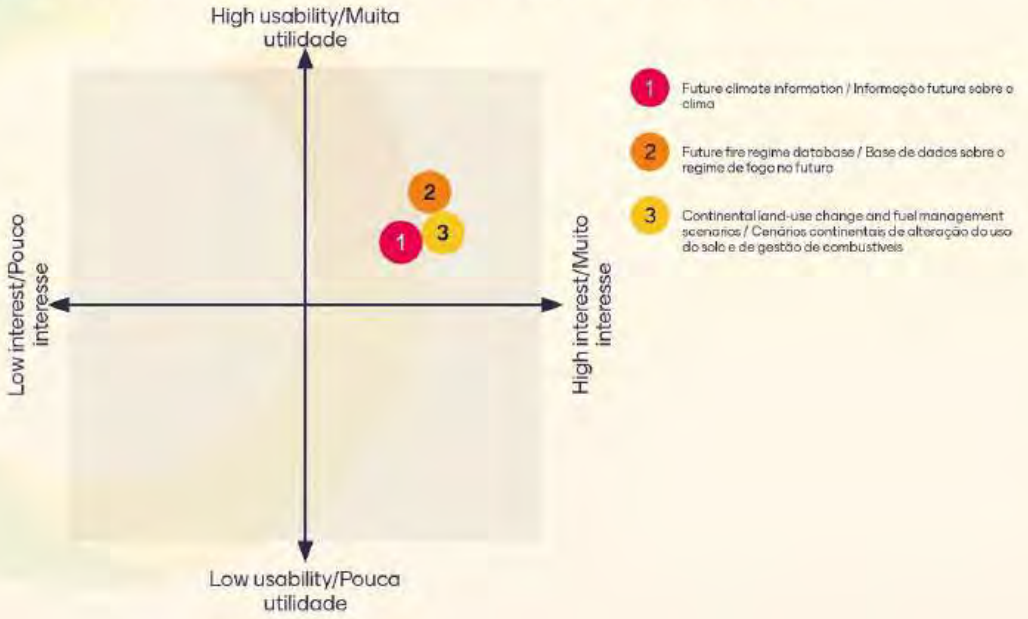
## 3. What other information for fire risk adaptation do you need? | Que mais informação sobre adaptação ao risco necessitaria?




## 4. Is the approach to fire risk adaptation products comprehensive? | A abordagem seguida para os produtos de adaptação ao risco é completa?

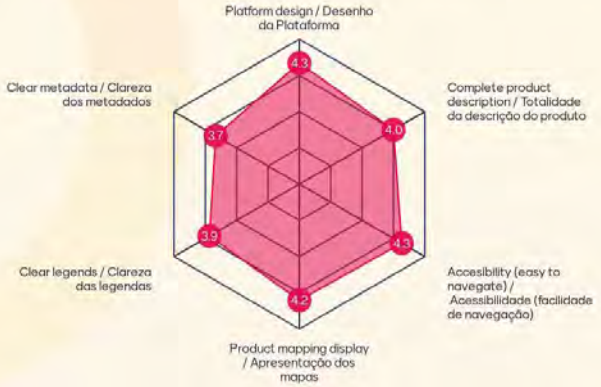


## 5. How interesting are these products? Would you use them in your activities? | Quão interessantes são estes produtos? Utilizá-los-ia na sua atividade



## Session 4: FirEUrisk display platform

# 1. Value the following characteristics of FirEUrisk Display Platform | Avalie as seguintes características da plataforma de visualização FirEUrisk.




# 2. To what extent do you agree with the following statements? | Em que medida concorda com as seguintes afirmações?

